UNIVERSIDAD DE GRANADA

Facultad de Ciencias Económicas y Empresariales
Departamento de Organización de Empresas
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TESIS DOCTORAL

INNOVACIONES MEDIOAMBIENTALES: ESTRATEGIAS CORPORATIVAS E INFLUENCIAS INSTITUCIONALES. /

SUSTAINABLE INNOVATIONS: CORPORATE STRATEGIES AND INSTITUTIONAL INFLUENCES.

MENCIÓN DE DOCTORADO INTERNACIONAL

Tesis doctoral presentada por :
Dante Ignacio Leyva de la Hiz

Director:
Juan Alberto Aragón Correa

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"Vive como si fueras a morir mañana.

Aprende como si fueras a vivir siempre"

Mahatma Gandhi

“Live as if you were to die tomorrow.

Learn as if you were to live forever.”

Mahatma Gandhi

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INTRODUCCIÓN.

1.1.- ACERCAMIENTO AL TEMA OBJETO DE ESTUDIO Y SU IMPORTANCIA.

La innovación es un aspecto fundamental tanto para el desarrollo de las empresas como de nuestra sociedad actual. Desde el punto de vista de las empresas, la innovación supone un cambio en alguno de sus planteamientos que normalmente se desarrolla buscando una mejora de la eficiencia y eficacia de sus actividades y que, idealmente, conduce a la consecución de ventajas competitivas duraderas en el tiempo (Brown and Eisenhardt, 2007). Estas ventajas competitivas derivadas de las innovaciones permiten que las organizaciones incrementen sus niveles de desempeño, obteniendo una rentabilidad superior a sus competidores.

Las innovaciones no sólo benefician a las organizaciones sino que, a través de éstas, la sociedad mejora su calidad de vida. Es por este motivo que cada vez es más frecuente que estados e instituciones internacionales establezcan la innovación como uno de los pilares fundamentales de sus agendas (Hoffman, 1999). En este sentido, hoy en día resulta cada vez más habitual encontrar indicadores de desempeño innovador tanto a nivel empresarial como nacional, tales como el gasto en Investigación y Desarrollo (I+D) en función del Producto Interior Bruto (PIB), el número de investigadores en proporción a la población de un país, el número de innovaciones llevadas a cabo durante un período de tiempo, etc. (Banco Mundial, 2015).

Sin embargo, en numerosas ocasiones las consecuencias positivas de las innovaciones (v.g. mejoras de las infraestructuras, incremento en la seguridad de los medios de transporte, mayor variedad de productos y servicios, etc.) han traído consigo una serie de efectos negativos, lo que diversos autores han denominado "*externalidades negativas*" (Porter and

Van der Linde, 1995). En este sentido, a pesar de que durante el pasado siglo XX y parte de este siglo XXI los avances tecnológicos han posibilitado la creación de un estado de bienestar impensable por nuestros ancestros, muchas de estas mejoras están teniendo un efecto devastador sobre el medio ambiente (Hart, 1995). Consecuencias como los insoportables niveles de contaminación en determinadas ciudades, escándalos medioambientales como el hundimiento del buque *Prestige* en las costas españolas en el año 2002 o los vertidos de la compañía petrolera BP en el golfo de México en el año 2010 están haciendo que el conjunto de la sociedad adquiera una mayor preocupación sobre el medio ambiente. Por tanto, conceptos como *efecto invernadero, cambio climático, niveles de contaminación atmosférica y acuífera* ya han dejado de ser exclusivos de una minoría científica para estar presentes en nuestro día a día. En otras palabras, la conservación del medio ambiente ha dejado de ser considerada en abstracto para convertirse en una preocupación en la cual se implican cada más actores de la sociedad. Como consecuencia, clientes, proveedores, trabajadores e incluso accionistas están más interesados en la interacción de sus empresas con el desarrollo sostenible y presionan en este sentido (Barczak, 2012; Paladino, 2008).

Esta situación, en la que se requiere un continuo incremento en los niveles de desarrollo sin que ello suponga un deterioro del medio ambiente, ha propiciado que las empresas se replanteen su forma de innovar. Hoy en día ya no resulta suficiente centrarse únicamente en la mejora de la calidad del producto o del servicio que se ofrece, sino que se tiene que hacer de manera respetuosa con el medio ambiente. Además, ciertas innovaciones tienen como principal objetivo el facilitar herramientas para reducir el impacto medioambiental de la propia empresa o de sus clientes. Para dar respuesta a estos objetivos, durante los últimos años han ganado importancia las denominadas innovaciones sostenibles o innovaciones medioambientales.

Las innovaciones medioambientales pueden ser definidas como aquellas "medidas llevadas a cabo por una serie de actores relevantes, los cuales: (I) desarrollan nuevas ideas, comportamientos, productos y procesos, los aplican o introducen, y; (II) contribuyen a la reducción de determinados niveles de contaminación o a la consecución de una serie de objetivos medioambientales específicos" (Rennings, 2000:322). La importancia de las innovaciones medioambientales se ve reflejada en diferentes aspectos como el gasto en inversión de las organizaciones, el empleo que generan, y las regulaciones medioambientales. Puesto que en los próximos capítulos de la presente tesis aportaremos numerosos ejemplos que muestran la relevancia de las innovaciones medioambientales, en esta primera introducción nombraremos unos pocos con el objeto de que el lector pueda comprender grosso modo su importancia actual.

Así, el Programa Medioambiental de las Naciones Unidas (UNEP, por sus siglas en inglés) (UNEP, 2013) destacó que mientras que en el año 2006 la cifra de personas con trabajos ligados a las energías renovables era de 2.3 millones, sus estimaciones hablan de más de 20 millones de empleados en el año 2030, es decir, de un incremento cercano al 1,000%. De manera paralela, aquellas innovaciones ligadas a tecnologías más contaminantes como los combustibles fósiles están experimentando un notorio descenso, el cual se está acentuando en estos últimos años (Houser et al., 2009). En esta misma línea, la Asociación Europea de Gestión de Investigación Industrial (European Industrial Research Management Association, en inglés) estima que la mitad de los proyectos de I+D desarrollados en empresas europeas contenían aspectos medioambientales relevantes (Nameroff, Garant, y Albert, 2004), estimándose asimismo que las innovaciones medioambientales representen un mercado de más de 315,000 millones de dólares en el año 2018 (Bennett, 2010).

Sin embargo, a pesar de la creciente preocupación sobre aspectos medioambientales por parte de la sociedad, y del elevado potencial que numerosos organismos internacionales acreditan sobre las innovaciones medioambientales, el estudio en profundidad de este tipo de innovación es muy escaso (e,g, Berrone, Fosfuri, Gelabert, and Gomez–Mejia, 2013). En este sentido, diversos autores (e.g. Starik, 2013) han realizado llamamientos a la comunidad científica para ahondar sobre las innovaciones medioambientales. En consecuencia, la presente tesis doctoral pretende fijar un marco de referencia tanto teórico como empírico que explique las particularidades de este tipo de innovaciones, prestando especial atención a las innovaciones medioambientales que se reflejan en patentes, así como sus influencias tanto a nivel organizativo como institucional.

Una vez acotada la temática general, en este trabajo presentamos cuatro estudios de campo que intentarán dar respuesta a las siguientes problemáticas:

- Las innovaciones medioambientales hacen referencia a un gran abanico de tecnologías en las que puede basarse la innovación y que pueden ser relativamente similares a las ya existentes o radicalmente diferente. En este sentido, ¿qué tipo de estrategia en materia de innovación medioambiental conduce a un mayor desempeño organizativo?, ¿es mejor explotar innovaciones medioambientales ya conocidas o explorar nuevas tecnologías verdes? Además, en numerosas ocasiones las organizaciones poseen una serie de recursos que no están siendo utilizados, lo que la literatura denomina "recursos ociosos" o *slack resources*. Aunque la no utilización de dichos recursos tiene un coste de oportunidad, éstos también pueden tener un carácter estratégico para la organización. En este sentido, además de estudiar la relación entre el grado de explotación/exploración y el desempeño, estudiaremos cuál es el papel de los recursos ociosos en dicha relación.

- Una vez que hemos analizado las innovaciones medioambientales desde un punto de vista interno, ¿cuál es la mejor estrategia llevada a cabo por la empresa en función de que lo que hacen sus competidores? Es decir, en este caso prestamos especial atención a las innovaciones medioambientales que están desarrollando los competidores para analizar cómo influyen en los desarrollos de innovación medioambiental de la empresa y su desempeño.

- Continuando con el análisis de la innovación medioambiental en términos relativos, mientras que la presión institucional puede conducir al desarrollo de innovaciones medioambientales en ámbitos similares a los de los competidores, esos desarrollos en ámbitos convergentes pueden incrementar los requerimientos para negociar con los competidores acuerdos de colaboración que pueden ser costosos. En este sentido, ¿qué consecuencias tiene para la empresa la presión institucional hacia una convergencia tecnológica medioambiental o la búsqueda de recursos y capacidades distintivas por parte de las organizaciones? Asimismo, estudiamos si las presiones institucionales hacia innovaciones medioambientales tienen un efecto negativo sobre el resto de innovaciones o, si por el contrario se producen sinergias entre ambos tipos.

- Finalmente, culminamos nuestra investigación, analizando el desarrollo de las innovaciones medioambientales de las empresas desde un punto de vista agregado en distintos países. En este sentido, estudiamos el efecto que los diferentes estilos de lo que se denomina "red política" del país (“*policy network style*”) tienen sobre el número y valor de las innovaciones medioambientales en distintos países desarrollados.

En consecuencia, en los siguientes apartados de esta introducción delimitaremos los principales conceptos utilizados en esta tesis doctoral, realizaremos una breve revisión de la literatura relevante, explicaremos los conceptos empleados y presentaremos una primera visión general de los resultados de nuestra investigación.

1.2.- OBJETIVOS GENERALES DEL ESTUDIO

Como se adelantaba anteriormente, la presente tesis doctoral pretende ahondar en el conocimiento de un tipo de innovación tan relevante desde un punto de vista social y económico como poco analizado en la literatura (Berrone, et. al, 2013), las innovaciones medioambientales. En este sentido, la presente tesis doctoral analiza tanto las estrategias que llevan a cabo las empresas en materia medioambiental como la influencia de sus competidores y características generales del país.

Ante la relativa escasez de estudios de innovaciones medioambientales, la presente tesis doctoral contiene cuatro trabajos de campo en los que se estudian los aspectos estratégicos de las innovaciones medioambientales de forma progresiva. En este sentido, el capítulo 2 incluye un análisis puramente interno de los factores que afectan a las innovaciones medioambientales, mientras que el capítulo 3 estudia las estrategias medioambientales en función de los competidores de la organización. Una vez realizado este análisis, contrastamos las influencias institucionales con las estrategias internas (capítulo 4) y finalmente estudiamos el papel facilitador o limitador de las instituciones desde un punto de vista más amplio, agrupando diferentes países industrializados (capítulo 5).

De manera más concreta, el capítulo 2 contribuye al debate entre explotación versus exploración al realizar un análisis desde el punto de vista de la madurez de las innovaciones medioambientales. A nivel general, y siguiendo el trabajo seminal de March (1991: 85), consideramos que una organización lleva a cabo una actividad innovadora explotadora cuando "refine y extiende las competencias, tecnologías y paradigmas que ya conoce", mientras que llevará a cabo una actividad innovadora exploradora cuando "experimente con nuevas alternativas". Mientras que estudios previos han analizado las ventajas y desventajas de uno u otro enfoque (Cohen and Levinthal, 1990; March, 1991; Nooteboom et al., 2007), la mayoría de estos trabajos han empleado una perspectiva estática y universal con el objeto de seleccionar el tipo más adecuado de innovación. Frente a esta perspectiva, nuestro trabajo ha considerado el grado de madurez de las innovaciones, aspecto que resulta fundamental para la toma de decisiones relacionadas con el portafolio tecnológico de una organización . De manera complementaria estudiamos el papel moderador que tienen los recursos ociosos (“*slack resources”*) sobre esta relación entre desempeño organizativo y tipo de estrategia innovadora.

El capítulo 3 centra su atención en aspectos externos a la organización y, específicamente, estudiamos qué estrategias en materia de innovación medioambiental llevan a cabo las organizaciones en función de las estrategias que siguen sus competidores. Es decir, ya no sólo tenemos en cuenta cómo se puede optimizar el portafolio innovador de la organización según sus actividades internas, sino que estudiamos cuál es la mejor estrategia según los movimientos estratégicos que realizan los competidores. Mientras que la literatura institucional presenta una serie de motivos que explican por qué las organizaciones generan innovaciones en áreas similares a sus competidores (e.g., Hoffman, 1999; King and Lenox, 2000; Whiteman, Walker and Perego, 2013), las razones por las cuales las organizaciones innovan en áreas tecnológicas diferentes a los competidores han recibido una atención muy limitada. En este sentido, empleamos la teoría de los costes de transacción (Williamson, 1975, 1985) para explicar este fenómeno.

El análisis de los costes de transacción de las innovaciones medioambientales parte de que un único producto contiene actualmente miles de patentes que son propiedad de diferentes competidores (Lin, 2013), por tanto para poder comercializar una invención es necesario realizar transacciones con otras empresas que cuentan con innovaciones patentadas relacionadas. Estas transacciones generan una serie de costes que pueden ir desde el mero cobro de derechos de autor o royalties hasta el bloqueo total de la comercialización, pasando por litigios sobre propiedad intelectual que le pueden suponer a la organización varios millones de dólares e incluso su supervivencia (Markman, Espina, and Phan, 2004). En este sentido, analizamos las estrategias llevadas a cabo por empresas innovadoras en presencia de los siguientes atributos: grado de especialización de los activos (*asset specificity*), alcance de las innovaciones, poder de negociación de las partes y grado de conocimiento sobre innovaciones medioambientales.

El capítulo 4 estudia cómo las presiones institucionales hacia la sostenibilidad afectan a la estrategia de la organización. Por un lado, estudiamos si se producen sinergias entre innovaciones medioambientales y no medioambientales, ya que existe un debate sobre si realmente son complementarias o si, por el contrario, las presiones externas fuerzan a las organizaciones a realizar innovaciones medioambientales en detrimento del resto de innovaciones (Starik, 2013). Por otro lado, estudiamos si dichas presiones institucionales afectan a las tecnologías en las cuales las empresas realizan sus innovaciones medioambientales. Puesto que en la actualidad existe una gran variedad de tecnologías medioambientales, en este capítulo estudiamos si las instituciones conducen a las empresas a innovar en las mismas áreas o si las empresas innovan en diferentes tecnologías para así desarrollar una serie de recursos y capacidades que sean distintivos.

En el capítulo 5 analizamos cómo las estrategias en materia de innovación se ven influenciadas por las instituciones nacionales. Para poder estudiar el efecto diferenciador de las instituciones en la innovación patentada seleccionamos cuatro de las economías con mayor peso a nivel mundial que, además, constituyen la base de referencia geográfica donde se desarrollan la mayor parte de las innovaciones en el mundo, más concretamente Estados Unidos, Japón, Alemania y Reino Unido. Tomadas conjuntamente, estas economías representan más del 85% del total de patentes registrada en la Oficina de Marcas y Patentes de

Estados Unidos (United States Patent and Trademark Office, USPTO por sus siglas en inglés), durante los 27 años de nuestro período de análisis.

A pesar de que cada país posee sus propias características distintivas, la teoría neo-institucional ha determinado una serie de similitudes según las relaciones que se establecen entre el gobierno y los grupos de interés, lo que se denomina en inglés "*policy network style*" (e.g. Scruggs, 1999; Streeck and Kenworthy, 2005). En este sentido, Estados Unidos y Reino Unido se engloban dentro de los sistemas denominados plurales ("*pluralistic*"), los cuales se caracterizan por tener una número indeterminado de grupos de interés que compiten entre sí para influenciar en las tomas de decisiones gubernamentales y que para ello realizan una serie de coaliciones temporales en función de sus propios intereses. Por el contrario, Japón y Alemania se engloban dentro de los sistemas neo-corporativos ("*neo-corporatist*"), caracterizados por una red política más estable y cooperativa, que prioriza los objetivos sociales colectivos frente a los intereses particulares. Una vez realizada esta distinción, en el capítulo analizamos con más profundidad las diferencias entre ambas agrupaciones para estudiar el efecto que tiene dicha relación entre los grupos de interés y el gobierno ("*policy network style*") sobre el impacto de las patentes medioambientales.

1.3.- EL INTERÉS EN LAS PATENTES MEDIOAMBIENTALES Y MARCOS TEÓRICOS UTILIZADOS.

Nuestro trabajo profundiza en el conocimiento de innovaciones medioambientales a través del estudio de las patentes, las cuales se definen como "un título legal que protege una invención técnica durante un período limitado. [La patente] otorga a su poseedor el derecho de evitar que terceras partes exploten dicha invención en aquellos países en los cuales se ha registrado" (EPO, 2010). Las oficinas de patentes nacionales y supranacionales ofrecen una alta protección sobre las patentes, con lo que se consigue que las organizaciones eviten que otras empresas se apropien de las posibles rentas generadas por sus invenciones. Este aspecto protector de las patentes resulta clave, ya que como Pisano (1990:154) reconoce, "los problemas de apropiabilidad han sido siempre una preocupación central en materia de innovación". Las innovaciones permiten la generación de recursos nuevos, raros, de imperfecta movilidad, difíciles de imitar y, en definitiva, valiosos, que permiten que las que las organizaciones obtengan ventaja competitiva y, en última instancia, mayores niveles de rentabilidad (Ahuja and Katila, 2001; Crossan and Apaydin, 2010).

Mientras que el análisis de las innovaciones a través de patentes ha recibido una importante atención en numerosos estudios previos (e.g. Hagedoorn and Cloodt, 2003; Lanjouw and Mody, 1996; Popp, 2003), el hecho de que las innovaciones medioambientales hayan ganado importancia más recientemente hace que el análisis de este tipo de patentes sea mucho más escaso. En general, nuestro trabajo no considera que las patentes medioambientales tengan unas características intrínsecas diferenciadas con respecto al resto de patentes que requieran un tratamiento analítico diferenciado, sin embargo su evolución y aplicación en campos recientes llevan a que constituyan un ámbito ideal donde poder verificar relaciones de interés que han recibido una menor atención en la literatura general. Adicionalmente, la importancia de las innovaciones medioambientales para el desarrollo sostenible y, por consiguiente, para el futuro del planeta, aconsejan también prestar atención diferenciada a su análisis y evolución.

La importancia de la evolución de las patentes medioambientales se ha reflejado en que las principales oficinas de patentes a nivel mundial han comenzado a utilizar en los últimos años códigos específicos para las innovaciones medioambientales. En este sentido, los exiguos estudios previos sobre patentes medioambientales realizaban un análisis basado en las palabras clave recogidas en los resúmenes (*abstracts*) de las patentes, lo cual conduce a una clasificación menos precisa de las patentes medioambientales (e.g., Anastas and Warner, 1998; Lee, Veloso and Hounshell, 2011; Namerof et al., 2004; Wagner, 2007). Esta limitación ha desaparecido recientemente gracias a la atención que le están otorgando las diferentes oficinas de registros de patentes a las patentes medioambientales. En este sentido, la Oficina de Patentes Europea (European Patent Office, EPO por sus siglas en inglés), en colaboración con la UNEP y el Centro Internacional de Comercio y Desarrollo Sostenible (International Centre for Trade and Sustainable Development, ICTSD por sus siglas en inglés), realizaron un proyecto conjunto encaminado a delimitar qué patentes tienen un contenido medioambiental, entendiéndose como éste aquel que reduce el impacto medioambiental del sistema productivo de una organización (EPO, 2010). A pesar de su reciente aparición, este criterio no sólo se está aplicando para aquellas patentes que se registran a partir del año 2010, sino que la EPO está actualmente empleando a sus expertos para reclasificar patentes que se concedieron con anterioridad a esta fecha en función del análisis de detalle de las patentes que se realiza para evaluar su concesión (EPO, 2010)..

De manera similar, la Oficina de Patentes y Marcas de Estados Unidos (USPTO) en el año 2009 lanzó el Programa Piloto de Tecnologías Medioambientales (Green Technology Pilot Program, en inglés). Este programa no sólo permite una distinción clara entre patentes con contenido medioambiental del resto, sino que favorece la generación de tecnologías medioambientales al ofrecer un proceso de revisión acelerado con respecto al resto de patentes (USPTO, 2009).

Una vez que hemos delimitado el concepto de innovación, de innovación medioambiental y el uso de patentes en este contexto, a continuación expondremos los diferentes conceptos y marcos teóricos que hemos utilizado en la presente tesis doctoral para analizar los planteamientos llevados a cabo por las empresas en materia de innovación medioambiental.

En primer lugar, merece especial atención dedicar unas líneas a la teoría de recursos y capacidades (*Resource-Based View, RBV* por sus siglas en inglés) (Barney, 1991; Peteraf, 1993; Penrose, 1959), la cual constituye una de las bases para comprender el comportamiento estratégico de las empresas. Grant (1991:3) define estrategia como "la forma en que una organización enlaza sus recursos y capacidades internas... con las oportunidades y amenazas creadas por el entorno exterior". En este sentido, la fundamentación teórica de la RVB (Barney, 1991) establece que 1) las organizaciones poseen una serie de recursos distintivos que las hacen intrínsecamente diferentes a sus competidores, lo que denominó *heterogeneidad de recursos*, y 2) estos recursos no están disponibles para todos los competidores (*imperfecta movilidad)*, lo que los hace valiosos y, por tanto capaces de generar una ventaja competitiva. Por su parte, el concepto de recursos hace referencia a todos aquellos factores de naturaleza tanto tangible como intangible que controla la organización y que, por tanto, están disponibles para llevar a cabo su estrategia (Barney, 1991).

Dada la amplitud y alto grado de aceptación de esta teoría, numerosos autores la han empleado para el análisis de los planteamientos medioambientales de la empresa. En este sentido, Hart (1995) introduce la perspectiva de recursos y capacidades naturales (*Natural Resource-Based View, NRBV* por sus siglas en inglés), según la cual las organizaciones se encuentran en un entorno social, cultural y tecnológico que posibilita el desarrollo de recursos y capacidades medioambientalmente sostenibles que simultáneamente permiten la protección medioambiental y la obtención de ventajas competitivas. Según la NRBV, los recursos y capacidades internos específicos que poseen las empresas son particularmente útiles en la generación de acciones medioambientales únicas, preventivas y voluntarias que permiten reducir el impacto medioambiental de dichas organizaciones.

Sin embargo, a pesar de las ventajas sobre una gestión proactiva de la estrategia medioambiental esgrimida por Hart (1995) y otros autores (e.g. Porter and Van der Linde, 1995; Aragón-Correa, 1998; Aragón-Correa and Sharma, 2003), existe un debate sobre si el comportamiento medioambientalmente responsable de las organizaciones se debe a este convencimiento sobre sus recursos y capacidades distintivos o de si es debido a las presiones institucionales (DiMaggio and Powell,1991; Hoffman, 1999). En este sentido, la teoría institucional sostiene que "la acción que realiza una empresa no consiste en una elección dentro de un universo ilimitado de posibilidades determinadas únicamente por aspectos internos, sino que se trata de una elección dentro de un número definido de opciones legítimas delimitado por los actores que conforman el *campo organizativo de la empresa*" (Hoffman, 1999:351). A su vez, el concepto *campo organizativo* engloba a todos aquellos agentes externos que ejercen influencia sobre la empresa, tales como gobiernos, proveedores, fuentes de financiación, sindicatos, etc., es decir cualquier agente que ejerza una influencia regulativa, normativa y cognitiva sobre la organización (Scott, 1995).

La influencia regulativa hace referencia a aquellos aspectos legales que diseñan el marco de actuación de la organización. Desde un punto de vista medioambiental, esta influencia se refiere a las diferentes regulaciones sobre los impactos de las organizaciones en su entorno natural así como el establecimiento de sanciones administrativas y penales a las empresas que incumplen con la normativa vigente. Por tanto, la teoría institucional sostiene que las organizaciones no tienen total libertad de acción, sino que deben actuar conforme al marco regulatorio de su campo organizativo (DiMaggio & Powell, 1983). Asimismo, las instituciones poseen un aspecto normativo (o social) en el cual se establecen las normas de comportamiento y actuación que deben ser llevadas a cabo por las organizaciones, es decir, su código deontológico (March, 1981). Este tipo de normas, si bien no están explícitamente definidas como las regulativas, también ejercen una fuerte presión sobre la forma de actuar de las organizaciones, e incluso pueden impulsar reformas regulativas.

A nivel medioambiental, determinadas actuaciones contaminantes llevadas a cabo por organizaciones no sólo han supuesto una caída de su reputación, que ha conllevado a la caída de sus ventas y por tanto, del beneficio empresarial, sino que han sido catalizadoras de regulaciones medioambientales más exigentes (EPA, 2015). A modo de ejemplo, la Agencia de Protección Medioambiental de Estados Unidos (US Environmental Protection Agency, EPA por sus siglas en inglés), reconoció que creó la Ley sobre Contaminación Petrolífera (Oil Pollution Act, OPA por sus siglas en inglés) "principalmente como respuesta por la preocupación pública como consecuencia del incidente de (la compañía petrolera) Exxon Valdez" (EPA, 2015).

Finalmente, los factores cognitivos hacen referencia a los aspectos culturales que de forma implícita influyen sobre el comportamiento de las organizaciones (Zucker, 1983). Estos factores no se encuentran recogidos en ninguna legislación como los regulativos, ni se expresan de forma explícita como los normativos, pero igualmente resultan fundamentales para que la organización desarrolle su actividad, siendo frecuente que las organizaciones posean expertos en materia cultural e incluso que antes de penetrar en un nuevo mercado se realicen análisis en este sentido o se lleven a cabo operaciones con empresas locales. Con respecto al medio ambiente, es frecuente pensar que algunas sociedades tengan un carácter más colectivo (Hofstede, 1980), lo que hace que presenten una mayor preocupación hacia temas medioambientales que aquellas sociedades más individualistas.

