UNIVERSIDAD AUTÓNOMA DE MADRID

FACULTAD DE CIENCIAS ECONÓMICAS Y EMPRESARIALES

DEPARTAMENTO DE ESTRUCTURA ECONÓMICA Y ECONOMÍA DEL DESARROLLO

Doctorate in Economics and Management of Innovation

A KNOWLEDGE ECONOMY APPROACH FOR THE DEVELOPMENT OF COUNTRIES BASED ON NATURAL RESOURCES

THE CASE OF CHILE

DOCTORAL DISSERTATION

SUPERVISORS: DRA. MARÍA PALOMA SÁNCHEZ MUÑOZ
DRA. MARÍA ISABEL ÁLVAREZ GONZÁLEZ

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Madrid 2014

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AGRADECIMIENTOS

A lo largo de las próximas páginas presento los resultados de mi investigación motivada por una serie de precedentes nacidos durante toda mi vida profesional, la cual ha transitado desde temas directamente relacionados al mundo productivo, en el sector agrícola y forestal, hasta la gestión de la investigación científica y su transferencia al sector privado. Aunque este sea, por tanto, un trabajo eminentemente técnico y analítico, el mayor respaldo lo he recibido de mi esposa, Carolina, quien incansablemente me ha acompañado en todas las aventuras emprendidas, apoyándome, y motivándome para lograr las metas propuestas. Sin su compañía y apoyo, este desafío difícilmente habría sido logrado, y más aún, probablemente no me lo hubiese planteado.

Aunque por sencillas que parezcan algunas de las cuestiones tratadas en esta investigación, sobre todo para quienes han tenido la oportunidad de estar insertos en un entorno que entiende que los procesos relacionados al conocimiento, la tecnologías y la innovación, no son productos que se pueden adquirir fácilmente en el supermercado o través de internet, sino que por el contrario son procesos que se construyen día a día a partir de las capacidades de todos los involucrados directa e indirectamente, este trabajo es de gran trascendencia para quienes hemos sido formados bajo una perspectiva económica más convencional y que nos movemos en una sociedad dominada por el corto plazo y lo desechable. Es por ello que haber contado con el apoyo financiero por parte del Instituto de Investigaciones Agropecuarias de Chile, y el tiempo requerido para completar mis estudios, ha constituido un gran aliciente y soporte para lograr mi cometido. Así también, a quienes creyeron en mi propuesta y me allanaron el camino durante esas primeras etapas de tan alta complejidad, me refiero a Maritza y Leopoldo. Tampoco deseo olvidar a Aldo, por su incansable y decidido apoyo para permitirme superar todas las barreras, y por creer que la ciencia es el verdadero futuro de una nación.

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SUMMARY

In the majority of countries, development and welfare are currently among the major concerns of policy makers. In order to achieve these targets, scholars and practitioners have developed theories and empirical models that offer information on the key factors driving countries' growth. From the Neoclassical theory, which argues that capital and labor are the main determinants of growth (Sala-i-Martin, 2000; Weil, 2006), to the New growth theory and the Evolutionary theory, which explore new ways to achieve these objectives. In fact, evolutionary proposals show how knowledge, within globalized and changing scenarios, could support new growth trajectories thanks to innovation, as Schumpeter (1947) argued decades ago.

Scholars from different perspectives have also remarked on the importance of knowledge and technology for countries' progress, industries and firms, because these provide new ways to create wealth, beyond the traditional production factors (Dosi, 1988; Freeeman, 1995; David and Foray, 2002). In fact, evidence shows that knowledge and innovation allow the disruption of economic determinism, obtaining increased marginal returns, interrupting the static processes, and avoiding restrictions identified by neoclassical vision. Furthermore, knowledge can support a continuing innovation process and the convergence of lagging countries, along with promoting changes in markets, the emergence of new industries, and the reactivation of traditional sectors, through dynamic processes defined as multi-causal and with bidirectional causality (Castellacci and Natera, 2013), which often lead to unpredictable results. As a consequence of these new opportunities, some economies have followed the orientations of international organizations, investing in intangibles, establishing strategies for the development of knowledge-based industries, and transforming their economies. Success stories are, e.g., USA, Korea, Taiwan, Singapore and Japan (Wright, 1990; OECD, 2010; Felipe et al., 2012).

Although this new perspective has contributed to development, mainly in economies based on knowledge and technology, this approach has not been widely used to solve the problems of primary industries, and particularly those specialized in natural resources (NR). Indeed, these economic activities have been less studied under a knowledge-based orientation. The works related to these specialized economies have generally taken into account a more conventional approach, and their findings point out that these resources can cause negative impacts on economy, environment and

society, which the literature has called "*the natural resources curse*". Consequently, recommendations have been oriented to transform NR-economies into knowledge and technology based ones (Rosser, 2006; Smith, 2007; Ville and Wicken, 2012). However, in recent decades some evidence shows that intangible factors could provide new alternatives to these economies, and improve the performance of NR sectors by incorporating intangibles as pillars to sustain growth. To reach this purpose, countries should invest more in human capital, institutions, innovation and technology (Ferranti et al., 2002; Bravo-Ortega and De Gregorio, 2007; Hauser et al., 2011).