De manera adicional a la teoría institucional, la presente tesis doctoral se basa argumentaciones teóricas recogidas por la denominada teoría neo-institucional (Katzestein, 1994; Murtha and Lenway, 1994; Schmitter, 1974). En concreto contribuimos a la literatura del análisis estratégico de las innovaciones medioambientales mediante el estudio de los diferentes estilos de redes políticas (*policy network style*), los cuales explican las interacciones entre el gobierno y los sistemas de representación, que están compuestos por activistas, sindicatos, negocios y otros grupos que afectan la toma de decisiones políticas (e.g. March and Olsen, 1989; Schmitter, 1974).

Además de las teorías de recursos y capacidades, y de las teorías institucionales en la presente tesis doctoral hemos empleado la teoría de costes de transacción (*Transaction Cost Economics, TCE* por sus siglas en inglés) para explicar el comportamiento estratégico de las organizaciones en materia de innovación medioambiental. La teoría de los costes de transacción sostiene que todas las transacciones -es decir, el intercambio de bienes o servicios- implican un coste para las partes involucradas debido a que los individuos poseen una racionalidad limitada y pueden comportarse de manera oportunista (Coase, 1937; Williamson, 2002). La racionalidad limitada asume que "mientras que los agentes humanos pretenden ser racionales, lo son de una manera limitada" (Williamson, 2002:174). Por tanto los límites cognitivos de los individuos, junto con un sistema información imperfecta hacen que estos sean incapaces de predecir todas las futuras contingencias derivadas de sus transacciones. De manera adicional a esta limitación cognitiva, la teoría de los costes de transacción introduce el concepto de oportunismo, el cual se define como "la búsqueda del propio interés mediante el engaño" (Williamson, 1975:6). En este sentido, el comportamiento oportunista de una de las partes implicadas en la transacción puede causar que dicha parte adquiera una posición ventajosa al aprovecharse del sistema de información imperfecta en el que se rodea toda transacción. Esta posición ventajosa perjudica al resto de partes implicadas en la transacción, lo cual dificulta el proceso de toma de decisiones.

Tomando de forma estricta las consecuencias negativas de los futuribles comportamientos oportunistas de las partes, se podría pensar que las organizaciones siempre preferirían producir internamente -lo que la teoría de costes de transacción denomina adoptar una estructura jerárquica- antes que realizar transacciones con el exterior -es decir, adquirir una estructura de mercado-. Sin embargo, mientras que todas las transacciones externas son costosas, las transacciones internas también lo son (e.g. costes burocráticos, de coordinación y control, etc.), por lo que las organizaciones deben analizar los costes de una y otra opción (Coase, 1937; Williamson, 1975). En este sentido, la teoría de costes de transacción sostiene que determinados atributos de las transacciones influyen de forma determinante en su coste y, en última instancia, determinan el coste último de cada una y si se prefieren o no a otras transacciones.

A este respecto, nuestra tesis doctoral se centra en determinados atributos que poseen las innovaciones medioambientales, y que afectan a la dinámica de los costes de transacción. De manera concreta analizamos la especificidad de los activos, el poder de negociación de las partes y la experiencia medioambiental para analizar las decisiones estratégicas que toman las organizaciones en materia de innovación medioambiental.

1.4.- ASPECTOS METODOLÓGICOS

La presente tesis doctoral utiliza datos de patentes -tanto medioambientales como no medioambientales- de las oficinas de Estados Unidos (USPTO) y Europa (EPO), las cuales suponen la mayor base de datos de patentes del mundo y la mayor base de datos de patentes regionales, respectivamente. Llegados a este punto es necesario precisar que la utilización de una base u otra no limita a las empresas que pertenecen a los países en los que se protege la patente. Dicho de otra manera, si por ejemplo una empresa Surcoreana como Samsung quiere proteger su producto en Europa tiene que registrar su patente en la oficina europea, con lo cual la EPO contiene información de empresas de todo el mundo, no sólo de aquellas empresas pertenecientes al espacio económico europeo. Esta situación sería idéntica en el caso de la oficina de patentes de Estados Unidos.

Con respecto al uso de patentes como variable para analizar innovaciones, hoy en día continúa el debate sobre su idoneidad como indicador. Por un lado, los detractores de esta medida sostienen que existen una serie de actividades innovadoras que no se suelen patentar (ej. innovaciones en procesos administrativos) y, además, que algunas empresas pueden preferir mantener en secreto sus innovaciones en lugar de patentarlas (Blind, Cremers, and Mueller, 2009; Fosfuri, 2006). Por otra parte, los defensores del uso de patentes (e.g. Hagedoorn and Cloodt, 2003; Popp, 2003) sostienen que hoy en día la gran mayoría de las innovaciones se patentan para evitar ser copiadas por la competencia con diversos métodos, tales como la ingeniería inversa. En cualquier caso, las patentes suponen una fuente de datos objetiva y homogénea, lo que permite comparar unas patentes con otras, así como realizar análisis longitudinales, como es el caso de esta tesis doctoral. En este sentido, Hagedoorn and Cloodt (2003: 1368) sostienen que el uso de patentes "está generalmente aceptado como uno de los indicadores más apropiados que permite a los investigadores comparar el desempeño inventivo o innovador de las organizaciones".

Junto a las ventajas anteriormente señaladas del uso de patentes como variable para medir la innovación, en el caso de las innovaciones medioambientales, el empleo de patentes resulta particularmente relevante por la información complementaria y objetiva que puedan aportar frente a otras fuentes (Berrone et. al, 2013). Cuando se trata de analizar aspectos medioambientales las patentes suponen una medida mucho más objetiva que los cuestionarios, ya que en éstos se puede pretender proyectar una imagen medioambientalmente responsable en lugar de reflejar el alcance real de las actividades realizadas por la organización (e.g., Anton, Deltas, and Khanna, 2004; Christmann, 2000).

1.5.- ESTRUCTURA DEL TRABAJO DE INVESTIGACIÓN.

La presente tesis doctoral está compuesta por seis capítulos que se agrupan en tres grandes bloques: introducción (capítulo 1), trabajos de investigación (capítulos 2, 3, 4 y 5), y consideraciones finales (capítulo 6).

En este primer capítulo introductorio nos hemos acercado a nuestro objeto de estudio, la gestión estratégicas de las innovaciones medioambientales, explicando brevemente los objetivos del resto del trabajo y los marcos teóricos que nos planteamos utilizar. En este sentido hemos delimitado qué se conoce en la literatura como innovación medioambiental, por qué resulta un tema de gran relevancia en el contexto actual, y por qué consideramos que dicha relevancia se verá notablemente incrementada en los años venideros.

Una vez que hemos delimitado el objeto de estudio, hemos analizado sus implicaciones tanto a nivel corporativo como desde un punto de vista de los agentes sociales y gobiernos, estudiando para ello las relaciones entre diferentes contextos institucionales y estrategias internas organizativas. Dada la complejidad y relevancia de nuestro tema de estudio, para analizar diferentes aspectos del mismo hemos anticipado la importancia de utilizar diferentes marcos teóricos, concretamente la teoría de recursos y capacidades (e.g. Barney, 1991), la teoría institucional (e.g. Hoffman, 1999), la teoría de costes de transacción (e.g. Coase, 1937) y la teoría neo-institucional (e.g. Streeck and Kenworthy, 2005).

El segundo capítulo, titulado "Los efectos de la exploración en innovaciones sobre el desempeño organizativo y el efecto moderador de los recursos ociosos: un análisis longitudinal sobre patentes medioambientales" (*The effects of exploitative innovations on firms' performance and the moderating influence of slack resources: A longitudinal analysis of environmental patented innovations.*), plantea un análisis longitudinal de las patentes medioambientales producidas por empresas del sector de "Componentes Electrónicos y Eléctricos" durante el período 2006-2009. Concretamente, analizamos cuál es la relación entre la estrategia exploradora o explotadora de la organización con el desempeño organizativo en el contexto de patentes medioambientales. En otras palabras, cuando una organización realiza innovaciones medioambientales, ¿qué estrategia conduce a un mayor desempeño organizativo? ¿explorar múltiples tecnologías medioambientales, centrarse en unas pocas o un enfoque intermedio? De manera adicional, estudiamos el papel moderador que tienen los denominados “recursos ociosos” (es decir aquellos que exceden los necesarios para mantener el nivel actual de producción) sobre esta relación entre una orientación exploradora/explotadora y el desempeño organizativo.

El tercer capítulo, titulado "Estudio de la divergencia de las patentes medioambientales mediante la perspectiva de la teoría de los costes de transacción" (*"A transaction cost perspective on divergence in firm's patented environmental innovations"*), realizamos un análisis longitudinal de las patentes medioambientales y no medioambientales producidas por empresas del sector de “Componentes Electrónicos y Eléctricos” durante el período 2005-2009. De manera más concreta analizamos la estrategia en materia de innovación medioambiental que lleva a cabo la empresa en función de las innovaciones medioambientales de sus competidores. El creciente desarrollo de este tipo de innovaciones ha hecho que surjan numerosas tecnologías medioambientales que compitan entre sí. Por tanto, en este entorno de variedad tecnológica medioambiental, una organización puede desarrollar una tecnología que sea poco conocida por sus competidores (divergencia medioambiental tecnológica) o por el contrario, desarrollar las tecnologías dominantes en el sector.

En el cuarto capítulo, titulado "¿Las diferentes innovaciones en la empresa y en la industria incrementan el número de patentes medioambientales? Una comparación entre la teoría de recursos y capacidades y la teoría institucional" (*"Do Different Innovations in the Firm and the Industry Increase the Number of the Firm’s Patented Environmental Innovations? The Resource-Based View versus Institutional Perspectives")*, realizamos un análisis longitudinal de las patentes medioambientales generadas por empresas del sector de “Componentes Electrónicos y Eléctricos” durante el período 2005-2009. Concretamente, estudiamos si las empresas generan patentes medioambientales diferentes debido a sus recursos y capacidades heterogéneos - tal y como sugiere la teoría de recursos y capacidades-, o si las influencias institucionales hacen que las empresas generen patenten similares a su industria -tal y como sugiere la teoría institucional-. Asimismo, estudiamos si las innovaciones medioambientales ejercen una influencia positiva sobre el resto de innovaciones (sinergia) o si por el contrario, las organizaciones innovan en materia medioambiental en detrimento del resto de tecnologías.

En el quinto capítulo, titulado "La influencia de los estilos de redes políticas en las patentes medioambientales en diferentes países: una perspectiva neo-institucional" (*"The influence of the Domestic Policy-Network Style on the Patented Environmental Innovations in Different Countries: A Neo-Institutional Perspectiv*e") realizamos un análisis longitudinal de todas las patentes registradas en Estados Unidos, Japón, Alemania y Reino Unido durante el período 1976-2003. De manera más concreta, estudiamos cómo los diferentes estilos de lo que se denominan “red política” en el país influencian (o no) tanto a la proporción de patentes medioambientales con respecto al total de innovaciones, como al impacto de las innovaciones medioambientales generadas en estos países globalizados.

Finalmente, en capítulo 6 de la presente tesis doctoral llevamos a cabo una recapitulación de las conclusiones más relevantes obtenidas por estos cuatro trabajos, prestando especial atención a las implicaciones que tienen dichos resultados tanto a nivel teórico como práctico. Y a su vez, dentro de las implicaciones prácticas de nuestros estudios dedicamos unas líneas a repasar las implicaciones que nuestros resultados podrían tener tanto para directivos como para gobiernos y demás instituciones que influyen en la toma de decisiones relacionadas con las innovaciones medioambientales en general y las patentes medioambientales en particular.

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CAPÍTULO 2

THE EFFECTS OF EXPLOITATIVE INNOVATIONS ON FIRMS' PERFORMANCE AND THE MODERATING INFLUENCE OF SLACK RESOURCES: A LONGITUDINAL ANALYSIS OF ENVIRONMENTAL PATENTED INNOVATIONS.

THE EFFECTS OF EXPLOITATIVE INNOVATIONS ON FIRMS' PERFORMANCE AND THE MODERATING INFLUENCE OF SLACK RESOURCES: A LONGITUDINAL ANALYSIS OF ENVIRONMENTAL PATENTED INNOVATIONS.

Abstract

Previous studies have widely debated the advantages and drawbacks of exploitative and explorative innovations in the context of technology-based alliances or acquisitions, but the consensus has been very limited. We propose that focusing on innovations with a similar level of maturity is a relevant dimension for a better understanding of whether exploitative or explorative innovations contribute more positively to firm performance. Specifically, we focus on a context of non-mature innovations measured by patented environmental innovations to propose that the exploitative choice leads to higher firm market-based performance, as measured by Tobin's Q. In addition, we contribute by proposing that the availability of resource slack negatively influences the positive relation between exploitative innovation and market performance in this context. We employ a longitudinal analysis of 5,845 environmental patents from the 75 largest companies in the Electrical Components & Equipment industry worldwide during the period of 2006-2009.

Keywords: Environmental innovation, exploration, exploitation, market-based firm performance, slack resources.

2.1.- INTRODUCTION

The innovation literature has generated strong debate regarding the pros and cons of firms' focus on a single technology (exploitation) versus the development of non-related research and development activities (exploration) (Cohen and Levinthal, 1990; March, 1991; Nooteboom et al., 2007). On the one hand, the exploitation approach to generating innovation allows firms to become experts in a specific field, thus increasing the speed and efficiency of innovations (e.g., Cohen and Levinthal, 1990; Moorman and Slotegraaf, 1999). On the other hand, the innovative exploration approach fosters the development of breakthrough innovations that may lead to higher financial returns when successful but that increase the risk of failure (e.g., Prahalad and Hamel, 1990; Spencer, 2003). Most previous papers have used a static and universal perspective in an attempt to select the most appropriate type of innovation. However, we claim that focusing on innovations with a similar level of maturity allows for a better understanding of whether exploitative or explorative innovations contribute more positively to firm performance over time. Specifically, we propose that exploitative innovation is more appropriate in non-mature fields. In addition, we extend the contingent perspective to analyze the moderating importance of a firm's resource slack on this relation.

The debate regarding explorative versus exploitative innovative corporate approaches cannot be resolved by simply attempting to determine the appropriate balance between both approaches. Some relevant studies have attempted to resolve the debate by proposing that neither excessive exploitation nor excessive exploration yields higher performance rates and suggesting that an intermediary approach maximizes firm performance (Ahuja and Katila, 2001; Mowery and Oxley, 1998; Nooteboom et al., 2007; Petruzelli, 2011). However, these previous works have showed contradictory results and raised serious doubts regarding the specific balance that is appropriate for each situation (Petruzelli, 2011).

We highlight the importance of assessing the features of analyzed innovations and firms' availability of resources to identify how exploitation or exploration may contribute to firms' financial performance. In our analysis, we focus on a group of non-mature (nascent) innovations related to the natural environment. In this paper, we consider a nascent innovation a technology that has recently become ready for manufacturing and commercializing (Wood and Brown, 1998) and has great market potential because "[b]oth the growing of production capacity and the evolution of the demand may take place during a (possibly long) period of time, by means of a gradual interaction of producers and users" (Saviotti and Pyka, 2008:169).

The relationship between the degree of exploitation/exploration and firm performance in the context of nascent innovations will be shaped by a firm's levels of slack, i.e., the excess of resources resulting from the current level of production (Nohria and Gulati, 1996). Previous works have attempted to determine which levels of slack yield higher performance, with no consensus. However, there appears to be general agreement that higher levels of slack promote exploration activities (e.g., Nohria and Gulati, 1996). However, because firms with lower levels of slack are more concerned with resource deviation, they usually negotiate with third parties more intensively, monitor current projects more strictly, and evaluate future projects more extensively than do firms with higher levels of slack (e.g., Miller and Leiblein, 1996). In other words, these firms optimize their exploitation activities because they are more predictable and thus easy to assess (March, 1991). In this study, we extend previous literature and go one step further by proposing that lower levels of potential slack have a positive effect on the relationship between firm performance and the degree of exploitation exhibited by the organization.

Finally, we aim to analyze the direct (positive) relationship between innovation and firm performance. Continuous innovation effort has become a common practice because by investing in research and development (R&D), a firm may build "rare, valuable, and inimitable sources of competitive advantage" (Phene et al., 370: 2006) that facilitate its sustained profitability (Roberts, 1999). This relationship provides the general background for our interest. Therefore, we also expect a positive relationship between the number of innovations and firm performance.

Our work analyzes environmental patents in the Electrical Components & Equipment industry because they are a good proxy of innovations in a non-mature context. The existing innovation literature has used a patent perspective to study innovations (e.g., Carnabucci and Bruggeman, 2009; Miller, Fern, and Cardinal, 2007; Shin and Jalajas, 2010). Miller, Fern, and Cardinal (2007) employed patents from a wide variety of US industries as a proxy of firm innovativeness and showed that knowledge transfer from other divisions has a positive effect on innovation impact if it is not significantly different. Shin and Jalajas' (2010) work used US patents from different R&D-intensive industries to analyze the existing technological relatedness among an organization's subunits and showed an inverted-U shaped relationship between diversification and corporate R&D activities. Similarly, Carnabucci and Bruggeman (2009) have studied the exploitation-exploration continuum among a mixture of heterogeneous industries and showed that a combination of both approaches yields higher knowledge growth, measured by patent data. None of these works has analyzed the implications of the innovative/explorative approach with regard to financial performance or the maturity of the particular innovations involved, assuming that it is possible to expect a homogeneous relation among a variety of industries.

We focus on environmental innovations, which are acquiring growing importance at multiple levels (national, international, and organizational) (e.g. Barczak, 2012) because of their multiple social, environmental, and economic implications and because they offer an appropriate context for non-mature innovation in the sampled industry (Brunnermeier and

Cohen, 2003; Jaffe and Palmer, 1997; Nameroff et al., 2004; Rehfeld et al., 2007; Rennings et al., 2006; Ziegler and Rennings, 2004). After the adoption of the Kyoto protocol in 1997, environmental patented innovations initially grew by approximately 20% yearly and have grown by more than 30% during the past few years, replacing higher-polluting sources, such as fossil fuels and nuclear energy (Bennett, 2010; EPO, 2010). The establishment of long-term goals, such as a 20% target for renewables by 2020, indicates that environmental innovations will continue to be developed in the future.

Our work makes two primary theoretical contributions. First, we elucidate the contradictory innovation literature that analyzes the exploration/exploitation dilemma by focusing on the context of a non-mature technology and discussing the influence of this circumstance in the final relationship. Second, we extend the previous literature on the relation between firm performance and explorative/innovative approaches by using a contingent perspective and studying the moderating effect of different levels of potential slack on the relationship. Although a number of scholars have assessed the effect of slack on firm performance, to date, we have not identified any studies that analyze the moderating role of the level of potential slack resources in this exploration/exploitation dilemma.

After this introduction, this paper covers the theoretical background, hypotheses, methodology, and results and then provides a final discussion of our results and new avenues of research. We use a sample of 5,845 environmental patents obtained by 75 firms in the Electrical Components & Equipment industry during the period of 2006-2009 and a selection of variables.

2.2.- THEORETICAL DELIMITATION AND CONTEXT

2.2.1.- Definition and importance of the environmental innovations

Innovation is becoming "even more critical in a time of prolonged economic volatility" (Barczak, 2012: 355) because it represents an important activity for the survival and development of organizations, hence standing as a key means of gaining and maintaining competitive advantage. Innovation represents new, rare, and valuable sources of knowledge that are linked to greater returns (Ahuja and Katila, 2001). In this paper, we focus on environmental innovations because they are acquiring growing importance at both the national and international levels.

Environmental innovations can be defined as “measures of relevant actors, which: (i) develop new ideas, behavior, products and processes, apply or introduce them, and; (ii) contribute to a reduction of environmental burdens or to ecologically specified sustainability targets” (Rennings, 2000: 322). The importance of environmental innovation is mirrored in the emergence of related jobs, investments, and regulation.

A shift from contaminating technologies to more environmentally friendly technologies has shaped the labor market. For instance, the United Nations Environment Programme (UNEP, 2008) estimated that in 2006, more than 2.3 million people were working in the renewable sector, forecasting an increase to 20 million by the year 2030. In contrast, the workforce working with high-contaminating fossil fuels was expected to experience a decline (Houser et al., 2009). Regarding investments, Rushton (1993) has estimated that in 1993, $10 billion of the $103 billion in R&D spending was allocated to environmental innovation. Namerof et al. (2004: 961) note that "the European Industrial Research Management Association found that for most companies, nearly half of all R&D projects have a significant environmental and safety content".

Finally, the occurrence of multiple environmental government actions is also a good example of public interest in firms’ environmental innovations (Marcus, Aragon-Correa, and Pinkse, 2011). It has been argued that environmental protection has a positive impact on both the economic system and citizens' wellbeing, so governments are strengthening their regulations to reduce pollution levels (Courvisanos, 2009; Holliday et al., 2002; Schmidheiny, 1992) through unilateral adoption and international agreements (Chen, 2008).

Although regulation remains an obvious element of pressure, other market forces influence companies' environmental innovations, such as suppliers, employees, shareholders, and customers (Barczak, 2012; Paladino, 2008). Several actors may indicate market and social interest in firms' environmental innovations.

Together, all of these features have been particularly relevant during the last two decades and show the emergence of corporate environmental innovations. Given their non-mature character, these innovations permit an increase in production capacity and consumer demand (Saviotti and Pyka, 2008). In 2009, environmental innovations represented total spending of $60-80 billion in terms of new or improved facilities and employment in the US. It is estimated that environmental innovations will create 410,000 green jobs in the European Union by 2020 and will represent a global market of $315 billion by 2018 (Bennett, 2010).

2.2.2.- The environmental patents

In this study, we used patent data to analyze environmental innovations. A patent is "a legal title which protects a technical invention for a limited period. It gives the owner the right to prevent others from exploiting the invention in the countries for which it has been granted" (EPO, 2010). Although patent use is not the only system of delimitating innovations (e.g., Cohen and Levin, 1989; Griliches, 1998; Hall et al., 2001), "patent data has been used successfully in other studies in technology and innovation research to proxy for innovative activity" (Wagner, 2007:1588).

The national patenting classifications are now paying a great deal of attention to patented environmental innovations. For instance, in 2009, the United States Patent Office (USTPO) created the category "green technologies" and offered an accelerated review process for patent applications in this category (USTPO, 2009). In 2009, the EPO, the United Nations

Environment Programme (UNEP), and the International Centre for Trade and Sustainable Development (ICTSD) launched a "joint project on the role of patents in the transfer of climate change mitigation technologies" (EPO, 2010). Adjunct to that project, the EPO elaborated the "clean energy technologies" patent category, which contains two subclasses, more than thirty groups (e.g., solar thermal energy), and hundreds of subgroups (e.g., control of turbines) related to environmental innovations. EPO is even reviewing patents granted before the delimitation of this category and tagging them as environmental when applicable (EPO, 2010).

Multiple scholars have attempted to shed light on the key determinants of innovations (e.g., Brunnermeier and Cohen, 2003; Jaffe and Palmer, 1997; Lee, Veloso and Hounshell, 2011; Nameroff et al., 2004). In the specific context of environmental patents, the influence of regulation has received special attention. For instance, Lee et al. (2011) studied the influence of the regulation of environmental patents in the US automotive industry between 1970 and 1998 and found that more stringent regulations are associated with significant increases in the number of environmental innovations. Nameroff et al. (2004) have showed a similar effect on green chemistry patenting by comparing the periods of strength regulation during the late 1980s and early 1990s with a decrease in regulation pressure from 1993 to 2001. However, Brunnermeier and Cohen's (2003) study of environmental patents in the US manufacturing industry during the period of 1983 through 1992 showed international competitiveness as a driver of environmental innovations rather than regulatory pressures.

Other scholars, such as Jaffe and Palmer (1997), set aside the definition of patented environmental innovations and analyzed the effect of environmental patenting on other innovations. Their work on R&D expenditures allocated to environmental innovations in the US manufacturing sector shows that higher levels of environmental R&D expenditures lead to higher future R&D expenditure, regardless of whether it is environmental. In general, the literature has showed the importance of delimiting a homogeneous scope of the analysis and, for instance, focusing on industries with similar regulatory and competitive situations.

2.2.3.- The electrical components industry and the emergence of environmental innovations

We test our hypothesis using a sample of large companies in the Electrical Components and Equipment industry. We chose this industry because it has faced relevant shifts toward greener production in recent years. For instance, among its primary objectives, the European directive on "Restriction of the Use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) and Waste of Electrical and Electronic Equipment (WEEE)", which came into force in February 2003, includes an increase in recycling and/or re-use of electronic waste, requiring heavy metals such as lead, mercury and cadmium to be replaced with safer alternatives and requiring Member States to collect at least "65% of the average weight of electrical and electronic equipment placed on the market over the two previous years" (European Commission, 2012). Furthermore, the directive prosecutes the "illegal trade of electrical and electronic waste to non-EU countries", assuring strict compliance with legislation that continues to be developed[1] (European Commission, 2012).

For illustrative purposes, Samsung, one of the leading companies in this industry, has claimed on its corporate web page that the firm has increased the number of "green" products by almost 90% and is close to reaching its goal of a 100% increase by 2013. Some of the corporate environmental innovations using patents include Samsung's 55-inch 2-sided Edge-lit 3D LED panel, a new technology that consumes 52% less power and is RoHS compliant, PVC-free, arsenic-free and mercury-free; the Samsung F4EG, an environmentally friendly hard disk that requires 23% less power and performs 19% better than previous products; and the Samsung WF520 Front-Loader Washing Machine, a washer that reduces power and water

1 The latest European normative regarding electrical and electronic equipment treatment is the WEEE Directive 2012/19/EU, published in issue L197 of the Official Journal on July 24, 2012 (European Commission).

use. In 2011, the company reduced greenhouse gas emissions, obtaining a level that was 40% less than the 2008 level, and it aims to continue this decrease by achieving a level in 2013 that is 50% less than the 2009 level, thus achieving a cumulative reduction of 85 million tons during the 2009-2013 period (Samsung, 2012).

We will focus on the larger companies in the industry because they usually have more resources to invest in R&D activities than smaller organizations, favoring the generation of greater numbers of innovations (Parayil, 2003). In addition, smaller companies do not use the patent system effectively and rely more on secrecy (Parayil, 2003).

2.3.- HYPOTHESES

2.3.1.- Environmental innovations and market-based firm performance

Innovations related to the natural environment have acquired growing importance in recent decades, so we can identify an increasing number of organizations that produce green innovations, whether they are motivated by the strengths of external pressures or because they view environmental innovation as a strategic opportunity that confers long-term advantages instead of an unrecoverable cost (Russo and Fouts, 1997). Environmental innovations are produced to a greater extent by proactive organizations because they view such an investment as an opportunity to develop new markets, new products, and competitive advantage (Paladino, 2008).

According to the natural resource-based view of firms (Hart, 1995; Russo and Fouts, 1997), the fact that proactive environmental technologies (i.e., pollution-prevention voluntary innovations) rely more heavily on organizational and knowledge-based resources increases the likelihood that these organizations will develop competitive advantage (Hart and Ahuja, 1996; Lee et al., 2011). Additionally, organizations that produce greener technologies may take advantage of the current trend toward friendly environmental production and may push governments toward more stringent regulation, increasing the production costs of their rivals and, simultaneously, attracting customers and improving their reputation (Berry and Rondinelli, 1998; Chen, Lai and Wen, 2006; Porter and van der Linde, 1995; Shrivastava, 1995).

Finally, some scholars have echoed arguments originally made by Shrivastava (1995) and Porter and van der Linde (1995), noting that organizations that introduce environmental innovations may obtain "first-mover advantages", which include higher prices for their products, the development of new markets, and an improved image, what may exert a positive effect over firm performance (e.g. Ford and Paladino, 2013).

These arguments suggest that the pursuit of environmental innovation is not an additional cost that organizations must bear to respond to a more stringent regulation but has positive effects that may improve performance. In this paper, we assess the link between firm performance and patented environmental innovation in accordance with previous ideas and studies showing that firms' market value is a variable dependent on some measure of patented innovations (e.g., Bosworth and Rogers, 2001; Griffiths, Jensen and Webster, 2005; Hall, 2007; Toivanen, Stoneman and Bosworth, 2002). The general background of our research is that there is a direct relationship between the number of environmental innovations and an organization's performance. Our hypothesis is:

H1: The higher an organization's number of patented environmental innovations, the greater the firm's market-based performance.

2.3.2.- The exploration-exploitation choice

We have suggested that organizations might invest in environmental technologies if they want to increase their performance, but we want to go slightly further and attempt to determine the orientation of the R&D portfolio that maximizes investments. In general terms, organizations can either expand upon a well-known technology or diversify their investment into unrelated technologies. Because the best-performing approach remains unclear (e.g., Cohen and Levinthal, 1990; Spencer, 2003), our next hypothesis will address this question.

Extending the delimitation of exploitation and exploration in our introduction, we use March's (1991) seminal work to define exploitation activities as the "refinement and extension of existing competencies, technologies, and paradigms [that lead to returns that] are positive, proximate, and predictable", whereas exploration is "experimentation with new alternatives [that lead to returns that] are uncertain, distant, and often negative" (March, 1991: 85). Exploring organizations may develop new capabilities that create value (Cohen and Levinthal, 1990), develop and introduce new products, create new markets that satisfy unmet needs, and benefit from first-mover advantages resulting from the absence of competitors in the short run (Prahalad and Hamel, 1990; Thukral, von Ehr, Walsh, Groen, van der Sijde and Adham, 2008).

This newness may lead to competitive advantages in the long run as well. For instance, Toyota's pioneer production of hybrid cars provided it with monopoly rents because of the novelty of its product, but it remains the world leader in the industry (Spencer, 2003). Although explorative activities can generate profitable breakthrough innovations, investing in unknown technologies is a risky approach (Bekkum, Pennings and Smit, 2009) because there is a significant possibility that such an effort will not yield positive results and may be a waste of time and money, even endangering an organization's survival (Carnabucci and Bruggeman, 2009).

By contrast, the exploitation of a well-known technology is more secure and allows organizations to master specific knowledge and generate "first-order competence", which "is considered to be a distinctive competence if it is superior to competition and leads to competitive advantage" (Rosenkopf and Nerkar, 2001: 288). This first-order competence may position the organization as a reference with regard to a specific technology within its industry, so competitors may avoid the pursuit of alternative technologies and follow the leader, reinforcing the organization's market position (Ford and Paladino, 2013; Rosenkopf and Nerkar, 2001).

Despite the advantages of exploitation, some scholars argue that focusing on a specific technology may be detrimental for organizations because their core capabilities can become core rigidities that may compromise their long-term performance or even their survival (Christensen and Overdorf, 2000; Leonard-Barton, 1992). Scholars suggest the use of an intermediary approach that strikes a balance between exploitation and exploration (e.g., Mowery and Oxley, 1998; Petruzelli, 2011). However, we believe that these authors might have overlooked the maturity of the technology when analyzing the relationship between the degree of exploitation and firm performance because this concern is more plausible in the context of mature technologies for which a technological change is needed in the short run.

Because environmental innovations are relatively nascent, their level of development may not yet have reached the point at which excessive exploitation is detrimental. For instance, although the number of costumers willing to pay more for electricity that is environmentally generated quadrupled between 1999 and 2002, reaching 711,500 (Bird et al., 2004), these consumers are "still relatively small in total number" (Delmas, Russo and Montes-Sancho, 2007:193), hence organizations that pay attention to market trends may notably benefit from green innovations (Ford and Paladino, 2013). Likewise, Delmas et al. (2007) estimated a four-time increase in the demand for green power between 2002 and 2010, and the UNEP forecasted a rise in the number of workforce members working with environmental technologies from 2.3 to 20 million by the year 2030 (UNEP, 2008). Following this line of reasoning, the growing trend of environmental patenting, which has grown by 30% annually for the past few years (Bennett, 2010), suggests that such innovations are at the beginning stage of development.

Exploitation in a context of nascent innovation generates synergies with the organizational absorptive capacity, as proposed by Cohen and Levinthal (1990). The higher the absorptive capacity of a firm, the faster its product development and the greater its organizational learning (Cohen and Levinthal, 1990; Kahn, Barczak, Nicolas, Ledwith and Perks, 2012; Paladino, 2008). This facilitates problem solving for known problems, in contrast to its more limited potential to generate newer technology that usually implies high, fixed learning costs, whether in terms of price (Hayes 1989; Simonton 1991) or in terms of time spent on employee training (Weisberg 1993). In a mature context, the workforce may find incentives to exploit their knowledge in a new emerging context. A dynamically changing field encourages a focus on specific technologies, which enables the understanding and the sharing of new ideas, eases coordination among different departments, and facilitates more efficient allocation of resources. Consequently, we hypothesize the following:

H2: There is a positive relationship between firm performance and the degree of environmental innovation exploitation in a context of nascent innovation.

2.3.3.- Slack resources and their influence on the exploration-exploitation choice

Slack can be defined as "the pool of resources in an organization that is in excess of the minimum necessary to produce a given level of organizational output" (Nohria and Gulati, 1996:1246). These available resources may include an excess of inputs, such as employees and machinery that are not working at full capacity, opportunity costs derived from underinvestment in technologies that may generate greater margins and revenues, or financial slack (Bradley, Shepherd and Wiklund, 2011; Burgeous and Singh, 1983; Tan, 2003).

There is a longstanding debate regarding the relationship between slack and firm performance. On the one hand, from an agency theoretic view, slack is an inefficient use of available resources because greater levels of slack could lead to less intense negotiations, the pursuit of overly risky investments, excessive diversification, a less intensive search for alternative options, etc. (e.g., Bowman, 1982; Nohria and Gulati, 1996). On the other hand, advocators of slack argue that it encourages strategic behavior, eases adaptation to new environments, fosters long-term thinking and allows for the exploration of uncertain investment opportunities that would otherwise never be used (e.g., Burgeous and Singh, 1983; Rajagopalan, 1997).

Despite these opposing views on the effects of slack resources on an organization, both supporters and detractors agree that slack promotes the exploration of new avenues of knowledge (Nohria and Gulati, 1996). Although some scholars view higher levels of slack negatively, scholars agree that these available resources foster exploration, whether beneficial or detrimental to the organization. In contrast, lower levels of slack imply that firms do not have a safety net for failure; thus, organizations are driven to focus on more certain, exploitative investments.

Although we expect that a greater focus on exploitation activities may produce higher levels of organizational performance (hypothesis 2), we believe that the level of slack resources may play a relevant role in shaping this relationship. Firms with little slack are usually more aggressive in negotiating with suppliers, evaluate present and future projects more extensively, and exhibit higher control and monitoring of current projects. In contrast, organizations with higher levels of slack resources may be less intensive in negotiations, relax their investment requirements, and allocate resources to "dubious projects, such as pet R&D projects and unrelated acquisitions" (Nohria and Gulati, 1996: 1248).

Given that exploitative activities are more predictable than explorative ones (March, 1991), they are easier to monitor, to evaluate with regard to progress, and to modify when performance does not match the expected level. For instance, in their study of 20 leading innovation researches, Kahn, Barczak, Nicolas, Ledwith and Perks (2012) state that best performing organizations are those capable of accurately track and measure innovation performance. In this context, we expect to observe a more positive relationship between exploitation and performance when an organization has lower levels of slack, whereas this relationship may be less positive when slack levels are higher. Consequently, we hypothesize the following:

H3: Exploitation in a context of nascent innovations is more positively related to firm performance when the organization has lower levels of slack, whereas this relationship is less positive when slack levels are higher.

2.4.- METHOD

2.4.1.- Sampling and data collection

Hagedoorn and Cloodt (2003: 1368) state that "raw patent counts are generally accepted as one of the most appropriate indicators that enable researchers to compare the inventive or innovative performance of companies". Similarly, some scholars advocate the use of patents because of the technical information that they provide as well as the abundant data available, their comparability, and their suitability for longitudinal analysis (Popp, 2003).

We based our analysis on the European Patent Office (EPO) Global Patent Index (GPI). We withdrew data only from the EPO database instead of using data from multiple patent offices for three reasons: (1) using several databases might yield conflicting results because of the different standards and different systems of granting patents as well as patentability requirements; hence, focusing on a single database is "necessary to maintain consistency, reliability, and comparability" (Ahuja and Katila, 2001: 205); (2) the EPO database contains patents from companies worldwide (e.g., European, North American, Japanese, Korean, etc.) that patent in Europe (GPI user manual, 2009); and (3) the EPO recently created a new classification for green technologies and applications developed to reduce the impact on climate change (EPO, 2010). Instead of using a qualitative abstract-based keyword to determine which patents have environmental content (e.g., Anastas and

Warner, 1998; Lee et al., 2011; Namerof et al., 2004; Wagner, 2007), we used the original environmental delimitation of patents developed by the EPO, thus ensuring that we do not miss any environmental patents.

Additionally, during our search, we filtered all patents using the European Classification System (ECLA) provided by the EPO. The ECLA is divided into eight sections (A-H), each of which is subdivided into classes, sub-classes, groups, and sub-groups. With regard to environmental innovations, the EPO has adapted the above-mentioned ECLA codes for green technologies, which contain dozens of subgroups, including over 17,000 patents to date (EPO, 2010). Because the same application can be published several times, we searched for only one document, the family representative[2], per application.

In relation to the sample selected, we decided to focus on the "Electrical Components & Equipment" sector, numbered 6190 in the COMPUSTAT database. This sector has faced multiple new environmental challenges in recent decades, including energy efficiency in the production and utilization of its products, the intensive use of raw materials, and large amounts of electronic waste (e.g., European Commission, 2012). We searched for patented environmental innovations issued from the year 2006 through the year 2009 by any company in the industry earning at least $1 million in net sales during the first year of our analysis, 2006. Given that not all companies issued environmental patents during the period analyzed and that COMPUSTAT had no market information for some companies, the final sample provided unbalanced panel data on 75 companies, comprising 216 observations from 2006 through 2009 and 5,845 patents (additional information is displayed in table 1).

2.4.2.- Measures

[2] According to the GPI user manual, the same application can be filed in different countries and thus can be published by several authorities. These publications have similar content and, together, form a simple patent family. When filtering one representative per family, we assure that the same patent does not appear several times.

Consistent with previous studies (e.g., Doidge, Karolyi and Stulz, 2004; Varaiya, Kerin and Weeks, 1987), we consider Tobin's Q a valid measure for assessing market-based firm performance. Tobin's Q is defined as the ratio of the market value of a firm to the replacement cost of its assets. We calculated Tobin's Q using data from COMPUSTAT (Chung and Pruitt, 1994). We employed a one-year lagged Tobin's Q because the positive/negative effects of innovations on performance may not be immediate (Pakes and Griliches, 1984).

The use of Tobin's Q for assessing firm performance has several advantages over other variables, such as accounting measures, because the latter can be more easily modified by organizations (Ernst, 2001). Additionally, unlike accounting ratios, Tobin's Q captures subtle dimensions of performance, such as intangible assets. In technological companies, for instance, the replacement cost of intangible assets is far greater than the cost of tangible assets, whereas accounting measures assume that such replacement costs are equal to book values (Varaiya et al., 1987).

In line with the existing literature regarding innovation and patents, we employed the number of environmental patents as a proxy of innovative performance (Hagedoorn and Cloodt, 2003). The number of patents presented by a firm in a specific domain indicates the degree of interest in exploiting this domain. In contrast, a firm exhibiting patents in different technological areas indicates that the firm uses a more explorative strategy.

To evaluate the exploration/exploitation approach, we have developed the "frequency of specific knowledge" (FSK) variable. This variable measures the degree of exploration exhibited by a firm. The FSK is calculated as the standard deviation of all of the ECLA codes contained in the patents issued by an organization, where the following are true:

$$\text{FSK} = \sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2}$$

N: the number of different ECLA codes in the firms' patents;

χ_i: the number of patents that contain a given ECLA code;

$\bar{x}$: the gross number of ECLA codes divided by the number of different ECLA codes.

The higher the FSK value, the more frequently specific knowledge is observed in the patents issued by a firm (exploitation pattern). Conversely, if a firm has the same number of each ECLA code (exploration pattern), the value of the FSK will be zero. In our analysis, we have sorted ECLA codes using six digits, or "groups", according to the EPO classification (GPI user manual, 2009).

With respect to organizational slack, the empirical work has assessed the level of slack using different items that may vary from one survey to another (see, for example, Sharma, 2000, for a review of different possibilities). Other empirical studies have used multiple indicators with different quantitative financial data. For instance, Miller and Leiblein (1996) reviewed the slack literature and found 13 accounting-based slack measures attempting to focus on different dimensions of organizational slack.

Consistent with Burgeous and Singh's (1983) work, we distinguished between available and potential slack, employing the current ratio (i.e., current assets divided by current liabilities) for the former and the return on assets (ROA) as an indicator of potential slack because "a high ROA would suggest that the [firm] was profitable and had the potential to generate slack" (George, 2005: 667).

In our study, we controlled firm size and age. The former is measured by the natural log of net sales, which are provided by the COMPUSTAT database, whereas firm age is determined by the foundation year of the organization according to the information displayed in the Bloomberg and JP Morgan databases.

2.5.- RESULTS

We employed the statistic program STATA 12 to test our hypotheses. Table 1 shows the descriptive statistics and the correlations for the study variables.

Insert Table 1 about here

The Hausman test (Hausman, 1978) endorses the use of fixed effects instead of random effects to estimate our model. Fixed effect models provide a more reliable estimation of the regression parameters because they eliminate the unobservable variables in conventional OLS regression estimates (Ernst, 2001). We used robust standard errors to avoid the problems of serial correlation and heteroscedasticity.

Because high multicollinearity may create problems in terms of the accuracy and stability of the model, we centered both measures of slack before building a multiplicative index between slack and the FSK index to test our prediction regarding a moderating influence (Cohen and Cohen, 1983). Table 2 shows the regression results for Tobin's Q as the dependent variable.

Insert Table 2 about here

The relationship between the number of patents and firm performance appears to be negative, contrary to hypothesis 1. However, the relationship between firm performance and the degree of exploitation is positive, thus supporting hypothesis 2. Therefore, it appears that it is not the raw number of innovations but the manner in which an organization combines its domains of knowledge that confers higher performance in our sample.

Finally, consistent with previous studies (Burgeous and Singh, 1983; Miller and Leiblein 1996; Nohria and Gulati, 1996), we employed several measures of slack in our empirical work, such as current and potential slack. Although managers in our sample may not consider the current level of slack when making decisions regarding their environmental investments, potential slack showed a significant moderating influence on the relation between exploitation and performance. A firm's level of potential slack had a significant interacting effect on the relationship between exploitation and financial performance.

Figure 1 plotted this interaction effect using procedures outlined in Venkatraman (1989) delimitate the specific influence of this moderating effect. Our results showed a positive relation between exploitation and firm performance when a firm has a low level of potential slack (upper line) and a negative relation when the potential slack is high (lower line), as hypothesized in hypothesis 3. Regarding our control variables, only firm age showed a significant relationship with firm performance (-.13, $p<0.05$).

Insert Figure 1 about here

2.6.- DISCUSSION, IMPLICATIONS, AND FUTURE RESEARCH

To date, there is no consistent empirical evidence that an exploitative approach yields better results than an explorative one, nor is there definitive empirical evidence for the converse. Advocates of exploration argue that by focusing on very concrete knowledge, an organization may build "first-order competence" (Rosenkopf and Nerkar, 2001), differentiating competence that leads to superior performance. Additionally, specializing in a given technology eases understanding among unities, fosters absorptive capacity (Carnabucci and Bruggeman, 2009; Kahn, Barczak, Nicolas, Ledwith and Perks, 2012) and minimizes risk because "[h]igh-risk projects in R&D are generally explorative in nature" (van Bekkum et al. 2009:1151).

In contrast, defenders of exploration argue that investing in different technologies facilitates the development of new products, the creation of new markets, and the enjoyment of first-mover advantages (Thukral et al., 2008) that might be sustained in time because the organization can become a reference worldwide (Cohen and Levinthal, 1990; Prahalad and Hamel, 1990).

We have attempted to shed light on how the exploration-exploitation dilemma of innovative approaches influences firm performance by stating the advantages and drawbacks of each and claiming that the debate is depending on the specific level of maturity of the technology and the internal slack of resources in the firm. Specifically we propose that within the context of non-mature environmental innovations, an exploitative approach leads organizations to achieve superior performance. It is interesting to observe that although the number of patented environmental innovations showed a negative significant effect on performance, perhaps indicating that the level of effort requires a longer period of time to recover investments, a more positive situation emerged in our finding that the level of exploitation in the sampled innovations was positively related to the market performance of the firm. We believe that these innovations are in the first stage of development and that, consequently, they may have not reached an "optimum" level of exploitation yet.

At the same time, it is important to emphasize that our results showed that potential slack resources have a robust moderating effect on the relation between exploitation and performance. Our results showed that lower levels of slack positively affect the relationship between exploitation and performance, whereas an increase in slack resources has a negative effect on this relationship. In the context of non-mature technologies, excessive levels of slack may be detrimental because they may drive companies to exert less control on exploitative innovations and to divert resources toward explorative activities, which have been shown to have a negative effect on performance in our sample.

We developed a specific index (Frequency of Specific Knowledge, FSK) to measure the degree of exploration pursued by an organization when developing environmental patents. Our analysis uses a sample of 5,845 patented environmental innovations among 75 firms in the Electrical Components & Equipment Industry during the years 2006 through 2009. The negative relation between the number of patented environmental innovations and performance in the sampled firms suggests that the analyzed innovations may require a longer period of time to recover the investments and efforts of a massive number of innovations. At the same time, our results show that it may be more relevant for managers to broaden the focus of their decisions, devoting more attention to the technological characteristics of the generated innovation and less attention to the number of innovations.

According to our expectations, the relationship between exploitation and firm performance is positive for our sampled firms. Our results show that the advantages generated by a higher absorptive capacity (Cohen and Levinthal, 1990) had no harmful effects in the analyzed sample, such as organizational inertia, which could hinder organizational performance (Moorman and Slotegraaf, 1999). Given that environmental technologies are at the beginning stage of development, organizations may not fear the negative consequences of exploiting these innovations.

National and supranational agreements on reducing pollution, along with greater environmental concern among customers, may cause companies to view environmental leadership as a competitive advantage (Chen, 2008). If an organization uses green technologies, customers will have greater trust in its products than in those of the organization's competitors, which may translate into higher returns given the increasing importance of environmentally friendly innovations.

The moderating effect of potential slack on the relationship between the degree of exploitation and firm performance is supported (hypothesis 3) and is particularly interesting. Because innovation activities may be long-term decisions, our measure of current levels of slack (i.e., current ratio) yielded results that are not significant, whereas potential slack is shown to influence the relationship between exploitation and performance. These results highlighted the importance of considering a long-term perspective when analyzing innovations, which reinforced the longitudinal nature of our analysis.

Organizations with lower levels of slack do not have a financial cushion to overcome unexpected costs, so they may exert greater control over innovation activities (Bowman, 1982; Nohria and Gulati, 1996). Because exploitative projects are more predictable than explorative ones in terms of outcomes and costs (March, 1991), it becomes easier for organizations to control them. Hence, lower levels of slack positively moderate the relationship between performance and the degree of exploitation.

Our results show that managers may want to increase R&D spending on environmental innovations because this may have a positive effect on firm performance. However, our results also suggest that it is important for managers to pay specific attention to evaluating the degree of maturity of the technology in the firm. Although an organization's identification of its own technology as mature should lead to more explorative efforts to guarantee improved market performance, exploitation should be selected when the technology is not mature. Managers' difficulties in determining whether the firm's technology is mature should generate reflection regarding the importance of collaborative initiatives with external advisers and research centers. The robust moderating influence of resource slack suggests that, paradoxically, managers may be able to generate more positive performance using exploitation when they face limited resource slack than can be generated when experiencing higher levels of slack resources. This result raises clear concerns regarding the appropriate level of resources for managers when generating innovation. Because a mere increment in available resources is not sufficient, managers should play a more active role by analyzing the composition of innovation projects conducted by the organization.

To complement our empirical analysis, future longitudinal studies should examine several sectors and compare the results and the differences among them. For example, such studies should determine which sectors show an inverted U-shaped relationship and whether some sectors use more exploitative approaches than others do. If this is the case, what other circumstances explain such behavior? Future studies should consider that indicators such as financial ratios may not generalize across industries (Miller and Leiblein, 1996). Additionally, future studies should implement other measures of the exploitation/exploration approach. They should employ different constructs and compare their variability or explanatory power using the developments made in this paper.

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Table 1. Descriptive statistics and correlations

	Mean	S.D.	1	2	3	4	5	6	7	8
1. Tobin Q	1.15	.94	-							
2. Size (Ln Sales)	13.86	2.24	-0.19***	-						
3. Age	54.83	37.77	-0.12*	0.44***	-					
4. Number of patents	12.38	24.72	0.08	0.37***	0.23***	-				
5. Frequency of Specific Knowl.	2.87	3.54	-0.06	0.36***	0.06	0.48***	-			
6. Available slack	2.40	2.20	0.17***	-0.36***	-0.21***	-0.16**	-0.09	-		
7. Potential slack	-0.0075	0.24	-0.14**	0.41***	0.13**	0.11	0.07	-0.06	-	
8. FSK* Available slack	-0.86	9.75	-0.12*	0.15**	0.15**	-0.02	0.03	-0.72***	-0.00	-
9. FSK* Potential slack	0.076	0.90	0.06	-0.29***	-0.09	0.01	0.04	-0.00	-0.91***	-0.07

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

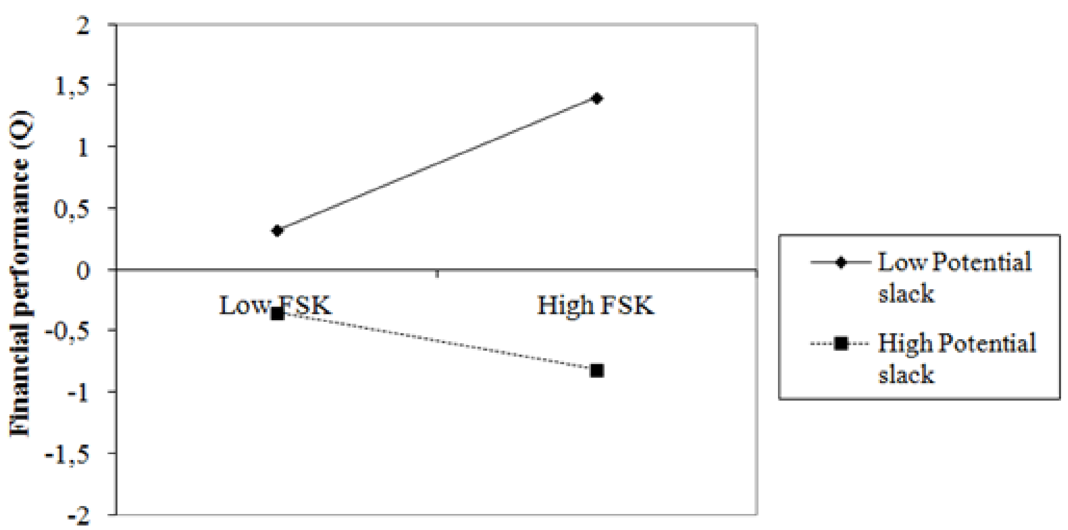
Table 2. Result of the regression analysis

	Model 1	Model 2	Model 3	Model 4
Size (Ln Sales)	-.0312	0.3198	.0547	.0820
	(.2010)	(.1807)	(.1757)	(.3072)
Age	-.1343**	-.1089**	-1.057*	-.1349**
	(.0576)	(.0546)	(.0538)	(.0584)
Number of patents		-.0131**	-.0158***	-.0136***
		(.0057)	(0.0048)	(.0049)
Frequency of Specific Knowl			.0265**	.0405***
			(.0117)	(.0150)
Available slack				-.0449
				(.0474)
Potential slack				-1.6788
				(1.1602)
FSK* Available slack				-.0047
				(.0065)
FSK* Potential slack				-.4527*
				(.2487)
R^2 (ΔR^2)	.2885 (-)	.3232 (.0347)	.3349 (0.0117)	.3780 (0.0431)

Dependent variable: one-year lagged Tobin's Q.
Robust standard errors are in parenthesis.
* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

FIGURE 1

Moderating effect of Slack on the Degree of Exploitation (FSK)



CAPÍTULO 3

A TRANSACTION COST PERSPECTIVE ON DIVERGENCE IN FIRMS' PATENTED ENVIRONMENTAL INNOVATIONS

A TRANSACTION COST PERSPECTIVE ON DIVERGENCE IN FIRMS' PATENTED ENVIRONMENTAL INNOVATIONS

Abstract:

The literature on the orientation of firms' environmental innovations has focused on the institutional factors explaining convergence around certain domains in an industry, but divergence has received limited attention. A firm shows environmental divergence when its environmental innovations fall outside the typical domains of its industry competitors' environmental innovations. We use the theory of transaction costs to show that high levels of asset specificity, bargaining power, and environmental expertise increase the incidence of patented environmental innovations related to domains in which industry competitors are less focused. Our results also show a positive relationship between divergence and market-based firm performance. Our methodology includes a five years longitudinal analysis of 6,768 environmental patents of 59 large companies in the worldwide electrical components and equipment industry.