This thesis deals precisely with these topics in order to identify the key elements that could support long-term growth in countries specialized in NR, beyond the role of traditional factors, as a way to contribute to designing development strategies and avoid the NR curse. Therefore, one of the main novelties of this research is to study the effect of natural resources on growth, taking intangible assets as key variables of this process. The theoretical arguments for this research are taken from the Evolutionary growth theory and the Knowledge economy framework, by performing an integrative analysis. These frameworks provide a more flexible, comprehensive, interconnected and multidimensional way for understanding the growth, including not only the technological and physical factors, but also the institutional and other contextual elements affecting growth , which provide a wider set of alternatives for building development policies.

Thus, the main aim of this work is *to identify the main determinants of economic growth and the development process of Chile, from a perspective that combines the knowledge economy principles and natural resources.* This general aim is addressed through four specific aims: (1) *to characterize the role of intangibles in the knowledge economy, the main work lines and management tools at a macro level*; (2) *to identify the factors that support economic development in successful countries with economies based on natural resources, considering an evolutionary approach*; (3) *to identify the determinants of the GDP gap in NR-based economies that affect their technical efficiency and catching-up processes*; and (4) *to know the key dimensions and pillars of growth of Chile and their evolution*. Although Chile is the final target of this study, a broader analysis is carried out in order to provide more useful and comprehensive results for other NR-based countries. In addition, Chile is selected as a representative NR-based country with an outstanding economic performance in order to detect a possible new path for development and, also, to suggest policies to solve its economic

slowdown observed in recent years, which has been interpreted as signs of *NR curse* and *middle income trap* (Pérez, 2012; Traub, 2013).

This study is performed through three main and interconnected works by using complementary analytical methods. The first analysis is related to intangibles and Intellectual capital in order to identify how to measure and manage them, and their importance in national wealth creation. This is conducted by a systematic literature review and an analysis of assessment models using cluster and correlation techniques. A second analysis is carried out to detect the key dimensions for growth in NR-specialized economies by estimating empirical growth models –static and dynamic– using panel data methodology. The models used include both traditional (capital, labor and NR) and intangible variables (technology, human capital, internationalization, and institutions) in order to integrate the different analytical frameworks. Finally, a third work, focused on Chile, is conducted to know the gap dynamics in these NR-countries, and especially in Chile. To this end, three analytical methodologies are combined in a complementary manner. The first is a model estimation of GDP gap (ppp) by using panel data, the second is a stochastic metafrontier production function, and the third is a convergence analysis. The assumption is that development trajectories are country-specific and can be supported in the original productive system using as key the investment in intangibles in primary sectors in order to add value to exports and diversify. In addition, it is expected that effects that are positive for growth deriving from knowledge and innovation are possible not only in high-tech and science-based industries, but are extensive to all types of sectors and fields of activity.

The literature review on Intellectual capital was carried out with information from three important academic databases (Web of Knowledge, Science Direct and Econlit) and the five most outstanding journals on intangibles, according to Serenko and Bontis (2009), while the data for the model estimations, gap evaluations and convergence analysis were obtained from important international databases: UNCTAD, WDI by WB, and CANA. The complete sample used for these analyzes was formed of 133 nations, for the period 1996-2008[1]. Countries were grouped according to the objectives of each analysis. Two groups of countries based on NR were made. One of them, called NR SPECIALIZED, integrates the economies whose exports of NR represent more than 50% of total exports; the second group, called SELECTED, is result of a cluster analysis, and includes countries whose economies are also based on primary production activities

[1] Some analyses and discussions are conducted for a longer period, which is specified in each section.

and additionally have a high or medium-high income (per capita GDP), according to the WB classification. This group (SELECTED) consists of: Argentina, Australia, Canada, Chile, Colombia, Kazakhstan, Mexico, Peru, Russia, and South Africa. The rest of groups corresponded to OECD and OPEC, used as contrasts.

Findings from the literature review on Intellectual capital (IC) confirm the importance of intangibles for economic growth, competitiveness, wealth creation, development, and welfare (Bontis, 2004; Corrado et al., 2009; Lin and Edvinsson, 2011). Despite its strategic role for economies, IC studies at a macro level are still recent, there is no widely accepted analytical framework, and there is a large dispersion of information adversely affecting their understanding.