Keywords: Environmental innovations, organizations and natural environment, transaction costs, technological divergence.

3.1.- INTRODUCTION

The institutional literature presents multiple arguments to explain why firms' innovations converge around common domains in an industry (Campbell, 2004), and peer pressure, regulation, and imitation have been the main factors offered to explain convergence in environmental innovations (e.g., Hoffman, 1999; King and Lenox, 2000; Whiteman, Walker and Perego, 2013). However, the reasons why some firms extend their environmental innovations outside of the typical domains in their industry have received very limited attention (Berrone, Fosfuri, Gelabert, and Gomez–Mejia, 2013; Starik, 2013). Our paper is an effort to understand the factors influencing divergence in environmental innovation and the consequences of divergence for firms' performance.

An analysis of divergence in the environmental arena is relevant because of their socioeconomic and competitive importance. Environmental innovations have gained importance during the last decade due to increases in citizen and regulator awareness, as well as in the market opportunities they generate (Khavul and Bruton, 2013; Russo, 2003; Surroca, Tribó, and Waddock, 2010). From a managerial perspective, the breadth of environmental issues offers firms opportunities to bring environmental innovation to domains both similar to and different from those of their competitors (Shrivastava, 1995). As such, some guidance about the pros and cons of these approaches is necessary.

Our analysis follows recent works using environmental patents to measure the volume and features of environmental technological innovations (e.g. Berrone et al., 2013), in contrast with traditional manager subjective evaluation. A firm's environmental divergence is delimited here as the firm's generation of environmental patents in technological domains in which competitors in the industry have few or no environmental patents. In other words, a firm will be environmentally divergent if the domain(s) of the firm's environmental patents differ from those of its competitors. The recent utilization of environmental codes by patent offices to classify patents and their growing popularity reinforce the interest of this approach. For example, between 2004 and 2009, the number of US patents issued annually increased by 13 percent for solar energy and 19 percent for wind energy, exceeding the rates for such technologies as semiconductors and digital communications and bringing the renewable energy patents in the United States from fewer than 200 per year in 1975–2000 to more than 1,000 annually by 2009. By comparison, there were only approximately 300 fossil-fuel-related patents in 2009, up from approximately 100 per year in earlier decades (Bettencourt, Trancik, and Kaur, 2013).

The existence of complex interactions among the multiple patents new products entail highlights the importance of paying attention to the multiple transactions that patents in turn entail (Ziedonis, 2004). A single new product may contain thousands of patents owned by multiple organizations that can mutually exclude each other, and transactions of (patented) innovations are necessary and relevant (Lin, 2011). To illustrate, 33 different firms each have more than 15 different patent families related to a modern wind turbine (Totaro, 2013). In this context, the multiple transactions involving patented innovations need specific attention. This work is original in using the theory of transaction cost economics (TCE) (Coase, 1937; Williamson, 1975, 1985) to analyze the causes and consequences of divergence in the domains of firms' patented environmental innovations in an industry.

Some works have suggested that technological divergence is an approach more frequently taken by small enterprises, as they may have not enough bargaining power to settle agreements (Blind, Cremers, and Mueller, 2009; Bosse and Alvarez, 2010). Previous research has mainly focused on how firms may try to increase their patents held in central domains and exchange them in large packages with other firms of their industry in "patent portfolio races" (Hall and Ziedonis, 2001). However, in this paper we use TCE (Coase, 1937; Williamson, 1975, 1985) to propose that asset specificity, bargaining power, and environmental expertise may lead to increase in a firm's technological divergence in the generation of patented environmental innovations. We further propose that this technological divergence positively influences the firm's performance via limiting transaction costs.

Transaction costs foster opportunistic behavior by transacting parties that influence firms' strategies and their implications (Williamson, 1975, 1985). In the field of patented innovations, the average cost of a litigation procedure was reported to be US $200,000 for each party, and the market value of each also saw an average 2 to 3.1 percent decline (Markman, Espina, and Phan, 2004). Even when parties reach an agreement about patents, their attorneys, engineers, and managers spend considerable time and money specifying the conditions of agreements (Blind et al., 2009; Markman, Gianiodis, and Phan, 2009). Technological negotiations with direct competitors may entail extraordinary nontrivial transaction costs, such as assessing the value of the small and multiple patents used in an agreement, negotiating costs with engaged parties, and monitoring costs to assure contract compliance in a central business for the given industry. In this context, we propose that some firms may safeguard against opportunistic behavior by technologically diverging from the technologies central to their industry.

Our work makes two theoretical contributions to the literature. First, previous work on corporate environmental innovations does not fully explain the logic of divergence. Institutional lenses explain environmental convergence well, and, in general, it is expected that firms' innovations will be strategically focused on the central domains of their industry. This paper, in contrast, uses transaction costs to explain innovation in dissimilar domains. Specifically, this paper answers recent calls to extend the literature on environmental innovations (Berrone et al., 2013; Starik, 2013) and also King's (2007) call to analyze the transaction costs of generating environmental innovations within firms.

Second, we contribute to the literature on strategic patenting (Hall and Ziedonis, 2001) in the environmental field by analyzing the influence of possible opportunistic behavior of counterparts (Williamson, 1975). This analysis complements attention paid to the generation of multiple defensive patents in central domains of an industry in portfolio races (e.g., Hegde, Mowery, and Graham, 2009; Joshi and Nerkar, 2011), and answers calls in this context (e.g., Foss and Foss, 2005; Mayer and Salomon, 2006) to bridge resource-based view (RBV; Barney, 1991) and TCE (Williamson, 1975, 1985) theories by analyzing how divergent approaches emerging from the avoidance of cost transactions may effectively become a valuable firm resource.

3.2.- THEORETICAL BACKGROUND: TRANSACTION COST ECONOMICS, INNOVATION, AND DELIMITATION OF DIVERGENCE

TCE states that the main reason to establish a firm is to avoid some of the transaction costs of using the price mechanism and of negotiating and writing enforceable contracts for each transaction (Coase, 1937). While all transactions (i.e., exchanges of goods or services) have cost for the parties involved, many entail additional nontrivial transaction costs because they foster opportunistic behavior by individuals who interact in a context of bounded rationality (Williamson, 1975, 1985). The innovation literature has been linked to TCE by a number of scholars (e.g., Blind et al., 2009; Fosfuri, 2006; Joshi and Nerkar, 2011), as “appropriability problems have always been an issue of central concern in the economics of innovation” (Pisano, 1990, p.154).

Joshi and Nerkar’s (2011) analysis of patent pools (agreements among several companies to share patents to develop a related technology) showed that both organizations belonging to the pool for a given technology and outsiders may avoid investing in that technology because of the expectation that their counterparts may behave opportunistically and appropriate improvements. Bosse and Alvarez’s (2010) analysis of alliances between small and large firms, as well as Ariño, Ragozzino, and Reuer's (2008) study of alliances among small firms, also showed that sharing technology may foster opportunistic behavior.

Opportunism may occur not only when an organization shares its technologies but also when other firms acquire them externally. Ulset's (1996) study of the Norwegian technology industry showed that R&D outsourcing is negatively affected by the potential sunk cost of the investments and that exclusivity contracts between seller and buyer are a disincentive to innovation for the former and generate a bilateral dependence in favor of the latter. Likewise, Helm and Kloyer's (2004) study of German companies showed that both suppliers and buyers of R&D are exposed to the risk of receiving less return from innovations than their counterpart and also to the hazard that a one-sided knowledge flow helps the exchange partner to become a competitor. Accordingly, Fosfuri's (2006) analysis of large multinational chemical firms showed that companies are less prone to license out their know-how if it spurs competition, creating a profit dissipation effect.

Empirical studies show that appropriability problems and opportunistic behavior may be fostered when organizations share (voluntarily or not) their know-how and analyze how organizations shape their patent portfolios to overcome their counterparts' opportunistic behavior (e.g., Ariño et al., 2008; Joshi and Nerkar, 2011; Reuer et al., 2002). Grindley and Teece's (1997) case study of electronics and semiconductor companies and Ziedonis's (2004) study of US semiconductor firms both show that some organizations patent more aggressively, seeking to avoid hold-up by a competitor. For instance, Ziedonis (2004) notes that US firms spent over $1 million on patent lawsuits during 1991, representing one third of total basic R&D spending that year. Other works analyzing organizations' strategic patenting also show this logic, even when they do not explicitly mention the TCE.

Blind et al.'s (2009) study of German companies shows that firms patent to block other organizations as well as to negotiate transactions with competitors, which can be considered opportunistic behavior. Likewise, Peeters and van Pottelsberghe de la Potterie's (2006) analysis of Belgian firms and Reitzig's (2003) study of the semiconductor industry showed that firms patent both to gain access to competitors' technologies and to improve bargaining position in cross-licenses, which implies a trade-off between appropriating others' quasi-rents and releasing some of the rents derived from one's own technologies. In general, TCE involves asset specificity, bargaining power, and the transacting parties' expertise as the most relevant factors for understanding opportunistic behaviors and the existence of nontrivial transaction costs surrounding innovations.

Asset specificity is widely considered as the transaction attribute with the highest explanatory power for opportunistic behavior (e.g., Williamson, 1975, 1985). The assets related to any innovation are specific when they "cannot be redeployed to another application or relationship without a significant loss in value" (Shervani, Frazier, and Challagalla, 2007, p. 638). Bargaining power, which is the ability to influence and modify a transaction for more favorable terms (Argyres and Liebeskind, 1999; Díez–Vidal, 2007), has become key, as organization must transact with other parties to develop and commercialize technologies (e.g., Hall and Ziedonis, 2001; Lin, 2011). Finally, the transacting parties' expertise means distinctive, specific professional knowledge that can lead a firm into certain domains of activity (Ahuja and Lampert, 2001), influencing transaction costs by reducing technological uncertainty and the costs of suppliers' qualifications.

In analyzing environmental innovations, different theoretical works have explicitly highlighted the importance of considering transaction costs to better understand opportunities to generate environmental innovations within a firm. King (2007) proposes that cooperation between corporations and environmental groups requires hybrid and intermediate forms of governance in response to high transaction costs. Tate, Dooley, and Ellram's (2011) theoretical work suggests that suppliers are more likely to adopt environmental practices if their information seeking, bargaining, and enforcement costs are minimized. Simultaneously, various empirical works have insisted on the importance of considering the specific features of environmental innovations.

Berrone and Gomez–Mejia's (2009) analysis of US companies notes that environmental innovations require large and risky investments, which are related to their asset specificity. In general, institutional factors foster firms' convergence on specific technological environmental domains in an industry (Berrone et al., 2013). We propose hypotheses explaining that factors related to opportunistic behavior may encourage firms' environmental divergence.

At this point, it is important to clearly differentiate divergence (i.e., our focus of interest) and other terms employed by literature and strategic research addressing innovation. Divergent innovation takes a competitive point of view that does not consider whether the technology is new or not (i.e. explorative vs. exploitative), or whether the search approach of that technology is local or goblal, but an external point of view that considers technologies that are not central to the portfolio of the firm's competitors. For instance, while literature on explorative innovation highlights that exploration involves the pursuit and acquisition of new knowledge (March, 1991; Walrave, van Oorschot, and Romme, 2011), the divergence may be better illustrated by entering well-known but unpopular technological devices in the industry. Similarly, the global (versus local) search innovation (e.g., Kogut and Zander, 1992; Rosenkopf and Nerkar, 2001) focuses on the technological distance of the firm's innovations and those in the neighborhood of the firm's current expertise or knowledge.

From a strategic point of view, whereas the literature on diversification strategy (Berry, 1975) concerns firms' investments in unrelated business activities (i.e., whether their competitors draw attention to them), this paper about divergence concerns only firms' activities in domains (which may or may not be interrelated) in which their industry competitors exhibit residual or no participation. At the same time, being divergent also differs from being a pioneer in a strict sense (e.g., Ahuja and Lampert, 2001) because diverging means keeping technological domains that are not central to the industry and that could be completely new (i.e., of a pioneering nature) or not. In this context, we propose that investing in technologies in which competitors have a major presence is more relevant to raising transaction costs than the internal or pioneering nature of the innovations. These differences are important for understanding our interest in the patenting approach regarding environmental innovations in the electrical components and equipment industry, as well as our subsequent hypotheses.

3.3.- RESEARCH SETTING

The electrical components and equipment (E&E) industry is highly competitive and global, with a small number of very large international firms. The E&E industry consists of companies manufacturing small-scale electrical equipment (e.g., motors, electric heating and cooling systems, small generators, and storage batteries), and electrical components (e.g., wires, cables transistors, electron tubes, and insulators). Our description of the industry in this section draws on exploratory analysis of the corporate annual reports of the 12 biggest firms in the E&E industry over three recent years according to COMPUSTAT.

An emphasized idea in all these reports is that most big firms in E&E are expanding their research, design, and development activities and de-emphasizing the manufacturing low-end products, which is often outsourced to developing areas. Demand for high-performance devices, rapid changes in technologies, and the outsourcing of production have resulted in fast growth in the importance of R&D activities in the industry. R&D investment in the whole German electronics industry (of which E&E is a subsector) has been estimated to be around $15 billion (over 6% of sales), and 30 percent of all the patents filed in Germany each year of a recent period were attributable to the industry (Deutsche Bank Research, 2009).

Products to improve energy efficiency and/or new devices for renewable generation of power have been two of the top drivers of the long-term growth trend in E&E (MarketLine, 2013). Almost every sampled company in our exploratory analysis of the corporate annual reports offers illustrations of environmental innovations in its products. LG's plasma lighting system ("the greenest lighting in the world"), Schneider Electric's innovation for water treatment, and TDK's neodymium magnets for wind power generators are examples (LG, 2012; Schneider Electric, 2013; TDK, 2013).

At the same time, the exponential demand, rapid evolution in technology, falling prices, and planned obsolescence have resulted in a fast-growing excess of electronic waste around the globe. Just to illustrate, each year the US discards around 50 million computers and 140 million mobile devices, but the Environmental Protection Agency estimates that only 25–27 percent of electronic waste is recycled (ICF, 2013). E&E items contain or are fixed with many materials, some of which are highly hazardous and environmentally sensitive. From a sustainability-oriented perspective, "in attaining sustainability, [...] societies [cannot] offload the problems of today onto future generations" (Khavul and Bruton, 2013, p. 287).

Aware of their impact, many companies in our exploratory analysis set environmental issues as a priority in mission statements in their corporate reports. For instance, Foxconn (2012, p. 9) states that it aims to "promote industrial transformation for the group as the ultimate goal is to have a sustainable enterprise"; Panasonic (2013, p. 31) states that "[for] striving to become a green innovation company, the environment was made central to all of our business activities"; Mitsubishi Electric (2013, p. 3) says it aims "to become a global, leading green company, enriching society with technology"; and Toshiba (2013b, p. 5) refers to working "to become one of the world's foremost eco-companies."

Many of the reports highlight the importance of patenting innovative processes and pay explicit attention to competitors' patents and possible litigation costs. For example, Eaton

(2013) notes lawsuits for "patent infringement" as a contingency that may affect the firm's financial statements, and Mitsubishi Electric (2013, p. 31) that "important patent filings, licensing, copyrights and patent-related disputes may adversely affect related businesses." Panasonic (2013, p. 28) shows concern about hold-ups: "Competitors or other third parties may also develop technologies that are protected by patents, which make such technologies unavailable or available only on terms unfavorable to Panasonic."

Other companies go one step further, explicitly describing their patenting strategy in their annual reports. Fuji Electric, Hitachi, LG, Mitsubishi Electric, and Toshiba, among others, emphasize the top importance of strategic patenting for both protecting and enhancing their intellectual property assets. Toshiba (2013a, p. 36) refers to directing its patenting strategy to become "an even stronger global contender"; Mitsubishi Electric (2013, p. 18), to "further [enhancing] its robust patent portfolio"; and Fuji Electric (2013, p. 28), to a strategy "based on respect for both the intellectual property rights it owns as well as those owned by other companies."

Further, the analyzed E&E industry annual reports often discuss corporate preference for patenting in central areas of the industry or for taking a divergent approach. Reports from Foxconn, Hitachi, and Toshiba show commitment to convergence; for example, Hitachi (2013, p. 39) refers to "strengthening international standardization activities" in the industry. However Panasonic (2013, p. 26) states that because a high level of competition may impair profitability, it "may choose not to fund or invest in one or more of its businesses to the same degree as its competitors in those businesses do." ABB (2013, p. 185) also says that technological consolidation results in "more powerful competitors and fewer customers."

The logic of divergence or convergence is embedded in the analyzed reports in multiple ways related to TCE. For instance, ABB (2013) and Areva (2011) highlight that their R&D intensive investments will be difficult to recover if just applied to the traditional domains of the industry. Alternatively, the existence of technologies with a broader scope may safeguard against opportunism and reinforce a convergence approach in the industry. For example, Toshiba (2013b, p. 39) states that the firm promotes "conferences with competitors aiming at standardization" seeking to reinforce the industry's technologies.

Additionally, these firms express excitement about gaining bargaining power in the industry via holding patents. For instance, Fuji Electric (2013, p. 28) states that it "aggressively utilize[s] patents in areas such as licensing and collaboration"; LG (2012, p. 20) claims to have the "phone with the most LTE patents in the world"; and Schneider Electric (2013, p. 30) states that the firm's strategy is based on "the consolidation of its global leadership in critical technologies."

3.4.- HYPOTHESES

3.4.1.- The Influence of Innovation Specificity on Firm Technological Divergence

Specific innovations lose their value when not applied to a given transaction (Williamson, 1985). This factor is particularly important nowadays because it is highly unlikely that a single company's innovations will generate a technology (Lin, 2011), so firms often need agreements (i.e. transactions) with multiple parties to develop and commercialize their own innovations. For instance, a recent analysis of the patents related to a wind generator shows that there are 6,755 patent families around the topic in the period 1990–2012, with the top six patent holders making only 49.4 percent of the patent filings (Totaro, 2013).

Transactions to generate value from a firm's specific innovations cost more when the firm needs collaborative agreements with other firms (Williamson, 1985). In the context of this research, when a company invests in environmental patents that may be only used if the firm closes an agreement with competitors (i.e., a highly specific asset), the firm becomes bilaterally dependent on that technology and its multiple competitors. In the worst scenario, some patent owners may hold up the use of the technology, which can devastate a company whose investments depend on that transaction. The dependence may also foster opportunistic behavior by licensors renegotiating contracts (e.g., Pisano, 1990), and the licensors may appropriate the quasi-rents generated by the licensee by significantly increasing royalty fees (Grindley and Teece, 1997). Additionally, because an organization has to transact with every company that holds patents related to its own technology in order to use and commercialize that technology, the dependence derived from an specific asset may be more harmful when a firm invests in central areas of its industry because more players are in the game.

A number of scholars have shown that firms may respond to counterparts' opportunistic behavior by exponentially increasing the number of their patents. For instance, Hall and Ziedonis's (2001) analysis of the semiconductor industry showed that a firm that invested in nonrecoverable, highly specific assets shifted from issuing 30 to 300 yearly patents "while maintaining a relatively stable R&D budget" (Hall and Ziedonis, 2001, p. 108). However, organizations that hold many related patents may also face nontrivial transaction costs. For instance, although Microsoft is a leader company holding many patents in key domains of its industry, during 2005 it still paid $1 billion in royalties, for access to others' technologies, and earned only $100 million for allowing access to its own technologies (Ricadela, 2006). This example suggests that a high number of patents in certain domains may not guarantee low transaction costs when dealing with specific assets. We will analyze the influence on divergence of two characteristics of technological innovation that relate to asset specificity: intensity and scope.

Specificity, intensity, and divergence.

The intensity of a firm's technological innovations refers to the level of resources the firm dedicates to improving its innovativeness (Ziedonis, 2004), and thus, technologically intensive firms are the ones that proportionally invest more in R&D than the sector average. High R&D investment intensity usually implies taking innovations through the whole process from idea generation to potential commercialization (Ziedonis, 2004). Although a firm may overcome hold-ups or difficulties through cross-licensing with competitors, such agreements entail sharing its own technologies, which dissipates rents from the original investments (e.g., Díez–Vidal, 2007; Patel and Ward, 2011). Although not every licensor may behave opportunistically, the greater the number of companies that share a technology, the greater the hazard that some will behave this way.

Very intensive investments are required for more unique environmental developments. For instance, Delmas (2002) notes that the certification process for obtaining a general environmental standard such as ISO 14001 may have a cost of from $100,000 to $200,000 for larger heavy industrial facilities, which is a minor part of their investments in environmental technologies. In contrast, the estimated total cost to put the first device using ocean wave energy into the water is $30m (Chazan, 2013). In general, the development of advanced environmental innovations may be complex and risky and usually requires intensive investment (e.g., Barnett and Salomon, 2006; Berrone and Gomez–Mejia, 2009).

If an organization invests heavily to generate environmental assets specific to technologies around which its industry has converged, it increases the hazard of suffering opportunistic behaviors, such as hold-up by competitors that also invested in these technologies; they may block the launch of a product or request monetary compensation for allowing its commercialization (Williamson, 1985). However, intensive investments outside the regular, converged-on domains of environmental innovation in an industry could generate less aggressive responses from direct competitors. For instance, Samsung has filed multiple environmental patents related to electric vehicle technologies, tires, motors, and on-board electronic devices (Lee, 2013), and the divergence of these innovations from the domains typical for Samsung's industry meant it avoided transacting with competitors in its traditional products and could instead transact with firms in the automotive industry, gaining a chance for a new growth engine.

Consequently, organizations that devote more resources to innovation may reduce the transaction costs related to their innovations by investing in their industry's noncentral domains. Hence, we propose:

> *H1a. The intensity of a firm's innovations is positively related with the extent of the firm's divergence from established industry domains in its patented environmental innovations.*

Specificity, scope, and divergence.

The scope of technological innovations refers to the number of different technological fields to which they are related (Lerner, 1994). Broad scope reduces asset specificity because these innovations can be used in a greater variety of transactions. Because a broader technological scope denotes higher asset redeployability, it may (relative to a narrow scope) reduce counterparts' opportunistic behavior in at least three ways.

First, a firm bypasses hold-ups by competitors in a given technological domain when wider scope allows it to develop in other technological areas. Second, firms with innovations of broader scope may benefit from sharing knowledge with competitors in nuclear areas of their industry, which lets the firms appropriate others' technological improvements (Joshi and Nerkar, 2011), and at the same time develop innovations in nonnuclear technological domains, possibly without losing temporary monopoly rents. Third, firms with innovations of broader technological scope may speed their commercialization by supplying general technologies to downstream producers for different segments of the final market (Bresnahan and Gambardella, 1998). All these opportunities are also relevant in the environmental arena.

Environmental innovations may have either a broad or a narrow scope (Shrivastava, 1995). For instance, innovations aimed to reduce packaging material and waste are of broad scope because they can be applied to a wide variety of technological domains and products. However, innovations that develop unicellular photosynthetic organisms represent a green technology with a very narrow scope that allows organizations to move from established domain of fossil fuels to the emergent field of algae biodiesel (Preiss and Kowalski, 2010). We propose that firms whose environmental innovations are of narrower scope tend to participate in divergent technological fields, finding less pressure from potential opportunistic behavior. Thus,

H1b. The scope of a firm's environmental innovations is negatively related with the extent of the firm's divergence from established industry domains in its patented environmental innovations.

3.4.2.- The Influence of Bargaining Power on Technological Divergence

Bargaining power can be defined as the "ability of one party to a contract to be able to influence the terms and conditions of that contract or subsequent contracts in its own favor" (Argyres and Liebeskind, 1999, p. 55). A firm may use this influence to reduce the transaction costs of negotiation with other parties (e.g., Joshi and Nerkar, 2011; Hall and Ziedonis, 2001; Hegde et al., 2009), hence easing the access and commercialization of a given technology. While the firm's bargaining power provides relevant advantages in the core commercial process of the industry, concerning the reduction of transaction costs for innovative developments it may be more effective in fields divergent from the industry, given the possibility of avoiding the exponential costs of dealing with multiple competitors in the industry, the chance of better preserving its influence in the future, and the limitation of risks linked to reactions of competitors. We discuss each of these arguments below.

First, dealing with a large number of competitors, usually a requirement to develop environmental innovations in convergent fields of the industry, may erode the benefits of a firm's bargaining power because the total negotiation costs are very high. For instance, Grindley and Teece (1997) point out that the process of reaching a cross-licensing agreement between two counterparts may take a year because each has to evaluate the quality of the counterpart's patents; the time might be the same or even grow when the powerful agent must deal with many counterparts at the same time. Although business activity in a divergent domain might also require a firm to negotiate agreements with multiple other organizations, the cost, time, and risk a firm incurs bargaining with (multiple) competitors is much higher in convergent domains than the cost of bargaining with (multiple) organizations without a direct link with the firm's main activity.

Second, firms with more bargaining power might better preserve their future influence in the industry if they have to deal with only a few competitors while developing innovations. Even given enough bargaining power to reduce the negotiation time or pay less than others for cross-licenses, the firm will usually have to provide at least a partial exchange of its particular know-how with other firms if they are all in the same nuclear technological area (Joshi and Nerkar, 2011; Rufín and Rivera–Santos, 2012). The exchange of know-how with many other firms in the industry to develop new products around very similar technologies might erode a firm's future bargaining power and reduce monopoly rents due to the high number of parties in transactions and the reduction in cost effectiveness of controlling the agreements and diluting the incentives to generate new innovations (Hegde et al., 2009).

Third, investments in nonnuclear technologies may not spur competitor safeguards because they are not considered as strong a threat as those in nuclear technologies (Gambardella and Giarratana, 2013). For instance, when Samsung announced environmental patents related with the automotive industry, it did not generate the same level of aggressive reactions from competitors that might have been generated by the announcement in the heart of the E&E industry. By making progress in fields outside the most traditional environmental interests in the industry, Samsung tried to safeguard its own technologies against competitors and take advantage of its bargaining power in less sensitive fields.

Therefore, companies with high bargaining power may lower their transaction costs when developing environmental innovations in noncentral technological areas. Consequently,

H2. A firm's bargaining power is positively related with the extent of the firm's divergence from established industry domains in its patented environmental innovations.

3.4.3.- The Influence of Expertise on Technological Divergence

The pioneering work of Bigoness and Perreault (1981) showed that firms possessing more internal, field-specific expertise were also more innovative than firms without such expertise. Similarly, Corbett (2005) has emphasized the importance of possessing "stocks of prior knowledge," while Zheng and Yang (2014, p.10) have argued that expertise "helps firms 'see through the fog' of ambiguities in knowledge discovery." Accumulating environmental expertise usually takes time (Marcus and Geffen, 1998), but expert organizations may benefit from faster learning and a higher absorptive capacity in different technological areas (Cohen and Levinthal, 1990).

Environmental expertise is especially useful for reinforcing the opportunities of developing innovations in multiple fields because environmental innovations "act as a major source of change" (Petruzelli, Dangelico, Rotolo, and Albino, 2011, p. 295). For instance, Kesidou and Demirel's (2012) study of UK manufacturing firms showed that the development of environmental innovations was positively linked to the development of organizational capabilities. This "virtuous cycle" of experience and competence (Ahuja and Lampert, 2001) enables the organization to develop a greater knowledge base, which may confer a relative advantage over other transacting parties.

Expertise in a particular topic also reinforces credibility as a supplier or a partner in transactions and exchange of knowledge in that topic even if the developments are in different fields. Jensen and Roy (2008) showed that firms tend to differentiate themselves by selecting auditors with a reputation for expertise in the firms' industry. Supplier expertise reduces incentives for transaction partner opportunism, transaction costs due to being locked in with a supplier who causes delivery and/or quality-related problems, and the effort and investment related to the qualification of a supplier (Song and Di Benedetto, 2008).

In this context, knowledge and expertise gained in environmental areas may exert more influence outside convergent environmental innovations. For instance, Artemis Intelligent Power pioneered a novel hydraulic drive technology and initially sought to apply it to the automotive industry, but later identified a more promising application in the offshore wind market (Chazan, 2013). In general, it is difficult to predict the evolution of environmental regulation and the most appropriate technology for each environmental dimension (Bowen, 2011; Marcus, Aragon–Correa, Pinkse, 2011; Schaefer, 2007). However different works (Montiel, Husted, Christmann, 2012; Sharma and Henriques, 2005) have shown that signaling environmental or social expertise with external certifications may reduce customers' costs of searching for and identifying suppliers with desirable but unobservable characteristics, costs associated with drafting agreements to ensure that suppliers possess the unobservable characteristics they claim, and costs of verifying whether contractual terms have been met. These works have also highlighted the important credibility problems of external environmental and social certifications. An objectively successful experience filing environmental patents may be a credible signal of environmental expertise with the clear potential to reduce the costs of identifying appropriate partners for transactions surrounding nonnuclear environmental innovations.

Thus, we propose that higher environmental expertise is more relevant when firms are diverging from their industry's innovations than when they are converging. Consequently, *H3: A firm's environmental expertise is positively related with the extent of the firm's divergence from established industry domains in its patented environmental innovations.*

3.4.4.- Technological Divergence and Firm Performance

Because patenting in areas where competitors are present may entail transaction costs such as litigation, delays in product development, hold-ups, high licensing costs, and sharing new developments (e.g., cross-licensing and patent pools), organizations that technologically diverge from their competitors may avoid these costs and obtain a positive effect on performance. When organizations diverge, they not only may reduce the transaction costs associated with multiply owned innovations in a nuclear area, but also may create market leadership (Spencer, 2003) and extract temporary monopoly rents (Patel and Ward, 2011), sometimes extending them by patenting related knowledge. Being the pioneer in a given technology allows an organization to enjoy a temporary monopoly position, capturing all market share while increasing its learning, which constitutes a cost advantage against future followers (Ghemawat, 1984; Lieberman and Montgomery, 1988).

Furthermore, a strategy of technological divergence enhances corporate image, making it easier for a firm to obtain funding for future projects at the same time as it may be considered as a reference for competitors and customers (Barney, 1991). Therefore, the organization may retain a large market share and offset the entry of new competitors through the creation of consumer loyalty (Spencer, 2003) and sometimes consumer switching costs, because "perceptions and preferences, once formed, are difficult to alter" (Lieberman and Montgomery, 1988, p. 46).

The customer switching costs and the learning related to divergent environmental innovations are also a way to maintain the first-mover advantages of technological divergence by limiting imitability (Hegde et al., 2009; Ziedonis, 2004). Additionally, a company may issue related and overlapping patents to build a fence against current and potential competitors (e.g., Blind et al., 2009; Lin, 2011). Competitors may try to invent around such a fence, but this approach becomes challenging when the firm holds key patents (Lin, 2011), and even when competitors develop similar technologies, the patent holder may sue them through the "doctrine of equivalents," whereby sufficiently equivalent knowledge is considered a major cause of infringement (Clarkson and Toh, 2010). As Blind et al. (2009, p. 428) states, "patents are also an instrument for securing one's own future technological space against competitors or for restricting competitors' future technological opportunities."

In the environmental arena, multiple firms' environmentally divergent innovations illustrate their financial interest. For instance, Toyota decided to diverge from the environmental technologies widely used in its industry, namely, those related to the gas engine, to develop a noncentral technology, the hybrid engine. This strategy of technological divergence not only gave Toyota monopoly rents but also allowed it to speed up the learning curve and achieve a competitive advantage to the point that it is currently still positioned as the market leader (Spencer, 2003).

Even if in the long run competitors develop relevant environmental patents in a firm's technological domain, the investments initially made by the firm help to maintain leadership in terms of reputation and market share (Spencer, 2003), reduce production costs, and increase the speed of creating new related products, thanks to early learning (Lieberman and Montgomery, 1988), and may place the firm in a privileged position for bargaining cross-licenses. Consequently,

> *H4: The relationship between the extent of a firm's divergence from established industry domains in its patented environmental innovations and the firm's performance is positive.*

3.5.- METHOD

3.5.1.- Sampling and Data Collection

Previous empirical works have encouraged the employment of patents because of the rich data available, their comparability, and their suitability for longitudinal analysis (Reitzig, 2003; Petruzzelli et al., 2011). This paper uses patent data from the European Patent Office (EPO) database, including all those multiple international firms have filed in up to 40 European countries. The EPO is one of the largest patent offices in the world (like its US and Japanese counterparts); we chose this database because the EPO uses a specific classification code for innovations with environmental content (EPO, 2010). Thus, classification by EPO examiners rather than subjective, abstract-based analysis by the authors (e.g., Lee, Veloso, and Hounshell, 2011) was the basis of our selection of patents. We used only the "family representative" document of each application (i.e., a given application is counted just once despite being filed in several national offices) and also used the EPO's European Classification System (ECLA) codes in the patent to sort the technological domains of the environmental patents analyzed.

The Electrical Components & Equipment (E&E), sector 6190 in COMPUSTAT, was our focus, one appropriate for our objectives, as discussed above. We searched the EPO data base to identify E&E firms that had COMPUSTAT data available and that had issued two or more patented environmental innovations during 2005–2009. The minimum of two provided higher consistency in the identification of a divergent approach. Given that COMPUSTAT did not offer information for some companies, the final sample provided unbalanced panel data on 6,768 environmental patents from 59 companies generating 197 observations from 2005 through 2009.

3.5.2.- Measures

Technological divergence. Following previous works (e.g., Clarkson and Toh, 2010; Lerner, 1994), we used patent class (ECLA classification code) to delimit technological domains. We measured the technological divergence of a firm's environmental patents from the E&E industry thus:

$$Divergence = \sum_{i=1}^{n} \left| \frac{NFPi}{TotalNFP} - \frac{NIPi}{TotalNIP} \right| \times \frac{NIPi}{TotalNIP},$$

where NFP_i is the number of the firm's environmental patents related to domain *i* and NIP_i is the number of the industry's environmental patents related to domain *i*.

If a firm's environmental patents are in the same technological domains and in the same proportion as the industry's average, the divergence value is 0, and the firm totally converges. Higher values of the index mean higher divergence from the industry. The analysis of the environmental technological divergence of each firm is quite time demanding, because the EPO database does not provide any system to make automatic the process of dealing with the ECLA codes of each individual patent.

Firm performance. To assess market-based firm performance, we employed Tobin's *Q*, defined as the ratio of market value to the replacement cost of assets and calculated from COMPUSTAT. We chose *Q* over other measures of financial performance because it better reflects the market's judgment about a firm's future, which are particularly important when dealing with innovation issues (Bharadwaj, Bharadwaj, and Konsynski, 1999). We used a one-year lag to capture effects, an appropriate period for balancing the non-immediate effects on performance and the high rate of obsolescence of the innovations in the sampled industry.

Firm technological intensity. Following previous research (e.g., Delios and Henisz, 2000), we used the ratio between R&D expenditures and sales to reflect R&D intensity. A higher value indicates higher technological intensity.

Firm technological scope. Scope was measured by the number of different technological domains in the analyzed environmental patents (e.g., Lerner, 1994) divided by the number of environmental patents issued by a focal firm. We also checked that the absolute value of the different technological domains in the firm's environmental patents offered similar results in our analysis.

Firm bargaining power. Previous work has used size as a proxy for a firm's bargaining power (e.g., Ariño et al., 2008; Shervani et al., 2007). We also used the natural log of net sales to measure firm size. The log was used to achieve a simple linear structure, constant variance, and normal distribution. Because sampled firms are worldwide, we tried to avoid bias due to changing currency rates by normalizing sales into 2005 US dollars.

Firm environmental expertise. Environmental expertise was measured as the number of environmental patents a firm held divided by its total number of patents (range = 0–1; higher values mean greater environmental expertise).

We used six different control variables in our analysis:

Firm age. Age, measured based on foundation year according to the Bloomberg and JP Morgan databases, was included to capture the effects of experience and learning on divergence (Hegde et al., 2009).

Country pollution level. This variable is calculated in metric tons per capita of CO_2 emissions in the country in which a firm has its headquarters, as reported in the World Bank database. This variable is a control for institutional factors influencing a firm's environmental approach (e.g., King and Lenox, 2000; Whiteman, Walker, and Perego, 2013)

Country energy production. This variable is measured as the energy production in kt of oil equivalents, according to the World Bank database. Organizations headquartered in countries with higher levels might tend to maximize short-term production (Pakes and Griliches, 1984), investing in well-known, convergent technologies.

GDP. Annual GDP growth (as a percentage, from the World Bank) is considered a proxy for munificence; firms in countries with higher growth rates may take risks that imply investing in divergent technologies (Aragon–Correa and Sharma, 2003).

Country inflation rate. This variable from the World Bank database reflects price volatility and variability and their potential to generate uncertainty influencing a firm's environmental approach. The environmental literature has noted the importance of uncertainty (e.g., Berchicci and King, 2007; Bowen, 2011).

3.6.- RESULTS

We tested our hypotheses using conventional panel data methods (fixed- and random-effects regression) with STATA. Because we had two dependent variables, we ran two separate regressions. For the first four hypotheses (1a, 1b, 2, and 3), we used the technological divergence measure as a dependent variable, whereas for Hypothesis 4, we used Tobin's *Q*. For both regressions, we took the Hausman test (Hausman, 1978), which endorsed the use of a fixed effect in both cases. Fixed-effects models are preferred over random-effects models because the former provide a more reliable estimate of parameters, as they eliminate the unobservable variables in conventional OLS regression estimates (Ernst, 2001). In addition, we used robust standard errors to avoid serial correlation and heteroskedasticity, and we controlled for the variability of the intercept over time by using year-specific dummies.

Table I includes the descriptive statistics of our variables. The correlations between the variables do not suggest any potential for serious multicollinearity in the regression analysis.

INSERT TABLE I ABOUT HERE

Table II presents the results of the first regression, in which variables reflecting hypothesized effects were entered individually. Model 1, the base model, includes only the control variables when technological divergence is the dependent variable. Models 2 through 4 include the hypothesized effect variables, intensity of technological innovations, specificity of technological innovations, and bargaining power, entered sequentially. Model 5 includes firm environmental expertise and completes the specification. The R^2 statistics indicate that every additional variable improved model fit.

INSERT TABLE II ABOUT HERE

We use the full model to discuss the results of hypothesis tests. Hypothesis 1a predicts a positive relationship between innovation intensity and environmental technological divergence. The coefficient on firm intensity ($\beta = 1.108$, $p < 0.01$) was positive and significant, supporting Hypothesis 1a. For the relationship between technological scope and divergence, the coefficient ($\beta = -0.0048$, $p < 0.05$) was negative and significant, suggesting that as a firm broadens its technological scope, it tends to converge, as hypothesized in Hypothesis 1b. Hypothesis 2 predicts a positive relationship between bargaining power and the technological divergence; results for bargaining power ($\beta = 0.0690$, $p < 0.01$) confirmed our predictions. Environmental expertise is positively related to divergence ($\beta = 0.1279$, $p < 0.10$), supporting Hypothesis 3. Hence, as organizations increase their expertise in the environmental arena, they tend to invest in nonnuclear environmental technological domains. Regarding control variables, the negative relationship between a firm's environmental technological divergence and country energy production ($\beta = -0.02272$, $p < 0.10$) shows that organizations whose decision makers are placed in more polluted countries tend to invest in convergent technologies.

The results in Table III are for the relationship between technological divergence and Tobin's *Q*. Models 6–10 include each of the independent variables in the first regression to control their potential effects on Tobin's *Q*. Model 11 includes technological divergence as an independent variable measured as the residual value of the variable in the first regression to avoid confounding effects of divergence and its antecedents. The positive and significant coefficient on divergence ($\beta = 0.7987$, $p < 0.10$) confirms our predictions that divergence is positively related with firm performance. There was no consistent pattern for the dummy variables for the different years.

INSERT TABLE III ABOUT HERE

3.7.- DISCUSSION, IMPLICATIONS, AND FUTURE RESEARCH

In the current context of multiply owned innovations, it is particularly important that firms make decisions that minimize the transaction costs of their counterparts' opportunistic behavior. Some scholars have argued that firms may reduce transaction costs by greatly increasing their number of patents (Hall and Ziedonis, 2001; Joshi and Nerkar, 2011). Some firms collect many patents around specific domains, including patents making very minor innovative contributions, to deter lawsuits and gain bargaining chips. Here, we assess whether the extension of a firm's patented innovations outside of the normal domains in its industry may complement this approach. The results show that different factors related with a firm's transaction costs influence the firm's environmental divergence. Results further suggest that firms' divergent patented innovations deserve research attention, given that our divergence variable had a positive relation with firm market performance in the sampled firms.

The rationality of converging around certain domains within an industry is clear when one takes an institutional view of environmental innovations (Berrone et al., 2013). Environmental regulation (e.g., Jaffe and Palmer, 1997), the institutional conditions in an industry (e.g., King and Lenox, 2000; Russo, 2003; Whiteman, Walker and Perego, 2013), and the combination of internal capabilities and industry (e.g., Aragon–Correa, 1998) have all showed their influence on the convergence of a firm's environmental innovations within the technological domains established in its industry. Our results extend the previous strategic patents literature (e.g., Goodman and Myers, 2005) by analyzing the variables related with the opportunistic behavior of competitors. This work contributes to the environmental literature by using transaction cost economics (Coase, 1937; Williamson, 1975, 1985) to extend the analysis of environmental innovations and delimiting four different factors related to transaction costs to better explain divergence from industry practice in a firm's environmental portfolio of patented innovations.

This work joins that of a small but growing group of scholars who are looking for the theoretical logic of corporate environmental approaches by using new perspectives. The traditional literature on organization and the natural environment has mostly used institutional or resource-based (RBV) lenses (Berchicci and King, 2007). Recent works have contributed by utilizing the agency perspective to analyze the impact of particular corporate governance mechanisms on firm environmental performance (Berrone and Gomez–Mejia, 2009; Kock, Santaló, and Diestre, 2012), or integrating institutional and RBV perspectives (Diestre and Rajagopalan, 2011). The implications of the transaction costs surrounding environmental innovations have received minor attention in previous works, yet they appear particularly important in the context of patented innovations.

The current analysis of the international electrical components and equipment industry during the years 2005 through 2009 confirmed the importance of transaction costs in relationship to firms' environmental patents. The TCE literature has identified a collection of factors that influence the nontrivial costs of the transactions between firms, highlighting asset specificity and bargaining power (Williamson 1975, 1985). In addition, suppliers' qualifications (Song and Di Benedetto, 2008) and firm expertise are also relevant and were utilized as variables in the analysis.

The results show that a high intensity of investments and a low scope of the domains related to a firm's environmental innovations (both related with the specificity of the assets involved); bargaining power; and environmental expertise are all positively linked with innovative divergence from typical E&E industry domains in the environmental arena. We will now briefly review each of the main results of our work.

When an organization invests intensively in highly specific assets, it becomes more dependent and fosters opportunistic behavior by its counterparts. Technological divergence may reduce transaction costs by diminishing the hazard of hold up by one of the multiple firms (including direct competitors) that own patents an organization needs to commercialize a product (Grindley and Teece, 1997). Conversely, patenting in less exploited areas tends to require patents owned by fewer firms and/or by firms with less direct rivalry, which eases negotiation, diminishes costs, and speeds the launch of a product.

Similarly, when an organization invests in broader technological domains, it may transact with multiple parties in multiple technological domains. The resulting asset redeployability not only mitigates hold-up behavior but also eases commercialization because broader technologies can be sold to a broader number of organizations. Consequently, our results show that organizations investing in broader technologies may not need to technologically diverge from their competitors as a safeguard against their counterparts' opportunistic behavior. However, environmental innovations related to a reduced number of technological domains generate specificity and are positively related with a firm's technological divergence in the sampled patented environmental innovations.

Regarding bargaining power, we propose that organizations with high bargaining power may enhance it when they technologically diverge from their industry. A firm's large size confers bargaining power over smaller organizations, especially in nonnuclear areas, because smaller firms with investments in these areas are more exposed to opportunistic behavior from a transacting party with greater financial resources (Ariño et al., 2008;

Shervani et al., 2007). Hence, large organizations may appropriate quasi-rents and negotiate transactions in more favorable terms when they diverge technologically.

Environmental expertise in a particular domain is especially useful to reduce the transaction costs outside the nuclear domains in an industry. Environmental expertise not only generates higher absorptive capacity and a faster learning curve (Cohen and Levinthal, 1990) but is also useful to signal a firm's environmental capabilities when uncertainty in that domain is particularly high. Our work reinforces and extends the previous findings of Jensen and Roy (2008) about the importance of industry expertise for selecting partners. Environmental expertise exerts more influence in noncentral areas in an industry because the knowledge in these areas is less developed, and hence a firm's expertise is particularly useful to reduce the uncertainty around environmental innovations and efforts to qualify suppliers.

From a theoretical point of view, these results also contribute to the literature on strategic patents (Hall and Ziedonis, 2001) by analyzing the factors that influence when counterparts may behave opportunistically (Williamson, 1975). This analysis complements research attention to the generation of multiple defensive patents through patent portfolio races (e.g., Joshi and Nerkar, 2011; Hegde et al., 2009). Our results are very appealing because they clearly show that patenting in divergent domains of an industry is not a strategy enacted by small organizations that lack the resources to maintain a strong absolute bargaining position against large corporations, as some have suggested (e.g., Ariño et al., 2008; Shervani et al., 2007). On the contrary, our results show that large corporations with strong bargaining power—that is, the organizations with the financial and economic resources to litigate with multiple organizations at the same time without compromising their survival (Blind et al., 2009)—are more likely to decide to file patents outside the regular domains in the E&E industry.

Finally, our results show a positive relation between technological divergence and firm performance and suggest support for claims for bridges between TCE and the RBV. Foss and Foss (2005) and Mayer and Salomon (2006) have offered an excellent analytical scheme regarding the influence of firm strategy on the interaction between resources, transactions, and generated competitive advantage. Why firms are heterogeneous and why they pursue different strategies are issues not directly addressed by TCE but central to the RBV; that the value strategizers will realize and appropriate from different combinations of resources depends partly on transaction costs has, however, received little attention in the RBV literature. Our results show that diverging from an industry in patented environmental innovations is positively related with four variables clearly connected to transaction costs, but at the same time, the emerging strategy of divergent technology not only reduces transaction costs but also may create market leadership and allow the extraction of temporary monopoly rents for the development of a different technology (Spencer, 2003).

The most notable limitation here is the exclusive use of patent data to measure innovative performance. The reliability and strength of patent data is the topic of debate (Helm and Kloyer, 2004; Reitzig, 2003), as some scholars argue that firms may rely on secrecy instead of patenting their inventions (Blind et al., 2009; Fosfuri, 2006). However, the rise of the pro-patent era (Ziedonis, 2004) has led organizations to tend to patent practically any invention, even when its relevance is dubious (Hall and Ziedonis, 2001). In addition, a number of scholars advocate the use of patents, as many empirical studies have found a significant positive relationship between patenting and innovation (Grindley and Teece, 1997; Patel and Ward, 2011), which is mirrored by the abundant literature based on patent data.

Another limitation of this work is that we analyze only a single industry. Although firms' motives and tendency to patent are quite stable within an industry (Clarkson and Toh, 2010) and vary widely from one industry to another, which may negatively affect comparability (Cohen, Nelson and Walsh, 2000), future papers may try to overcome these difficulties and extend our work through a cross-sectorial analysis. Finally, the integration of different theoretical approaches may extend our analysis to better explain how external factors influencing the emergence of sustainable businesses (Russo, 2003; Delmas, Russo, and Montes–Sancho, 2007) can also influence the transaction costs of innovations in the different related domains.

Our paper has many potential implications for practitioners. Specifically, it shows that managers should not only seek to increase their firms' numbers of patents to protect the firms' innovative developments, but also should carefully consider the selection and distribution of the technological domains of their patents. In other words, managers might want to pay specific attention not only to what their firms are patenting but also to what technological domains their competitors are mostly patenting in. There is a clear incentive to file patents around nuclear innovations in an industry; however, our results help to show that there is also a robust business case for divergent innovations in certain situations. In a more general view, while managers have traditionally been largely concerned with decisions of buying or making, our results suggest that they might have to devote in the future much more effort to internal and external combinations of resources, particularly in the context of innovative developments.

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Table I. Descriptive statistics and correlations

	Mean	*S.D.*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1. Technological Divergence	0.13	0.10	-									
2. Firm Performance	1.04	0.58	0.18**	-								
3. Age	65.14	39.49	-0.15**	-0.046	-							
4. Country Pollution Level	9.64	3.49	-0.24***	0.14*	0.38***	-						
5. Country Energy production	0.38	0.65	-0.035	0.25***	-0.032	0.39***	-					
6. GDP	1.19	4.19	0.077	0.13*	-0.24***	-0.18**	0.51***	-				
7. Country's Inflation	0.43	2.13	0.23***	0.23***	-0.081	0.029	0.65***	0.53***	-			
8. Technological Intensity	0.045	0.033	-0.106	0.25***	0.13*	0.34***	0.11	-0.18**	0.014	-		
10. Technological Scope	7.43	6.80	-0.057	-0.15*	0.24***	-0.057	-0.16**	-0.096	-0.11	-0.16**	-	
11.Bargaining Power	14.96	2.00	-0.087	-0.21***	0.27***	-0.12	-0.09	-0.030	-0.060	-0.13	0.44***	-
12. Environmental Expertise	0.17	0.23	0.18**	0.024	-0.12	-0.092	-0.19**	-0.11	0.026	-0.12	-0.13*	-0.25***

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Table II. Result of the regression analysis (dependent variable: Technological Divergence)

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*
Age	.0026 (0.149)	.0065 (.0146)	.0047 (.0146)	.0105 (.0130)	.0105 (.0125)
Country Pollution Level	.0128 (0.155)	.0133 (.0160)	.0160 (.0162)	.0113 (.0170)	.0150 (.0157)
Country Energy prod.	-.01290 (0.1170)	-.1674 (.1226)	-.1412 (.1172)	-.2113 (.1206)*	-.2272 (.1138)*
GDP	.0006 (0088)	.0034 (.0086)	.0015 (.0087)	.0078 (.0081)	.0078 (.0078)
Country's Inflation	-.0015 (0051)	-.0013 (.0051)	-.0016 (.0048)	-.0014 (.0048)	-.0008 (.0046)
Technological Intensity		.7217 (.0031)**	.7293 (.3069)**	.9533 (.2811)***	1.108 (.3044)***
Technological Scope			-.0040 (.0020)**	-.0048 (.0019)**	-.0048 (.0019)**
Bargaining Power				.0628 (.0185)***	.0690 (.0166)***
Environmental Expertise					.1279 (.0731)*
R^2 (ΔR^2)	.0930 (-)	.1233 (.0303)	.1575 (.0342)	.1947 (.0372)	.2209 (.0262)

Robust standard errors are in parenthesis.
* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Table III. Result of the regression analysis (dependent variable: one-year lagged Tobin's Q)

	Model 6	*Model 7*	*Model 8*	*Model 9*	*Model 10*	*Model 11*
Age	-.0647 (.0500)	-.0566 (.0623)	-.1244 (.0938)	-.1337 (.0961)	-.1248 (.0960)	-.1180 (.0916)
Country Pollution Level	.0567 (.0520)	.0593 (.0607)	.1086 (.1131)	.1097 (.1152)	.1199 (.1149)	.1306 (.1191)
Country Energy prod.	-.0972 (.5806)	.1210 (.7614)	-.7314 (.9849)	-.5497 (1.090)	-.6419 (1.070)	-.7461 (1.074)
GDP	-.0125 (.0286)	-.0005 (.0346)	-.0427 (.0528)	-.0511 (.0531)	-.0470 (.0541)	-.0423 (.0513)
Country's Inflation	-.0065 (.0136)	-.0016 (.0158)	-.0211 (.0251)	-.0224 (.0255)	-.0206 (.0259)	-.0182 (.0272)
Technological Intensity		.0917 (.0626)	.0826 (.0766)	.0555 (.1016)	.0405 (.1076)	.9270 (.5380)*
Technological Scope			.0005 (.0101)	.0008 (.0100)	.0011 (.0106)	.0039 (.0101)
Bargaining Power				-.1145 (.2566)	-.1308 (.2546)	-.0826 (.2421)
Environmental Expertise					-.1851 (.3056)	-.0233 (.3343)
Technological Divergence						.7987 (.4697)*
R^2 (ΔR^2)	.3553 (-)	.3834 (.0281)	.3904 (.0090)	.3927 (.0023)	.3948 (.0021)	.4071 (.0123)

Robust standard errors are in parenthesis.
* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

CAPÍTULO 4

DO DIFFERENT INNOVATIONS IN THE FIRM AND THE INDUSTRY INCREASE THE NUMBER OF THE FIRM'S PATENTED ENVIRONMENTAL INNOVATIONS?

THE RESOURCE-BASED VIEW VERSUS INSTITUTIONAL PERSPECTIVES.

DO DIFFERENT INNOVATIONS IN THE FIRM AND THE INDUSTRY INCREASE THE NUMBER OF THE FIRM'S PATENTED ENVIRONMENTAL INNOVATIONS? THE RESOURCE-BASED VIEW VERSUS INSTITUTIONAL PERSPECTIVES

Abstract:

This paper proposes that both the resource-based view and institutional theory predict a positive relation between the number of patented environmental innovations and non-environmental innovations held by a firm because they both are subject to the influence of similar factors. However, whereas the resource-based view predicts that the domain differences between the patented environmental innovations owned by a firm and those in the industry will positively affect the firm's patented environmental innovations, the institutional perspective predicts a negative relation for such firms because the differences imply a deficient convergence toward shared interests in the industry. Our results derive from a sample of 5,568 environmental patents from 60 large companies in the electrical components and equipment industry worldwide and show a positive relation between patented environmental and non-environmental innovations in a firm but a negative influence on the firm's patented environmental innovations resulting from the firm's differences with the environmental priorities in the industry.

Keywords: organizations and the natural environment, innovation, environmental patents, resource-based view, institutional theory.

4.1.- INTRODUCTION

Environmental innovations will create or maintain up to 60 million new jobs over the next 20 years (UNEP, 2013) and will likely provide solid competitive advantages for innovative companies that own the rights to such innovations (Forsman, 2013). Although many studies have previously focused on the implications of environmental innovations in firms (e.g. Schiederig, Tietze, and Herstatt, 2012 for a review), recent research has called for more attention to detail with respect to the volume of corporate environmental innovation and its orientation in the context of specific industries (e.g., Aguilera-Caracuel and Ortiz, 2013; Berrone, Fosfuri, Gelabert and Gomez-Mejia, 2013).

The complementary potential of a firm's environmental innovations and other innovations in the firm and in the industry is the source of considerable debate. Although some executives and regulators have claimed in recent years that environmental innovations might divert the resources for more central innovations in firms, other scholars have claimed that environmental and non-environmental innovations may be complementary (Starik, 2013). At the same time, whereas some firms have focused their environmental innovations on certain of the industry's shared fields to avoid wasting resources and to increase their legitimacy, other firms have attempted to find unique environmental fields far from the interests of their competitors in the industry (Marcus, Aragon-Correa, Pinkse, 2011). This paper aims to better understand whether the existence of non-environmental innovations in a firm and the differences between the firm's and the industry's environmental innovations are (positively or negatively) related to the number of such firm's environmental innovations.

The academic literature on organizations and the natural environment has been mostly positive regarding the compatibility between environmental innovations and non-environmental innovations in a company; however, there has also been a differentiated analysis of the generation of environmental and non-environmental corporate innovations (e.g., del Río, Peñasco, and Romero-Jordán, 2013). It is surprising that the previous literature has paid only limited attention to empirically analyzing whether the ad-hoc analyses of internal requirements and external pressures implies that creating environmental innovations and creating non-environmental innovations follow different patterns. Additionally, the different theoretical frameworks of these studies raise conflicting ideas about the corporate advantages of focusing on similar (or different) environmental fields as the rest of the industry. The resource-based view and institutional theory are the two most commonly utilized theoretical views in the literature regarding organizations and the natural environment (Berchicci and King, 2007), and this manuscript will discuss the expectations of each theory regarding corporate environmental innovations.

The natural resource-based view (Hart, 1995) has insisted that a firm's specific internal resources and capabilities are particularly useful in generating unique, preventive, and voluntary environmental actions to reduce firms' environmental impacts. Several studies have shown the positive relations between different forms of corporate environmental innovations and the organizational capabilities of stakeholder management (e.g., Henriques and Sadorsky, 1999; Kassinis and Vafeas, 2006; Rueda-Manzanares, Aragon-Correa, Sharma, 2008), shared vision (e.g., Hart, 1995), or continuous learning (e.g., Lin, 2013; Marcus and Geffen, 1998; Sharma and Vredenburg, 1998), among others. In addition, it remains unclear how the resource-based view might integrate the influence of institutional dimensions into how firms generate innovations.

Institutional scholars expect environmental innovations in the industry to cluster around common fields (Berrone, Fosfuri, Gelabert and Gomez-Mejia, 2013). Llach et al. (2014) showed that institutional support was more important than customer pressures in generating environmental innovations in a sample of small and medium-sized firms. A firm's environmental similarity is defined in this paper as describing the extent to which a firm's environmental patents are related to technological domains in which the environmental patents of industry competitors have an important presence. To summarize, whereas the resource-based view assumes that the unique orientation of a firm's environmental patents is positive, the institutional perspective suggests that the firm will obtain a positive influence from its own innovations when the fields of the firm's environmental innovations are congruent with those of the industry.

This study makes two theoretical contributions to the literature. First, although previous natural-resource-based research has focused on the importance of specific internal resources and capabilities in generating environmental innovations, this paper will show that environmental innovations and non-environmental innovations in a firm are related highlighting the commonalities of internal resources that generate innovations. This hypothesis is also congruent with the institutional expectation that certain external incentives generally influence all the firm's innovations.

Second, this paper demonstrates that companies' heterogeneous endowments of resources and capabilities do not necessarily imply heterogeneous interests in developing environmental innovations in fields unrelated to those typically associated with the industry. Contrary to the expectations of the resource-based view and in support of the institutional paradigm's argument, the results show a positive relation between the number of a firm's environmental patents and the similarities of those patents to other environmental patents in the same industry. These results extend the recent findings of Berrone et al. (2013) and del Río, Peñasco, and Romero-Jordán (2013) regarding the combined influence of institutional and internal factors in developing specific environmental innovations. Taken together, this paper's results provide an opportunity to better understand the compatibility of the two most commonly utilized theoretical perspectives in the environmental innovation literature: the resource-based view and institutional approaches.

This work also has important practical implications. The specific attention paid to the compatibility between non-environmental and environmental innovations will greatly benefit managers' interests and limit the intensity of problems related to environmental progress. Additionally, a more specific understanding of the existence (or lack thereof) of a positive relation between the number of a firm's environmental patents and the similarity of those patents to other patents in the industry will help firms better understand how to select fields that will generate future innovations.

Following this introduction, the paper begins with the theoretical background and hypotheses and then moves in successive sections to the methodology, the results, and a discussion of the results and new research avenues. The methodology includes a sample of 5,568 environmental patents obtained by 60 firms in the electrical components and equipment industry over the 2005-2009 period, along with a selection of variables from different databases.

4.2. THEORETICAL DELIMITATION OF PATENTED ENVIRONMENTAL INNOVATIONS

Innovation has become critical to the survival and development of organizations in a wide variety of industries because it is a key process used to gain and maintain competitive advantages (Brown and Eisenhardt, 2007). Innovation represents new, rare, and valuable sources of knowledge that are linked to greater returns (Ahuja and Katila, 2001). Although the literature offers multiple definitions and classifications of organizational innovation, it often focuses on the concept of innovation as a technological outcome related to a firm's generation of value-added novelty for its products or production (Crossan and Apaydin, 2010). These technical innovations include products, processes, and technologies that are used to make products or provide services (Gopalakrishnan and Damanpour, 1997).

The term “environmental innovation” has a meaning that is almost identical to that of "general innovation," with the additional requirement that environmental innovation generates a lower environmental impact than existing intra- or inter-organizational alternatives, even when the firm’s intentions to reduce its environmental impact might not necessarily be ecological in nature. In short, environmental innovations include any changes by a firm that directly contribute to a reduction in its environmental impact (Bönte and Dienes, 2013, Rennings, 2000). A recent review of the literature on environmental innovation (Schiederig, Tietze, and Herstatt, 2012) found that the delimitations of green, eco, environmental, and sustainable innovation exhibit minor (or no) differences in descriptive precision, and the label of environmental innovation may generally include all these terms.

In some cases, it may be particularly difficult to make a clear distinction between the antecedents (and consequences) of environmental and non-environmental innovations because general innovations frequently include technological progress that affects a firm’s impact on the natural environment. In illustration of this point, Namerof et al. (2004: 961) note that “the European Industrial Research Management Association found that for most companies, nearly half of all R&D projects have a significant environmental and safety content.” Thus, most technological progress typically includes saving fuel, reducing noise, reducing emissions, and/or more efficiently utilizing raw materials; even when environmental motivations may not be the firm’s primary inspiration, the majority of its technological innovations help to reduce environmental impact compared to previous alternatives.

In this context, environmental patents offer an important and objective opportunity to analyze environmental innovation outputs. This opportunity contrasts with the limitations of identifying a firm’s environmental innovations via manager self-evaluation, as is typically done in many previous studies (Berrone, Fosfuri, Gelabert, Gomez-Mejia, 2013). Since the adoption of the Kyoto Protocol in 1997, the number of environmental patents has grown by approximately 20% annually, and that number has increased by more than 30% since the main patent agencies began to provide specific environmental classification codes and to give administrative priority to environmental patents (EPO, 2010). For example, between 2004 and 2009, the number of patents issued for solar and wind power increased annually by 13% and 19%, respectively, which exceed the rates for technologies such as semiconductors and digital communications. In addition, the number of renewable-energy patents granted in the United States has risen from fewer than 200 annually during the 1975-2000 period to more than 1,000 annually by 2009 (Bettencourt, Trancik, Kaur, 2013). The next section of this paper will provide hypotheses regarding the number of patented environmental innovations in a firm.

4.3. HYPOTHESES

This section will first analyze the relation between environmental and non-environmental patented innovations and the congruency of the expectations of the resource-based and institutional perspectives. This section will also analyze the different assumptions emerging from each theoretical view regarding the relation between the number of a firm's patented environmental innovations and the level of similarity between the environmental innovations in the firm and the industry.

4.3.1.- The relation between environmental and non-environmental innovations in a firm: The congruent perspectives of the resource-based and institutional views

Comparing the internal resources and capabilities involved in generating non-environmental and environmental innovations shows a substantial overlap in the two types of innovations. A recent review of the strategic management of organizational innovation (Keupp, Palmie and Gassmann, 2012) has shown that the topic of "resources" plays a major role in the reviewed literature, and almost 50% of the 223 reviewed empirical papers used resource-related independent variables. These resources include, among others, organizational mission (Adams et al., 2006), organizational learning (e.g., Crossan et al., 1999), R&D intensity (Parthasarthy and Hammond, 2002), and/or slack resources (Damanpour, 1991). A comparison of these resources with the factors included in the natural-resource-based view suggests that there is a clear potential for the existence of complementary approaches.

The seminal work of Hart (1995) provides the general framework for the natural-resource-based literature, highlighting the importance of shared vision, continuous learning, and stakeholder management. Since Hart (1995), the empirical literature has thoroughly described the relation between firms' resources and their proactive environmental strategies (e.g., Bönte and Dienes, 2013; Lin, 2013; Marcus and Geffen, 1998; Sharma and Vredenburg, 1998; Sierzchula, Bakker, Maat, and van Wee, 2012). The only potential difference between the suggested endowment of internal resources for environmental and general innovation is that there is a different emphasis on stakeholder management. Nevertheless, even in cases in which the natural resource literature has more clearly highlighted the importance of collaborative approaches with stakeholders to generate environmental innovations (e.g., Rueda-Manzanares, Aragon-Correa, Sharma, 2008; Henriques and Sadorsky, 1999; Kassinis and Vafeas, 2006), this collaboration also appears appropriate for generating non-environmental innovations outside the environmental arena.

Additionally, the dynamic capabilities perspective has extended the analysis of the importance of internal resources in generating general and environmental innovations. The dynamic nature of business activities requires firms to continuously extend their internal resources to innovate and create new competitive advantages (Cockburn, Henderson, and Stern, 2000; Rosenbloom, 2000). Dynamic capabilities consist of a set of specific and identifiable processes that, although idiosyncratic to firms in their details, have significant commonality in the form of best practices across firms, which allows firms to generate new and value-creating strategies (Eisenhardt and Martin, 2000). The literature on general innovation has claimed that dynamic capabilities enable organizational innovation (e.g., Elkins and Keller, 2003). Similarly, Aragon-Correa and Sharma (2003) proposed that a proactive strategy to manage the interface between a business and its natural environment has the dynamic capability to enable an organization to align itself with changes in its general business environment. In this context, our review of the literature suggests that an appropriate endowment of internal resources and capabilities for generating environmental innovations is completely congruent with an appropriate endowment of firm resources to generate innovations that are not related to the environmental implications of the firm's activities.

Notably, the institutional literature has traditionally assumed a similar perspective because external incentives (or lack of incentives) have a global influence on the firm's innovations. Aragon-Correa and Sharma (2003) also proposed that the uncertainty, dynamism, and complexity of a firm's general environment moderate the relation between a firm's resources and its environmental proactivity. In fact, the existence of internal resources with the potential to generate any type of innovation in the firm and external institutional influences may generate synergies that affect both environmental and non-environmental innovations in a firm.

Thus, it is possible to expect that generating environmental patents does not hinder a firm from obtaining other patents and is also positively related to those other patents because all such patents share and reinforce a common pool of basic resources and capabilities and are also related by a similar general external trend toward innovative approaches. Therefore, our first hypothesis is the following:

H1: The generation of a firm's environmental patents is positively related to its generation of non-environmental patents.

4.3.2.- The differences between a firm and its industry: The competing resource-based and institutional perspectives

This section analyzes the competing logic of the resource-based and institutional perspectives to determine whether differences between the fields of the firm's and the industry's patented environmental innovations have a positive or negative relation with the number of the firm's patented environmental innovations. We will first discuss the resource-based logic and propose a subsequent hypothesis. We will later discuss the institutional logic and its hypothesis.

The resource-based view (e.g., Barney, 1991; Dierickx and Cool, 1989; Peteraf, 1993) explicitly addresses the importance of a firm's unique orientation and firm-level diversity. Consistent with the seminal theoretical approach of Penrose (1959), the resource-based view posits that companies are idiosyncratic and heterogeneous bundles of assets and resources and that each firm's possession of a unique set of scarce, valuable, and difficult-to-imitate resources explains intra-industry heterogeneity (Barney, 1991). Strategic management scholars have focused on companies' differentiated strategic commitments to their businesses and the resulting variety of strategic positions within their industries (Noda and Collins, 2001).

A variety of studies has illustrated the specific orientation of different firms' environmental innovations. An analysis of patent data related to low-emissions vehicles has shown that all automobile manufacturers have progressively adopted a position in that field; however, the results also showed differences in both the balance of technologies and the patterns of specialization adopted by different automobile manufacturers (Oltra and Saint Jean, 2009). Similarly, Sierzchula, Bakker, Maat, and van Wee (2012) analyzed 884 alternative fuel vehicles from 1991 to 2011 and concluded that electric vehicle technology was dominant but that auto manufacturers were working on a variety of technological solutions.

The specific resources in different firms operating in an industry may generate relevant differences, not only in terms of the orientation of the firms' innovative outputs but also in the quantity of the innovations that are thereby generated. In this context, the previous literature has shown that the existence of slack resources (assuming that they are not excessive) is positive, not only in terms of the number of innovations but also in terms of greater experimentation (Nohria and Gulati, 1996). Similarly, unabsorbed resources, both generic and unique, result in higher exploration when a perceived environmental threat is high (Voss, Sirdeshmukh, and Voss, 2008). Thus, those firms with appropriate resources are more likely to be oriented to generate not only unique and different innovations compared with the applicable industry but also a higher number of innovations. In this context, differences between the fields of environmental innovations in a firm and in the industry are positive for the firm because they generate a virtuous cycle of more company environmental innovations as a result of the competitive advantage caused by the unique situation of the firm in the industry. Thus, our next hypothesis is the following:

H2a: A firm's generation of environmental patents is positively related to the difference between the technological fields of that firm's environmental patents and the fields of its industry's environmental patents.

However, institutional pressures push the emergence of certain common fields of patented environmental innovations in the industry. The growing importance of multiple environmental governmental actions is a good example of the public interest in specific fields and topics related to companies' environmental innovations (Marcus, Aragon-Correa, and Pinkse, 2011). In addition, there are other market forces that influence the orientation of firms' environmental innovations, such as suppliers, employees, shareholders, and customers (e.g. Anttonen et al., 2013; Hoffman, 1999; King and Lenox, 2000).

Green suppliers may decide to sever relations with highly polluting organizations because continuing to do business with such organizations may affect their own reputations

(Henriques and Sadorsky, 1999). Simultaneously, specific technological developments by leading suppliers influence the interests and environmental opportunities of other firms in the industry. Customers and consumers pay closer attention to topics of particular interest to them and may influence a firms' orientation toward environmental products and services (Anttonen, Halme, Houtbeckers, Nurkka, 2013). Finally, the media's coverage of specific issues can easily expose the public to environmentally irresponsible actions undertaken by organizations in specific fields (Buysse and Verbeke, 2003).

These external pressures have become more important over the most recent two decades and have influenced the emergence of corporate environmental innovations and its concentration in certain fields. The importance of similar institutional contexts suggests that firms will typically follow similar environmental patterns as followed by their respective industries (King and Lenox, 2000). This tendency implies that the differences between a firm and its industry reflect atypical situations, which are likely to be more related to being a new firm in an industry, adaptation problems, or immaturity in the environmental arena than to being the leader in a new strategic priority.

Thus, although the resource-based view suggests that the existence of appropriate internal resources or capabilities positively influences the number and differentiated orientation of a firm's environment-related innovative outputs, the institutional literature emphasizes that external pressures in the industry will push a firm's environmental innovations toward common fields and that the most advanced firms will most likely be paradigmatic. In this context, the new hypothesis drawing on the institutional arguments that competes with the previous hypothesis drawn on the resource-based view is the following:

H2b: A firm's generation of environmental patents is negatively related to the difference between the technological fields of that firm's environmental patents and those of its industry's environmental patents.

4.4.- METHOD

4.4.1.- Sampling and data collection

Several studies in the innovation literature have utilized patent data because of their comparability, availability, and suitability for longitudinal analysis (Reitzig, 2003; Petruzzelli, Dangelico, Rotolo and Albino, 2011). This study employs patent data from the European Patent Office (EPO) database. The EPO is one of the three largest patent offices in the world (along with the US and Japanese offices) and provides inventors with a uniform application procedure to file and protect patents in up to 40 European countries. Additionally, the EPO database recently integrated a specific classification code for patents with environmental content, which includes over 17,000 patents to date (EPO, 2010) and is particularly useful for the purposes of this research because it allows for the direct selection of environmental patents instead of using a more qualitative, abstract-based analysis to identify them (e.g., Lee, Veloso and Hounshell, 2011). Because the same patent claim might generate different patents in different regional offices, the analysis used only the family representative for each application to avoid that bias.

The sample focused on the "Electrical Components and Equipment" sector, number 6190 in the COMPUSTAT database, for two main reasons. First, this sector has recently faced substantial environmental challenges, such as intensive use of raw materials and the generation of large amounts of electronic waste, which are driving firms to invest in technologies aimed at increasing the efficiency of energy and material consumption (e.g., European Commission, 2012). Second, this industry is characterized by intense patenting activity (e.g., Cohen, Nelson, and Walsh, 2000; Grindley and Teece, 1997), which suggests that firms in this industry rely more on patents to protect their inventions than on non-legal protection mechanisms (such as complex interdependences or secrecy), which reinforces the suitability of patent data for the present study.

The sample included companies that obtained two or more environmental patented innovations during the period of analysis, i.e., 2005-2009. This criterion is consistent for assessing the organizational approach because “one could argue that obtaining a first patent in a new area could arise because of luck [whereas] a second patent in a new area is prime evidence of the initiation of a pattern of investment in that area, indicates a firm-level commitment to that area and is a much stronger indicator of a deliberate choice to focus there than a first patent" (McGrath and Nerkar, 2004:6-7). Additionally, given that COMPUSTAT did not contain information for certain companies, the final sample resulted in unbalanced panel data on 5,568 environmental patents from 60 companies that generated 191 observations from 2005 through 2009.

4.4.2.- Measures

Environmental dissimilarity. This variable measures the difference between the technological fields of a firm’s environmental patents and those of its industry’s environmental patents as a whole. Utilizing patent classes to account for different technological fields is congruent with previous empirical research (e.g., Clarkson and Toh, 2010; Lerner, 1994). The EPO database provides technological classes of patents using the EPO’s European Classification System (ECLA classes). We measured environmental dissimilarity compared with the industry according to the following formula:

$$Environmental\ dissimilarity = \sum_{i=1}^{n} \left| \frac{NFEi}{TotalNFE} - \frac{NIEi}{TotalNIE} \right| \times \frac{NIEi}{TotalNIE},$$

where NFEi is the number of environmental patents related to the field i, measured at the firm level, and NIEi is the number of environmental patents related to the field i, measured at the industry level.

The value of environmental dissimilarity is 0 when a firm's environmental patents are in the same technological fields and proportion as its sector's average. Therefore, a value of 0 indicates that a firm's environmental patent portfolio is identical to its sector's average.

Number of environmental patents. The count measure of patents is a traditional proxy for innovative output in a company (e.g., Hagedoorn and Cloodt, 2003). Additionally, the EPO classification system provides specific information to sort firms' patents into environmental and non-environmental classes, which provides a more reliable measure than abstract-based searches (e.g., Lee, Veloso and Hounshell, 2011).

Number of non-environmental patents. The aforementioned methodology is also useful in accounting for an organization's patents that do not have explicit environmental content.

Control variables. The analysis includes five variables to control for the potential effects of two internal and three institutional variables that might affect the final number of patented environmental innovations.

Firm age. The analysis considers the year that the firm was founded according to firm age information contained in the Bloomberg and JP Morgan databases. In this regard, firms may have more visibility and be more concerned about their corporate image and reputation (Jensen and Roy, 2008).

Firm size. This paper uses the natural log of a firm's net sales to measure firm size. Because firm size is positively associated with a higher level of resources (Ariño et al., 2008; Damanpour, 1991) and more environmental innovations (Triguero, Moreno-Mondéjar, and Davia, 2014), larger organizations might obtain more environmental patents.

Country's pollution level. This variable represented the CO_2 emissions for the firms' country of location in metric tons per capita, according to the World Bank database. Higher levels of CO_2 emissions mean that an organization is headquartered in a highly polluting country. Higher polluting countries may be less concerned about the natural environment, which would discourage environmental innovations in companies (Aragon-Correa and Sharma, 2003).

Country's public spending on education. This variable was drawn from the World Bank database and represented government monetary resources allocated to education, measured as the percentage of educational spending as a portion of total government expenditures. Public spending on education typically reflects local citizens' interest in social and environmental issues (Gottlieb, Vigoda-Gadot, Haim, Kissinger, 2012).

4.5.- RESULTS

STATA software was utilized to generate the results. The dependent variable was the number of environmental patents obtained by the organization. Due to the longitudinal nature of the data, we ran the Hausman test (Hausman, 1978), which endorses the use of fixed effects for the regression. Fixed-effects models are more suitable than random-effects models in this context because the former eliminate the unobservable variables of conventional OLS regression estimates (Ernst, 2001), which results in a more reliable estimation. Additionally, utilizing robust standard errors avoids the problems of serial correlation and heteroskedasticity, and the generation of year-specific dummy variables provides a control for the variability of the intercept.

Table 1 includes the descriptive statistics for all the variables. The correlations between the variables do not suggest any potential for serious multicollinearity in the regression analysis, and the VIF factors are completely acceptable. Table 2 presents the results of the regressions. Model 1 in Table 2 presents the base model and only includes the control variables when the number of firm's environmental patents is the dependent variable. For this regression, Model 2 also includes the first hypothesized effect variable, i.e., the number of non-environmental patents. Finally, Model 3 also includes the second hypothesized effect variable, i.e., the differences between the environmental patents in the firm and those in the industry. The R-square statistics indicate that each additional variable improves the model fit for each regression.

Hypothesis H1 predicts a positive relation between the number of a firm's non-environmental patents and the number of its environmental patents. The coefficient for non-environmental patents is positive and statistically significant ($p<0.01$) in Model 2, which supports Hypothesis H1. With respect to the relation between the number of a firm's environmental patents and that firm's environmental dissimilarity, the coefficient is negative and statistically significant ($p <0.001$) in Model 3, which supports Hypothesis H2b. Thus, these results show that a high number of environmental patents held by a firm is negatively related to the differences between the fields addressed by that firm's environmental patents and the fields addressed by the environmental patents held by other firms in the same industry. The coefficients of the control variables are not statistically significant for the sampled firms, and there is no consistent pattern for the dummy variables for the different years.

4.6.- DISCUSSION, IMPLICATIONS, AND FUTURE RESEARCH

Empirical papers adopting the natural-resource-based perspective (Hart, 1995) have shown the existence of a positive relation between different firm resources and capabilities and a firm's environmental innovations. The institutional papers have also provided evidence regarding the influence of external pressures. However, the analytical emphasis on the differentiated analysis of internal requirements and external pressures for environmental innovations also raises potential concerns about the possibility of conflicts between the requirements for environmental innovations and other innovations in the firm. The popular literature and anecdotal evidence have increased these concerns by describing environmental innovations as distracting from the central competitive progress of businesses.

The first hypothesis in this paper proposes the existence of a positive relation between the number of a firm's patented environmental innovations and its patented non-environmental innovations. The results from the sampled firms support this hypothesis and extend previous findings by showing that the existence of environmental innovations is positively related to other types of innovations. Moreover, this positive relation suggests that environmental innovations might generate synergies with a firm's general innovative capability, as originally stated by the natural-resource-based view (Hart, 1995). However, our results also indicate the importance of reconsidering the focus of future resource-based analyses of firms' environmental innovations.

The theoretical analysis of the relatively minor differences between the resources necessary for environmental and non-environmental innovations in a firm and the positive relation between the generation of environmental patents and other corporate patents in the sampled firms suggest that identifying the resources necessary for environmental innovations will require less effort in the future, particularly considering the abundance of literature addressing general innovations (Crossan and Apaydin, 2010). However, more research is required to clarify how firms may reinforce the generated synergies among their different innovations and, in particular, how the reduction of firms' environmental impacts might reinforce innovations that are not related to the natural environment.

It is also relevant that the results showing the positive relation between environmental innovations and other innovations in a firm are congruent with institutional theory. The empirical literature on the connections between the natural environment and institutional pressures in industry (Hoffmann, 1999) has primarily noted the specific institutional forces that influence the environmental evolution of industries. After nearly two decades, society's environmental interests have likely matured; as a result, firms' environmental innovations might now be more closely related to general external incentives to generate innovation than they are to specific environmental factors. In this sense, the structural nature of institutional pressures regarding the natural environment might only influence the final orientation of environmental efforts rather than the existence of environmental progress. More research will be required to confirm these preliminary ideas on the influence of institutional pressures.

Hypotheses H2a and H2b offer competing views regarding the potential relation between the number of a firm's environmental innovations and the similarities (or differences) between the fields of the firm's environmental innovations and those of other firms in the same industry. The results show a positive relation between the number of a firm's patented environmental innovations and the level of their similarities to the fields of environmental innovations in that industry. These results thus support Hypothesis 2b, which draws on the institutional perspective.

These findings reinforce and extend the main conclusions of the recent research of Berrone et al. (2013) and of del Río, Peñasco, and Romero-Jordán (2013) regarding the importance of institutional factors in fostering a firm's environmental innovations and their convergence in specific fields within an industry. The rationale for these results indirectly highlights the importance of common environmental regulations (e.g., Marcus, Aragon-Correa, Pinkse, 2011; Starik, 2013), the institutional conditions in an industry (e.g., Hoffman, 1999; King and Lenox, 2000; Llach et al., 2014), and demand (Anttonen et al., 2013).

The results do not support the possible influence of the heterogeneous endowment of resources on the selection of different fields for patented environmental innovations. However, these findings are consistent with previous research in the automotive industry and extend findings that show that environmental technologies simultaneously address common core fields in that industry, whereas they may be different in each firm (Oltra and Saint Jean, 2009; Sierzchula, Bakker, Maat, van Wee, 2012). Even when a specific corporate resource endowment and strategic interest might generate different technical solutions, the technological fields in need of technical solutions are similar within a given industry. The corporate leaders in generating environmental patents also converge on the most popular fields in the sampled industry.

Finally, this work is original because it classifies patented environmental innovations by their similarities to other innovations in the same industry, and it answers the call of Schiederig, Tietze, and Herstatt (2012) to provide further research "in the classification of green innovations." This accomplishment is particularly important when the descriptive literature is providing broad evidence regarding the exponential growth of environmental patents each year.

The two control variables related to an organization's general characteristics (size and age) do not show a substantial influence on the sampled environment-related patented innovations. Although previous studies have suggested that size might be a relevant restriction for generating patents, the results confirm the findings of Camisón-Zornoza et al. (2004) regarding the lack of a consistent relation between size and innovation. The relatively large size of the firms in the sample allows them to generate environmental and general patents, but size is not positively related to the number of patents generated by the sampled firms. Similarly, the results also show that small firms do not obtain patents in fields other than those in which the rest of the industry is active (as has been suggested by some previous patent literature; e.g., Ariño et al., 2008). With respect to age, the results show that environmental reputation related to environmental patents might not be particularly attractive for the older firms in the sample. Nonetheless, because the vast majority of the sampled firms' patented innovations are located in a few similar countries (i.e., the USA, Japan, Korea, the UK, and Germany), the institutional control variables may not be able to reflect the potential influence of the countries in the analysis.

This study reinforces the interest in future research on the potential path-dependent and iterative nature of the innovation process; therefore, an appropriate model should adopt an evolutionary approach and allow for equifinality (Hobday, 2005). Similarly, it will be particularly useful to better understand how to create and dynamically adapt resources for integrating more environmental dimensions into a firm's general innovations and to answer the more general question of how firms can develop resources and managerial motivation for innovation (Teece et al., 1997). In this context, it will be useful for future research to analyze both the relative impact of internal and external factors on changes to the innovation process over time as new organizations form and the importance of integrating stakeholder interests into the different dimensions of eco-innovations.

It is important that sufficient steps be taken to critically identify the two main limitations of the information provided. First, although patent-based measures of innovative performance have been widely used in previous studies (e.g., Crossan and Apaydin, 2010; Hagedoorn and Cloodt, 2003), utilizing patent data has generated a longstanding debate over the reliability of such data and the strength of such data as a valid indicator (Reitzig, 2003), e.g. the administrative innovations are usually omitted from analyses utilizing patent data. Second, although firms' motives and their tendency to patent are stable within their industries (Clarkson and Toh, 2010), patenting behavior may vary widely from one industry to another and negatively affect the comparability of the results (Cohen, Nelson and Walsh, 2000). Future papers might attempt to extend our work through cross-sectional analyses.

This paper has many potential implications for practitioners. Specifically, the results show that managers should not only seek to increase the number of patents to protect their firms' innovative developments but also consider the selection and distribution of the technological fields of their patents. In other words, managers should pay specific attention not only to what their firms are patenting but also to the main technological domains in which their competitors are patenting and act accordingly.

The positive relation between patented environmental innovations and other innovations in a firm is also particularly attractive to practitioners. Although environmental motivations might fuel a firm's urgency related to certain innovations, there are multiple innovative outcomes that are possible. Simultaneously, even when environmental motivations are not the primary driver of managers' efforts to generate corporate innovations, a firm's general innovations might generate a positive and important effect in terms of reducing its environmental impact. Finally, our results suggest that managers should be much more active in the future in generating positive synergies among different types of innovations and understanding the interactions between internal and external factors that have the potential to influence firm innovations.

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Table 1. Descriptive statistics and correlations

	Mean	S.D.	1	2	3	4	5	6	7
1. Number of environmental patents	28.60	54.73	-						
2. Number of non-environmental patents	870.88	1885.9	0.78***	-					
3. Environmental dissimilarity	0.155	0.106	-0.10	-0.21***	-				
4. Firm age	56.07	38.96	0.12*	0.09	-0.18***	-			
5. Firm size	13.84	2.23	0.36***	0.34***	-0.20***	0.40***	-		
6. Country's pollution level	10.41	4.43	-0.09	-0.08	-0.07	0.08	-0.17***	-	
7. Country's public spending on education	12.04	3.16	0.08	0.02	0.20***	-0.22***	-0.11*	0.15**	-

* $p < 0.10$; ** $p < 0.05$; and *** $p < 0.01$

Table 2. Results of the regression analysis

	Model 1	Model 2	Model 3
Firm age	0.1417 (2.2456)	0.8308 (2.0808)	1.0704 (2.029)
Firm size	4.2405 (6.0169)	2.5721 (5.9110)	3.2680 (5.7730)
Country's pollution level	-4.4855 (5.5751)	-3.0843 (5.3020)	-2.6428 (5.1054)
Country's public spending on education	3.8170 (6.1679)	5.0152 (6.3390)	3.6293 (6.3408)
Number of non-environmental patents		0.0038 (0.0016)**	0.0031 (0.0017)*
Environmental dissimilarity			-40.553 (19.816)**
R^2 (ΔR^2)	.0718 (-)	.0886 (.0168)	.1189 (.0303)

Dependent variable: Number of environmental patents
Robust standard errors are in parentheses.
* $p < 0.10$; ** $p < 0.05$; and *** $p < 0.01$

CAPÍTULO 5

THE INFLUENCE OF THE DOMESTIC POLICY-NETWORK STYLE ON THE PATENTED ENVIRONMENTAL INNOVATIONS IN DIFFERENT COUNTRIES: A NEO-INSTITUTIONAL PERSPECTIVE.

THE INFLUENCE OF THE DOMESTIC POLICY-NETWORK STYLE ON THE PATENTED ENVIRONMENTAL INNOVATIONS IN DIFFERENT COUNTRIES: A NEO-INSTITUTIONAL PERSPECTIVE.

Abstract:

Increasing awareness over sustainability issues in developed countries have resulted in a worldwide rise of the number of environmental innovations (i.e. those innovations aimed to reduce businesses impact over the environment) to unprecedented levels. However, whereas this tendency is somehow uniform among developed countries, the impact of environmental innovations is far from homogeneous, hence being affected by the policy network style of these countries. On the one hand, pluralistic countries (i.e. those characterized by undetermined and clashing interest groups) lack the necessary stability to foster environmental innovations of higher impact, whereas neo-corporatist countries (i.e. those characterized by cooperative and limited interest groups) confer a more stable policy system that facilitates a major impact of environmental innovations. Our analysis from a longitudinal analysis of 1,972,400 patents from the US, Japan, Germany and the UK during the period 1976-2003 confirms our predictions.

Keywords: innovation, environmental patents, neo-institutional theory, institutional theory, pluralistic, neo-corporatist.

5.1.- INTRODUCTION

The number of environmental patented technologies have increased by 20% yearly since 1997 and more than 30% during the last few years (Bennet, 2010), and the global market for sustainable technologies is expected to reach $315 billion by 2018 (Day and Schoemaker, 2011). Even after this dramatic progress, it is still urgent that the countries provide the appropriate context to encourage firms' sustained future environmental progresses in order to face the problems that Earth has (Porter and Van der Linde, 1995). In this context, it is surprising that our knowledge about the domestic conditions influencing the development and impact of environmental innovations is still very limited.

Neo-institutional theory is one of the main theoretical perspectives to understand organizational behavior as influenced by other organizations and wider social forces—especially broader cultural rules and beliefs (Schmitter, 1974). In this context, the influence of the policy network styles has been one of the variables raising special academic and popular controversy (Streeck and Kenworthy, 2005). On one hand, countries with pluralistic policy networks are characterized for having a large number of interest groups (e.g. lobbies) that compete against each other (Scruggs, 1999; Streeck and Kenworthy, 2005; Williamson, 1989). This open, dynamic, and relevant competition has been traditionally delimitated as a positive influence for the firms' innovation in developed capitalistic countries. On the other hand, neo-corporatist systems are characterized for having a higher cooperative policymaking that prioritize social protection (Scruggs, 1999; Streeck and Kenworthy, 2005), what it is normally assumed a more suitable atmosphere for developing environmental innovations contributing to the general progresses.

We propose that whereas the increasing proportion of environmental patents may reflect a similar interest on environmental progresses among developed countries, the different policy network styles influence the final impact of the generated environmental innovations. Given that environmental innovations pose uncertain, risky investments (eg. Brewer, 2005; Kolk and Pinkse, 2008), they may need stable policies in order to develop their potential, i.e. acquire a higher impact. In this regard, countries with pluralistic policy networks are characterized for having a large number of interest groups that compete against each other (Scruggs, 1999; Streeck and Kenworthy, 2005; Williamson, 1989), what may hinder the necessary stability for generating environmental innovations of higher impact. However, neo-corporatist systems are characterized for having a higher cooperative policymaking that prioritize environmental and social protection (Scruggs, 1999; Streeck and Kenworthy, 2005), what may create a more suitable atmosphere for developing environmental innovations of higher impact.

This study makes several important contributions to the literature. First, we reinforce and extend the emerging body of literature regarding sustainability innovations (e.g. Berrone, Fosfuri, Gelabert, and Gomez–Mejia, 2013), and we do so by analyzing patents, i.e. a more objective measure than survey questionnaires (e.g., Anton, Deltas, and Khanna, 2004; Christmann, 2000), which tend to give a biased response aimed to create a sustainable corporate image. And second, we contribute to the neo institutional theory by examining the effects of different policy network styles over the development of environmental innovations, even when all the countries are developed. We conduct our analysis by examining the totality of patents issued in the United States

Patent and Trademark Office (USPTO) during the period 1976-2003 by the US, UK, Japan and Germany. Thus, we consider the greater economies of America, Asia[3] and Europe, what is in line with other studies that aim to take a greater picture of sustainability issues (e.g. Lanjouw and Mody, 1996).

Following this introduction, the paper begins with the theoretical background and hypotheses and then moves in successive sections to the methodology, the results, and a discussion of the results and new research avenues. The methodology includes a sample of 1,972,400 patents from the US, Japan, Germany and the UK during the period 1976-2003, along with a selection of variables from different databases.

5.2.- THEORETICAL BACKGROUND AND HYPOTHESES

5.2.1.- The policy network style in the context of neo-institutional theory

Exploring cross-country institutional diversity has proven to be a fruitful way to better understanding the beneficial/detrimental effects of national institutions over many relevant issues (e.g. Schmitter, 1974). In this regard, we employ neo-institutional theory for understanding why environmental innovations have different impact across developed countries. More specifically, we focus our attention on the policy network style, i.e. the interactions between the government and the system of interest representation (e.g. March and Olsen, 1989; Schmitter, 1974), which is compounded by labor unions, businesses, activists, and other groups that aim to influence policy decisions. Policy network style is classified into two broad categories, pluralistic and corporatist systems (Katzestein, 1994; Murtha and Lenway, 1994; Schmitter, 1974).

[3] Although China has recently raised as the second worldwide economy, during our period of analysis its GDP was consistently lower than Japan's (World Bank).

Pluralistic systems are defined as those organized "into an unspecified number of multiple, voluntary, competitive, non-hierarchically ordered [...] categories", (Schmitter, 1974: 96). Pluralistic countries like the US and the UK do not have a few and dominant interest groups, but many fragmented advocators with different and conflicting interests that create very fragile coalitions for their own goals (Jepperson, 2002; Streeck and Kenworthy, 2005), an approach that results on decentralized and weaker policymakers than in corporatist countries (Schmitter, 1974; Streeck and Kenworthy, 2005). These changing coalitions add uncertainty over already uncertain investments, such as the environmental innovations. Without an stable, long-term regulation over polluting activities, companies' environmental innovations may not reach their full potential, hence resulting in low-impact

Corporatist systems are are those characterized by a "limited number of singular, compulsory, noncompetitive, hierarchically ordered and functionally differentiated categories" Schmitter (1974:93-4). Within corporatist systems, some scholars differentiate between state-corporatist and neo-corporatist systems (e.g. Streeck and Kenworthy, 2005), being the former more frequent in authoritarian regimes and the latter more frequent in northern European countries (e.g. Germany, Austria, Norway, Sweden) and eastern Asian democracies (e.g. Japan and South Korea) (Streeck and Kenworthy, 2005; Kim, 2008). Neo-corporatist systems combine a strong and stable policymaking corporatism with an increased concern over social and environmental issues (Schmitter, 1974; Scruggs, 1999; Streeck and Kenworthy, 2005), what may be more favorable toward further development of environmental innovations.

5.2.2.- The influence of the domestic development rate on the homogeneous increase of the proportion of environmental innovations.

During the last few decades, consumers, organizations and policymakers have increased their interest over the achievement of more sustainable practices. This interest may be spur by a proactive strategy that considers sustainability as a source of lasting competitive advantage (e.g. Aragón-Correa, 1998; Aragón-Correa and Sharma, 2003), or because of pressure groups such as media, taxpayers, shareholders and activists (Arora and Cason 1995; Arora and Cason 1996; Henriques and Sadorsky 1996; Khanna and Damon 1999; Khanna and Anton 2002; Sharma and Henriques 2005) (Hoffmann, 1999). Either way, concern about sustainability has prompted as a key issue that is present in the national political agendas For instance, China -a traditional large pollutant country- has recently released a national program aimed to develop a market for cars that run on renewable energy (Techniasia, 2015). In this regard, China has set a goal of 5 million of "green cars"(climate-friendly cars) by the year 2020, and for that purpose it is giving out fiscal incentives toward companies that invest in environmental R&D. Likewise, the European Commission established in 2003 that 65% of electronic waste must be recycled or re-utilized, including the replacement of heavy metals for less contaminant ones (European Commission, 2012), an approach that is not reachable with current polluting technologies. In some cases, governments go further and make specific agreements with contaminant companies, as in the case of Ash Grove Cement Company, an US firm that was fined by $2.5 million and agreed on investing $30 million in pollution control technologies (EPA, 2013). In addition to these innovation-driven measures, governments are also making use of larger sanctions to deter unsustainable practices. While Japan was the first country in the world to apply criminal laws toward pollutant organizations that endanger human health (Kondrat, 2000), other countries like the US have increased the quantity of their penalties toward these companies. For instance, after the Gulf of Mexico oil spill made by BP the US government fined the petroleum firm to $13.7 billion for violating the Clean Water Act (Reuters, 2015). Likewise, American Honda Motor Inc. spent $267 million to settle allegations and was fined by $12.6 million for the sale of vehicles with disabled emission control diagnostic system (EPA, 2014). In the same line, in 2012 Germany established a €2.7 million ($3.7 million) fine to air craft operators that did not complied with the European Union emission-trading rules (ETS) (Bloomberg, 2014).

Not only governments exert an increasing interest toward sustainability, but suppliers, shareholders, employees, customers, etc. (Barczak, 2012; Paladino, 2008) also demand firms to achieve more sustainable practices all over the world. For instance, the Coalition for Environmentally Responsible Economies (CERES), an nongovernmental organization, requests multinationals like Nike to disclose information about their environmental practices in both developed and developing countries (Reid and Toffel, 2009

This growing concern is resulting into a sharp increase of environmental innovations among developed countries. Just in the United States, the number of environmental patents grew from 200 yearly during the period 1975-2000 to more than 1,000 in 2009 (Bettencourt, Trancik, and Kaur, 2013). Likewise, in Japan environmental patents grew from 150 in 1975 to more than 600 in 2001 (Johnstone, Haščič, Poirier, Hemar, and Michel, 2012). Also, the European Patent Office (EPO) reported that during the last decades the number of environmental patents in developed countries are steadily increasing by more than 20% yearly (EPO, 2010).

Since developed countries share a common interest toward environmental innovations, these increases may be similar among such developed countries. Therefore, the proportion of environmental innovations over all innovations may be homogeneous among developed countries.

In other words, the growing importance of environmental innovation is not an issue of a single country, but developed countries, so that their figures may be very similar.

Therefore, we hypothesize the following:

H1: The proportion of environmental innovations over all innovations is similar among developed countries

5.3.2.- Policy network style: pluralist vs. neo-corporatist systems

Despite this growing tendency toward environmental innovations among developed countries, the effective implementation of such innovations is far from homogeneous, as countries pose different institutional profiles that play a key role in the further development of environmental innovations. The idiosyncratic characteristic of these innovations makes neo-corporatist systems more favorable to environmental innovation than pluralistic systems for several reasons. First, environmental technologies may represent significant sunk costs. For instance, the search of alternative technologies aimed to reducing pollution requires large investments and does not guarantee the discovery of any greener technology (Markman, Espina, and Phan, 2004), what may have hamper firms' profitability. Likewise, the solicitation of environmental certifications such as EMAS -the European Environmental Management Standard- and the ISO 14001 -the international environmental standard- may imply significant changes in organizational production and management systems whether the firm decides to implement environmentally responsible practices or not (Delmas, 2002).

In addition to this, environmental technologies are surrounded by greater levels of uncertainty than non-environmental ones (eg. Brewer, 2005). Environmental technologies are relatively nascent (i.e. their development have started much later than well-known polluting technologies), so if firms lack a stable regulation system that fosters the development of green technologies over a long period of time they may opt for investing in technologies that have been already proved to be profitable, albeit they have detrimental effects over the environment (Kolk and Pinkse, 2008. In this regard, pluralistic systems are characterized by having a policy system in which a wide variety of actors continuously compete against each other to influence government decisions. Hence, in pluralistic countries like the US and the UK, organizations may overcome this policy instability through the development of technologies that are profitable in the short run. By contrast, neo-corporatist countries regulate around a limited number of actors that act more cooperatively (Schmitter, 1974), hence building a better atmosphere for environmental innovations. For instance, the Japanese car manufacturer Toyota took advantage of that regulatory system for developing and commercializing the hybrid-engine technology, a pioneer approach that reported Toyota higher rents than their competitors and that allowed it to keep as the world leader in the industry (Spencer, 2003)

Another reason why environmental innovations are more likely to have a higher impact (i.e. value) in neo-corporatist systems over pluralistic systems is that environmental innovations generate a societal benefit that cannot be completely captured by organizations. While some environmental scandals as the BP oil spill in the Gulf of Mexico and the sold of bottled mineral water with benzene (a highly toxic component) by Perrier can be easily tracked and usually punished, the positive effects of environmental innovations is more porous. These porous, positive externalities (Porter and Van der Linde, 1995) like lower levels of carbon emissions, cleaner water, higher air quality, etc. are likely to be more valued by neo-corporative systems as they "strive for collective benefits and social consensus in addition to advocating their own narrow interests" (Rivera, 2010:59). On the other hand, pluralistic countries like the US and the UK have a less cooperative, more individualistic perspective, hence allocating their resources toward complying to environmental regulation instead of taking a proactive approach.

Therefore, we propose the following:

H2: In neo-corporatist countries environmental innovations have higher impact than in pluralist countries.

5.4.- METHOD

5.4.1.- Sampling and data collection

Previous empirical studies in the innovation literature have encouraged the use of patent data because of their availability, comparability and suitability for longitudinal analysis (Petruzzelli, Dangelico, Rotolo and Albino, 2011; Popp, 2003; Reitzig, 2003). This paper uses patent data from the National Bureau of Economic Research's (NBER) database, that contains all patents granted in the US between 1976 and 2006 by the U.S. Patent and Trademark Office (USPTO). This database includes for each patent, information about its application date, granted date, the country to which it belongs, and the number of citations received.

Additionally, in December 2009 the USPTO launched the *Green Technology Pilot Program*, which gave priority to environmental patents through allowing them an accelerated review process, and classified patents into environmental and non-environmental ones according to a series of specific classification codes (USPTO, 2009. Hence, we employ this classification scheme instead of a more qualitative, abstract-based keyword search that could result in a less accurate classification (e.g., Lee, Veloso and Hounshell, 2011). As Marin (2014: 307) states, focusing on classification codes "is likely to underestimate the number of environmental patents, thus giving rise to more conservative estimates".

For our analysis we selected all granted patents from 1976 to 2003 from US, Japan, Germany and the UK. We chose these countries because the US, Japan and Germany represent the biggest economies in their continent, thus their policy strategies may exert a higher impact worldwide. Additionally, we consider the UK for its historical economic and cultural linkages to the US, what allows us to group them as pluralistic countries and compare them to neo-corporatist countries. This sample resulted in a total number of 1,972,400 patents, what accounts for the 85.1% of the total number of patents contained in the USPTO database in our period of analysis.

5.4.2.- Measures

5.4.2.1-. Dependent variables

*Proportion of environmental patents over all patents.*This variable measures, for each country, the proportion of environmental patents out of all patents. Since we are employing the USPTO there is a strong bias toward US patents (Hall, Jaffe and Trajtenberg, 2001), hence the US has higher number of patents, both environmental and non-environmental ones. In order to avoid this bias we use both the number of total patents and environmental patents at country level.

Impact of environmental patents. This variable measures, for each country, how the proportion of environmental patents over total patents varies when considering only breakthrough patents, thus:

$$Value\ of\ Environmental\ patents = \frac{\%\ breakthrough\ env.patents - \%\ env.patents}{\%\ environmental\ patents}$$

where the percentage of breakthrough environmental patents contains those environmental patents included in the top 5 percent cited patents.

In line with previous studies (e.g. Trajtenberg, 1990) we measure the value of patents through their forward citations. Since citations are not immediate, older patents will have higher probability of being cited, hence biasing this measure toward older patents and underestimating more recent ones. We avoid this bias by deleting all patents granted during the last three years of our sample, thus although our database contains patents granted until the year 2006 we decide to account for patents granted until 2003. We selected three years because our sample is based on the NBER database, and Hall, Jaffe and Trajtenberg's (2001) analysis of this database recommended this *3-year safety lag*, since they showed that after three years all patents received about 95% of their total citations.

Since the nature of this database generates a bias of citations toward the US (Hall, et al. 2001), we measure all patents at country level. In other words, for each country we first select the top 5 percent patents as breakthrough, whether they are environmental or not. Then we measure the proportion of environmental patents within these breakthrough patents. Finally, we compare the proportion of these breakthrough environmental patents with the proportion of all environmental patents.

4.2.2-. Dependent variables and control variables.

Policy network style. For this variable we employ a binary variable called *pluralistic* which is 1 for the US and the UK -i.e. pluralistic countries- and 0 for Japan and Germany -i.e. neo-corporatist countries- (Schmitter, 1974; Kim, 2008; Streeck and Kenworthy, 2005).

We used four different institutional control variables from the World Bank that might influence the propensity toward patented environmental innovations.

GDP. Annual GDP growth is considered a proxy for munificence; countries with higher growth rates may take riskier investments such as environmental technologies (Aragon–Correa and Sharma, 2003).

Country's public spending on education. This variable represents the country's expenditure on education as a percentage of total public spending. Governments with higher expenditure on education reflects higher concern over social and environmental issues (Gottlieb, Vigoda-Gadot, Haim, Kissinger, 2012).

Country's fuel exports. This variable measures the percentage of mineral fuels exported by a country compared to total exports. Higher level of fuel exports indicate a higher dependency over non-environmental technologies, hence countries with higher fuel exports will disincentive environmental innovations (Porter and Van der Linde, 1995)

Country inflation rate. This variable reflects price instability, and it is associated in the environmental literature with uncertainty (e.g., Berchicci and King, 2007; Bowen, 2011). Thus we predict a negative relationship between inflation and environmental innovations.

5.5.- RESULTS

In order to test our hypotheses we ran two different regressions with STATA software. For the first hypothesis we used the percentage of environmental patents as dependent variable, whereas for the second hypothesis we used the *value of environmental patents* variable. Given the nature of our sample we used random-effect estimation methods. The Arellano-Bond test, an overidentifying restrictions test that is asymptotically equivalent to the Hausman test (Arellano and Bond, 1991) confirmed the reliability of our models. In addition, we used robust standard errors to avoid serial correlation and heteroskedasticity, and we controlled for the variability of the intercept over time by using year-specific dummies.

Table 1 includes the descriptive statistics for all the variables. The correlations between the variables do not suggest any potential for serious multicollinearity in the regression analyses, and the VIF factors are completely acceptable.

INSERT TABLE 1 ABOUT HERE

Table 2 presents the results of the regression when the proportion of environmental patents is the dependent variable, and Table 3 presents the results of the regression when the value of environmental patents is the dependent variable . Model 1 in Table 2 presents the base model and only includes the control variables when the percentage of the country's environmental patents is the dependent variable. For this regression, Model 2 also includes the first hypothesized effect variable, i.e., the similarity in the weight of environmental innovations for the countries in our sample. Model 3 presents the base model and only includes the control variables when the *value* *of environmental patents* is the dependent variable. For this regression, Model 4 also includes the second hypothesized effect variable, i.e., a higher value of environmental patents in neo-corporatist countries (i.e. Japan and Germany) than those pertaining to pluralistic countries (i.e. the US and the UK). The R-square statistics indicate that each additional variable improves the model fit for each regression.

INSERT TABLE 2 ABOUT HERE

We use the full models to discuss the results of hypothesis tests. Hypothesis H1 predicts that the proportion of environmental patents over all patents is similar among developed countries. The coefficient on the UK ($\beta = 0.0078687$, $p < 0.001$) is significant but with a low magnitude. This coefficient indicates than in the UK the proportion of environmental patents over all patents is a 0.79 percent larger than in the US, i.e. less than 1 percent, hence showing a high similarity between the proportion of environmental patents over all patents in the UK with respect to the US. The coefficient on Japan ($\beta = -0.0097626$, $p < 0.001$) is also significant and with a low magnitude -less than 1 percent of difference-, hence showing high similarity between the proportion of environmental patents over all patents in Japan with respect to the US. The coefficient on Germany ($\beta = 0.0080062$, $p < 0.001$) is also significant and with a low magnitude -less than 1 percent of difference-, hence showing high similarity between the proportion of environmental patents over all patents in Germany with respect to the US. These results support hypothesis 1.

INSERT TABLE 3 ABOUT HERE

Hypothesis 2 predicts that the impact of environmental patents is higher for ne-corporatist countries than for pluralistic countries. The coefficient on the neo-corporatist group (β =0.3591374, $p < 0.001$) is positive and significant, hence showing that neo-corporatist countries generate environmental patents with higher impact than pluralistic countries. Regarding control variables, for the first regression country' s level of GDP shows no statistically significance, public spending on education is positively related to the proportion of environmental patents over all patents (β = -0.0020473, $p < 0.001$), level of fuel exports is negatively related to the proportion of environmental patents over all patents (β = -0.0003771, $p < 0.001$), and inflation is negatively related to the proportion of environmental patents over all patents (β = -0.0004383, $p < 0.001$). For the second regression, only the level of fuel exports shows a relationship with the impact of environmental innovations (β = 0.020485, $p < 0.005$). This positive relationships shows that in countries with higher fuel exports their environmental innovations may have a lower presence but when they decide to invest in such technologies, they have high , probably as a mean of creating high quality substitutes for their current technologies.

5.6.- DISCUSSION, IMPLICATIONS, AND FUTURE RESEARCH

Environmental consequences of polluting activities are becoming more visible, hence increasing social awareness in developed countries . Scandals like BP oil spill in the Gulf of Mexico or the unbreathable air polluting levels in some Chinese cities (Reuters, 2015), has made that governments consider the achievement of sustainable production levels as a priority, hence strengthening their environmental regulations and increasing their sanctions over pollutant companies (European Commission, 2014; EPA, 2014). In this regard, environmental innovations are acquiring a growing relevance.

Whether driven by external pressures or because of a conviction of the competitive advantages of sustainability approaches (Aragón-Correa, 1998), organizations from different countries are increasing their number of environmental innovations. In this regard, despite different nations posse distinctive idiosyncratic institutions, we first hypothesize that the increasing attention toward environmental technologies is similar among developed countries. More specifically, we argued that the proportion of environmental innovations over all innovations is similar among developed countries. Our analysis of 1,972,400 patents from the US, Japan, Germany and the UK during the period 1976-2003 confirm our predictions.

However, despite this similarity of patenting trends, environmental innovations posse some singularities that make some policy network styles more effective than others. Environmental technologies are surrounded by higher levels of uncertainty than non-environmental ones (eg. Brewer, 2005, and Kolk and Pinkse, 2008). They are relatively new so organizations may lack prior experience to make predictable investments. This newness sometimes results in a lack of facilities, as in the case of electric vehicles. Although the development of climate-friendly cars is a promising market, the number of charging stations -i.e. the equivalent to traditional gas stations- is still very low, so that if organizations want to produce electric cars they have to bear the additional cost of investing in new facilities, a sunk cost that may not be recoverable. In this regard, countries with a neo-corporatist policy network style may leverage the uncertainty of environmental innovations by generating a more stable regulatory atmosphere. Neo-corporatist countries like Germany and Japan are characterized for having a fixed and limited number of interest groups than act more cooperatively, hence easing the achievement of collective agreements. On the other hand, pluralistic countries like the US and the UK posse a varying number of competing interest groups that form unstable coalitions in the pursue of individual interest, what may impede the needed policy stability for environmental innovations. Additionally, environmental innovations exert a positive effect over society that goes beyond organizations' boundaries, so that it cannot be fully appropriated by these organizations. Since pluralistic countries pose a more individualistic culture, they will be less prone toward environmental innovations. Consequently, in hypothesis 2 we predicted that neo-corporatist countries will generate higher-impact environmental innovations than pluralistic ones, what was also confirmed in our analysis.

These findings reinforce and extend the emerging body of literature regarding sustainability innovations (e.g. Berrone, Fosfuri, Gelabert, and Gomez–Mejia, 2013) and draws the attention toward national institutions as one of the most important drivers for innovations (e.g. Fligstein, 1991; Rivera, 2010). Our analysis of the totality of patents registered in the USPTO by the three major industrialized countries (Lanjow and Mody, 1996) and the UK during the period 1976-2003, showed that policy network styles play a relevant role in the achievement of high impact environmental innovations and calls for a deeper understanding how these idiosyncratic contexts affect developed countries.

Our analysis of environmental innovations through patents may be regarded as less biased than questionnaire surveys analyses because the later may induce answers aimed to project a "socially desirable image" (Berrone, Fosfuri, Gelabert, and Gomez–Mejia, 2013: 892). However, the use of patent data is not exempt from limitations and it is a topic of debate (e.g. Helm and Kloyer, 2004; Reitzig, 2003), as some scholars pose that firms do not patent all their inventions and prefer protecting them through secrecy and other instruments (Blind, Cremers, and Mueller, 2009; Fosfuri, 2006). However, the great protection given by the patent system -claimed by some scholars as overprotective (e.g. Heller and Eisenberg, 1998)- has made that organizations rely more on these instruments. Another limitation of our work is that since it is a longitudinal analysis dating from the year 1976, sustainability variables were not as well developed as they are nowadays, like for example those included in the Environmental Sustainability Index (Esty, Levy, Srebotnjak, and Sherbinin, 2005). This index compiles very useful information regarding sustainability but it was first released in 2002 and unfortunately is not issued on a yearly basis, what hinders a longitudinal analysis of almost three decades like ours. In this regard, future works could compile sustainability variables that can be used for analyzing a long period of time, what will undoubtedly increase the predicting power of their results.

This paper has relevant implications for managers and policymakers. It highlights the importance of a stable policy system for overcoming the uncertainties related to sustainability, hence facilitating the achievement of more valuable environmental innovations. Hence a mere increase of the proportion of environmental innovations over all innovations may not be enough. Managers may take riskier investments that yield returns in the long term (Ahuja, Lampert, and Tandon, 2008; Scherer, 1999). Also, more valuable environmental innovations result in lasting competitive advantages, what increases firm performance and confers first-mover advantages in these new technologies in terms of temporary monopoly rents, pushing governments toward more restrictive environmental regulations, etc. (Spencer, 2003). For policymakers, more valuable environmental innovations not only increases country's financial wealth and innovative capacity but increases society's wellbeing through the reduction of pollution level, a target that is already in the forefront agenda of national and international institutions.

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Table 1. Descriptive statistics and correlations

	Mean	S.D.	1	2	3	4	5
1. Proportion of environmental patents	0.044	0.008	-				
2. Value of environmental patents	-0.230	0.358	-0.15	-			
3. GDP	2.723	1.966	-0.03	-0.22*	-		
4. Country's Public Spending on Education	4.664	0.978	0.46***	-0.28**	0.23*	-	
5. Country's Fuel Exports	3.840	4.625	0.20*	0.03	-0.09	0.33**	-
6. Country's Inflation	3.477	3.585	0.13	-0.024	-0.13	0.44***	0.48***

† $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 2. Result of the regression analysis

(dependent variable: Proportion of environmental patents)

	Model 1	Model 2
GDP	-.00074 (.00068)	.00006 (.00008)
Country's Public Spending on Education	.00472 (.00252)†	.00205 (.00032)***
Country's Fuel Exports	.00033 (.00024)	-.00038 (.00005)***
Country's Inflation	-.00051 (.00020)†	-.00044 (.00016)**
Dummy UK		.00787 (.00084)***
Dummy Japan		-.00976 (.00024)***
Dummy Germany		.00801 (.00013)***
R^2 (ΔR^2)	.0174 (-)	.1767 (.1593)

Robust standard errors are in parenthesis.
† $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 3. Result of the regression analysis

(dependent variable: Value of environmental patents)

	Model 3	Model 4
GDP	-.02934 (.02146)	-.02806 (.02118)
Country's Public Spending on Education	-.10852 (.09836)	-.00382 (.10367)
Country's Fuel Exports	.00760 (.01004)	.02045 (.00824)*
Country's Inflation	.00347 (.01716)	.00584 (.01430)
Dummy UK & US		-.35914 (.11090)***
R^2 (ΔR^2)	.0656 (-)	.1557 (.0901)

Robust standard errors are in parenthesis.
† $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

CAPÍTULO 6

CONSIDERACIONES FINALES.

6.1.- CONCLUSIONES E IMPLICACIONES PARA LA TEORÍA Y LA PRÁCTICA

El objetivo de este último capítulo es sintetizar las principales aportaciones ofrecidas por los cuatro trabajos que componen la presente tesis doctoral, y que se han expuesto en los capítulos 2, 3, 4 y 5. Dada la extensión de los mismos consideramos necesario realizar una síntesis de las conclusiones más relevantes, así como las implicaciones que dichos trabajos tienen sobre el desarrollo teórico de la literatura y su aplicabilidad para la toma de decisiones estratégicas. A continuación se presentará un resumen de las principales conclusiones de cada capítulo, describiendo las relaciones que existen entre los distintos capítulos y cómo va variando el centro de atención en cada caso.

En el segundo capítulo contribuimos al debate existente sobre las ventajas de llevar una actividad innovadora explotadora frente a explorar nuevas tecnologías, al considerar que este dilema depende del grado de madurez de la tecnología así como del nivel de los recursos ociosos (*slack resources*) que posee la empresa. De manera más concreta, proponemos que dentro del contexto de innovaciones medioambientales no maduras, una estrategia explotadora conduce a un mayor desempeño organizativo. En otras palabras, las ventajas generadas por una mayor capacidad de absorción (Cohen and Levinthal, 1990) parecen generar efectos más positivos en la muestra analizada que los posibles riesgos relacionados con la inercia organizativa derivada de invertir en las mismas tecnologías (Moorman and Slotegraaf, 1999). Asimismo, resulta interesante observar que a pesar de que nuestros resultados muestran que el número de patentes medioambientales tienen un efecto negativo sobre el desempeño -lo que quizás indique que este tipo de innovaciones requieren un mayor período de tiempo para ser rentables-, cuando la organización se centra en pocas tecnologías medioambientales su valor de mercado aumenta. Por tanto, consideramos que dichas innovaciones se encuentran en sus primeras fases de desarrollo y que, por tanto, pueden que no hayan alcanzado todavía un nivel "óptimo" de explotación.

De manera adicional, nuestros resultados muestran que los recursos ociosos potenciales que posee la empresa tienen un efecto moderador sobre esta relación positiva entre explotación y desempeño organizativo. Concretamente, unos niveles excesivos de recursos ociosos potenciales pueden tener consecuencias negativas ya que pueden hacer que las organizaciones sean más laxas a la hora de establecer mecanismos de control sobre sus actividades de explotación.

Los resultados de este segundo capítulo sugieren que los managers deben prestar especial atención al grado de madurez de sus tecnologías cuando diversifican o acotan su portafolio de innovaciones, siendo recomendable centrarse en pocas tecnologías cuando estas se encuentran en sus primeras fases de desarrollo. La dificultad para la explotación de tecnología no madura y para la generación de nueva tecnología sugiere el interés de que los directivos consideren colaboraciones con expertos externos y centros de investigación. Asimismo, los resultados sobre el papel moderador de los recursos ociosos muestra que, paradójicamente, un alto nivel de estos recursos resulta pernicioso para la empresa ya que permite la creación de un colchón financiero que desincentiva la gestión eficaz y eficiente de la organización.

En el tercer capítulo tomamos un enfoque más amplio, pasando de centrar exclusivamente nuestra atención en los aspectos internos de la organización para estudiar ahora también qué estrategias llevan a cabo nuestros competidores. Puesto que en la actualidad un sólo producto puede contener miles de patentes procedentes de empresas que se pueden excluir mutuamente (Lin, 2011), analizamos las consecuencias de innovar en ámbitos de tecnologías habituales en la industria -o lo que es lo mismo, converger tecnológicamente- frente a innovar en campos tecnológicos donde los competidores de la industria tienen una menor presencia –divergencia tecnológica-. Nuestros resultados muestran que la divergencia tecnológica está relacionada positivamente con el desempeño organizativo cuando las tecnologías y la organización tienen una serie de características. Concretamente, nuestros resultados muestran que aquellas organizaciones con altos niveles de experiencia medioambiental y poder de negociación, así como aquellas que poseen activos muy específicos tienden a divergir tecnológicamente de sus competidores, lo que tiene un efecto positivo sobre su desempeño.

Desde un punto de vista teórico, nuestros resultados contribuyen a distintos aspectos de la literatura de estrategias sobre patentes (*strategic patenting*) (Hall and Ziedonis, 2001) y la de organizaciones y entorno natural desde el punto de vista de la teoría de costes de transacción (Williamson, 1975, 1985). Nuestros resultados resultan especialmente interesantes al mostrar claramente que patentar en dominios divergentes no es una estrategia llevada a cabo por pequeñas empresas que carecen de los recursos necesarios para mantener una fuerte posición de negociación contra grandes empresas como se ha sugerido en literatura previa (e.g., Ariño, Ragozzino and Reuer, 2008; Shervani, Frazier and Challagalla, 2007), sino todo lo contrario. Es decir, las grandes corporaciones son más proclives a divergir tecnológicamente para así evitar que sus competidores se apropien de sus rentas de monopolio.

Los resultados de este capítulo muestran que los managers no sólo deben prestar atención al número de patentes para proteger sus innovaciones sino que también deben prestar una atención estratégica a los dominios tecnológicos en los que puede ser más apropiado patentar considerando cuáles son las estrategias de sus competidores. En este sentido, mientras que los managers se han centrado tradicionalmente en las decisiones de compra-venta de patentes con competidores, nuestros resultados sugieren que una mayor atención a la selección estratégica del ámbito de la innovación podría facilitar condiciones ventajosas en esas transacciones.

En el cuarto capítulo comparamos las influencias externas que ejercen las instituciones , en el ámbito de las innovaciones medioambientales, frente a la influencia de la dotación de recursos internos de la organización. El análisis se realiza de forma indirecta prestando atención a la relación entre el número de patentes desarrolladas por la empresa y su similitud con los ámbitos en los que trabaja la industria. Nuestros resultados muestran en primer lugar una relación positiva entre el número de patentes medioambientales y no medioambientales, lo que resulta congruente tanto con la perspectiva de recursos y capacidades naturales (*natural-resource-based view*) (Hart, 1995) como con la teoría institucional (Hoffmann, 1999). Desde el punto de vista de la primera, nuestros resultados sugieren que las innovaciones medioambientales pueden generar sinergias con la capacidad de innovación general de la organización. Asimismo, la teoría institucional propone que las innovaciones medioambientales están hoy en día relacionadas con los incentivos generales sobre innovación.

Mientras que tanto la perspectiva de recursos y capacidades naturales (*natural-resource-based view*) (Hart, 1995) como con la teoría institucional (Hoffmann, 1999) explican la relación positiva entre innovaciones medioambientales y no medioambientales, ambas suponen puntos de vista contrapuestos en cuanto a la relación entre el número de innovaciones medioambientales y las diferencias o similitudes con los dominios tecnológicos de los competidores. Concretamente, nuestros resultados muestran que, a pesar de que las empresas poseen recursos heterogéneos y de imperfecta movilidad (Barney, 1991), las presiones institucionales hacen que éstas patenten en tecnologías medioambientales similares a sus competidores. Estos resultados refuerzan la importancia de las regulaciones medioambientales (e.g., Marcus, Aragon-Correa, and Pinkse, 2011; Starik, 2013) y las condiciones institucionales de una industria (e.g., Hoffman, 1999; King and Lenox, 2000; Llach, Alonso-Almeida, García-Castellví and Bagur-Femenias, 2014).

Los resultados de este capítulo muestran que los managers de empresas que realizan innovaciones medioambientales tienden a prestar una especial atención a los aspectos institucionales relacionados con el medio ambiente en su industria, y que los incentivos o influencias que ejercen las instituciones pueden ser claves a la hora de promover una determinada tecnología medioambiental. Además, la relación positiva entre patentes medioambientales y no medioambientales mostrada en nuestros resultados supone un argumento adicional al tradicional mito de que las innovaciones medioambientales son un mero coste que la organización debe asumir, para considerarlas también fuentes de ventajas competitivas que a su vez complementan al resto de innovaciones.

En el quinto capítulo volvemos a ampliar nuestro punto de mira y, en lugar de analizar las innovaciones medioambientales en un sector concreto, realizamos un estudio a nivel país. Concretamente estudiamos las patentes -medioambientales y no medioambientales- de Estados Unidos, Japón, Alemania y Reino Unido. Nuestro análisis de estos cuatro países desarrollados muestra el efecto que tienen los diferentes estilos de "red política" (*policy network style*) sobre la proporción de patentes medioambientales con respecto al total, así como el impacto que tienen estas. De manera más concreta, nuestros resultados muestran que a pesar de que los países poseen redes políticas (y contextos) diferentes, no fue posible encontrar un porcentaje diferente de patentes medioambientales sobre el total, lo que sugiere que la importancia actual del medio ambiente comparte un nivel similar de prioridad en las grandes economías mundiales.

Sin embargo, a pesar de esta atención hacia temas de sostenibilidad a nivel global, la teoría neo-institucional (Streeck and Kenworthy, 2005) explica la influencia de las diferentes redes políticas sobre el impacto de las innovaciones medioambientales. Nuestros resultados apoyan esas ideas mostrando que aquellos países caracterizados por un sistema neo-corporativo ("*neo-corporatist*") producen innovaciones medioambientales con un mayor impacto que aquellos con un sistema plural (“*pluralistic”*). Por tanto, los sistemas neo-corporativos, cuyas redes políticas están basadas en una cooperación y orientación colectiva, favorecen el desarrollo de aquellas innovaciones medioambientales consideradas más valiosas.

Los resultados de este capítulo muestran que un sistema regulatorio estable y en el que las empresas, sindicatos, usuarios, activistas, etc. actúan en base a unas reglas de juego no individualistas favorecen la generación de innovaciones medioambientales de mayor impacto. Asimismo, puesto que la tendencia de las economías desarrolladas hacia la proporción de innovaciones medioambientales es similar, un sistema estable permitiría a las organizaciones maximizar sus inversiones en materia medioambiental.

6.2.- LIMITACIONES Y FUTURAS LÍNEAS DE INVESTIGACIÓN

Finalmente es necesario considerar las limitaciones de los trabajos de investigación presentados en esta tesis doctoral. Cada uno de los capítulos de la tesis presentaba diferentes líneas de trabajo relacionadas con los desarrollos específicos que en el mismo se presentaban. Este apartado de la tesis pretende sólo reunir y resumir algunos de los principales aspectos que allí se presentaban de cara a facilitar una visión conjunta de todos ellos simultáneamente. En este apartado, las futuras líneas de trabajo partirán de la consideración de las limitaciones de los trabajos desarrollados. La reducción de las limitaciones actuales puede también conducir al desarrollo de futura investigación de interés.

La limitación más notable de nuestros trabajos si se pretenden extraer conclusiones generales relacionadas con las innovaciones medioambientales en las empresas es el uso exclusivo de patentes como variable *proxy* para analizar dichas innovaciones. En este sentido, tal y como comentamos en el primer capítulo de esta tesis doctoral, la utilización de patentes para el desarrollo de investigaciones sobre innovación sigue siendo hoy día fuente de numerosos debates tanto a favor (e.g. Hagedoorn and Cloodt, 2003; Popp, 2003) como en contra (Blind et al., 2009; Fosfuri, 2006). Puesto que en ese primer capítulo especificamos las ventajas de nuestro análisis, en este apartado sugerimos como futura línea de investigación el potencial de un análisis simultáneo de patentes y de otros tipos de información secundaria que puedan actuar como indicadores del grado de innovación medioambiental en las empresas. De esta forma, no sólo podríamos captar las percepciones subjetivas de diferentes agentes en materia de innovación sino que, por ejemplo, podríamos escrutar la concordancia entre sus respuestas en encuestas o información e intenciones expresadas en informes corporativos y sus acciones medidas en patentes. Así podríamos comprobar si los informadores transmiten una información fidedigna de sus prácticas y estrategias o si, como sugieren algunos autores (e.g. Berrone et. al, 2013), en materia medioambiental las respuestas obtenidas en encuestas se encuentran sesgadas por el interés del informante en transmitir una imagen de organización socialmente responsable debido a las presiones tanto institucionales como de activistas, proveedores, consumidores, accionistas, etc. (Barczak, 2012; Paladino, 2008).

Una vez que hemos comentado las limitaciones de la variable que hemos empleado en todos nuestros trabajos, a continuación expondremos las limitaciones específicas de cada uno de nuestros cuatro estudios de investigación.

En este sentido, en relación al capítulo 2 -en el que estudiábamos el dilema entre exploración y explotación- futuros análisis podrían examinar y comparar diferentes sectores. Estos estudios podrían, por ejemplo, determinar en qué sectores la relación entre el desempeño y la exploración/explotación tiene forma de U invertida, es decir, en qué sectores es mejor encontrar un balance entre explotación y exploración. Si este fuese el caso, ¿qué otras circunstancias explican este comportamiento? Asimismo, futuros estudios podrían emplear diferentes constructos para medir el grado de explotación/exploración de una empresa y comparar su variabilidad o poder explicativo empleando los desarrollos realizados en este trabajo.

Con respecto al capítulo 3 -que analizaba las condiciones en las cuales una divergencia tecnológica conducían a un mayor desempeño organizativo- futuros trabajos podrían estudiar sectores de baja intensidad tecnológica. Nuestro sector ("Componentes Electrónicos y Eléctricos") está caracterizado por una elevada propensión a patentar, lo que algunos autores han denominado "carrera de patentes", es decir, el aumento del número de patentes en mayor proporción que el gasto en I+D (Hall and Ziedonis, 2001). Mientras que el análisis de esta industria está justificado por los objetivos específicos que en nuestro trabajo se planteaba (relacionados con analizar en qué condiciones los costes de transacción relacionados con la existencia de esa gran cantidad de patentes pueden justificar la divergencia), sería interesante ampliar el debate entre convergencia/divergencia a otros sectores aunque para ello sea necesario complementar el uso de patentes con otras variables que midan la capacidad innovadora.

En relación al capítulo 4 - que compara las teoría natural de recursos y capacidades (Hart, 1995) con la teoría institucional (Hoffmann, 1999) -, futuros estudios podrían emplear el análisis comparativo que hemos realizado de estas dos teorías para estudiar otros fenómenos relacionados con el medio ambiente. Por ejemplo, ¿qué impacto tienen eventos puntuales como determinadas catástrofes naturales o accidentes medioambientales relacionados con las empresas a la hora de reorientar las tecnologías medioambientales? Específicamente, ¿se produce algún cambio sustancial en la orientación medioambiental de las empresas como consecuencia de esos eventos?, ¿qué tipo de empresas adquieren una posición de liderazgo hacia los nuevos requerimientos regulatorios consecuencia de esos cambios?

Finalmente, en el capítulo 5 -que compara diferentes países industrializados- nuestro análisis se realiza desde el año 1976 hasta el año 2003. A pesar de que se trata de un estudio longitudinal considerable, es cierto que la mayoría de variables medioambientales se han generado en los últimos años, por lo que resulta especialmente difícil incorporar este tipo de variables a los primeros años de la muestra. Sin embargo, determinados actores como la Oficina de Marcas y Patentes de Estados Unidos (United States Trademark and Patent Office, USTPO por sus siglas en inglés) introdujo en 2009 criterios específicos para determinar qué patentes tenían contenido medioambiental y los ha aplicado a todas las patentes desde el año 1976. En este sentido, futuros trabajos también podrían establecer una serie de criterios y aplicarlos hacia atrás en el tiempo, de manera que se pueda complementar no sólo el análisis de las innovaciones medioambientales, sino del resto de prácticas en materia de sostenibilidad realizadas por las organizaciones.

En la presente tesis doctoral se han realizado diferentes análisis con el objetivo de profundizar en el conocimiento de las innovaciones medioambientales. A pesar de ser un fenómeno relativamente desconocido, la creciente relevancia de este tipo de innovaciones hace que cada vez más académicos, empresas, instituciones y gobiernos presten su atención a las innovaciones medioambientales para continuar con su desarrollo tecnológico a la vez que mejoran la calidad de vida del conjunto de la sociedad.

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