In order to evaluate and manage nations' intellectual capital, diverse models have been developed, which differ from those designed to assess firms' intangibles, although they maintain –directly or indirectly– their basic components: human capital, structural capital, and relational capital. At the national level, two main work lines on intangibles were identified, one closer to the study of IC at a firm level, driven mainly by scholars, and another developed by international organizations and business schools, more oriented toward measuring development, innovation capacity and competitiveness using intangibles as explanatory variables. These two groups differ in their conceptual base, methodology, components and objectives. Despite the differences, reported country rankings tend to converge, which would indicate that there are several ways to measure the intangibles of countries that provide similar information, but require different inputs (indicators) and analytic capacities. Thus, to manage IC at a national level, policy makers could use any of the analyzed models, except HDI (Human Development Index), which includes intangibles that do not exactly reflect a country's growth capability, such as health.

The analysis of the factors that determine a country's product, in economies based on NR, showed that NR could have a positive impact on GDP if traditional variables are appropriately combined with intangibles, as proposed by the Knowledge economy. These findings confirm that NR are important for growth in some countries (SELECTED) while in others, such as developed economies (OECD) and OPEC, their impact is not significant or may even adversely affect development. Furthermore, different impacts of renewable and non-renewable resources were observed. Agriculture did not have a significant effect on growth in SELECTED, while in the rest of groups it was negative and significant. In the case of mining, this had a positive and significant impact on GDP only in SELECTED, while oil showed a positive influence in all samples.

The empirical analysis also revealed the importance of the international dimension as a channel to access embodied technologies and foreign knowledge via FDI (foreign direct investment). In addition, the positive effect of local innovative capabilities and the generation of technologies facilitating the development path of countries specialized in NR have also been detected. This would indicate that not only absorptive capacities, but also innovative capabilities are required in these economies, which is one of the keys to sustaining development and increasing the long-term productivity of NR industries. Furthermore, institutions were also identified as an important factor for growth, since they facilitate the control of the pressures resulting from the exploitation of natural resources and provide a stable environment for investors and producers.

It is clear from the results that the option adopted by successful resource-based countries is different from that followed by the OPEC or other NR-specialized economies. They have been able to overcome difficulties arising from fluctuations in commodity prices and internal social and economic pressures, taking advantage of long-term strategies oriented by the Knowledge economy and globalization, in a similar way to developed countries, describing a new development path. This path assumes primary resources as a pillar of the economy, and investment in intangibles within the NR sector as a key to add value and diversify products and exports, without leaving this industry.

The case of Chile confirms once again that economies based on NR-industries can successfully face the potential negative effects of resource exploitation by means of strategies that combine traditional economic principles with the Knowledge economy framework. For these countries, the promotion of more physical investment, openness, inward FDI, and innovation capabilities, along with the strengthening of institutions, are crucial for the definition of growth strategies and converge.

Although the data show that the Chilean economy has converged to the leaders, and that the reforms and policies implemented have been successful in areas such as institutions, education, investment, international trade and openness, some important weaknesses still remain, as the lack of innovation capabilities. It is therefore extremely important to strengthen the capacity for building local capabilities, not only as a means to enhance the absorption capacity but also for endogenous knowledge creation in NR-based sectors. To achieve this, it is necessary to promote transversal competences (e.g. ICT, nanotechnology, robotics, etc.) and disciplines directly related to the production system (e.g. in areas such as biotechnology, remote sensing, safety,

environmental protection, etc.), in order to add value to exports and diversify them. At the same time, it is essential to create and maintain good institutions. Particularly in the case of Chile, the focus should be on improving government effectiveness and regulatory capacity, and also on paying more attention to the control of corruption. Another area that requires prompt action is social inequality, because Chile has one of the worst levels in the region and an even poorer ranking compared to developed countries. A rapid solution is needed, both for humanitarian reasons and to reduce the risk of potential social outbreaks affecting some of the current pillars of the economy, such as the enabling environment for local and foreign investment and the efficiency in production and export processes.

Thus, future policies should encourage increased spending on R&D (public and private), associated to the key NR-sectors and in complete harmony with entrepreneurs (local and foreign); to improve the quality of education and strengthen access to university studies, in response to the demand for local capability; while, at the social level, a greater effort is needed to reduce the income gap, through mechanisms that also contribute to productive activity based on NR. In this regard, more and better education is widely recognized as a mechanism to achieve this purpose, as well as access to basic services and goods and changes in labor policy.

Despite the consistency in the results and findings, this research has also some limitations that are common to this type of works and scientific field, despite the precautions taken in the analytical analyses and the literature review. The most important weaknesses are related to data and proxies used to evaluate intangible variables. However, the results are robust and widely supported by the scientific literature. Additionally, another weakness is derived from the macro approach used, leaving open research areas for future studies.

Finally, the findings have opened up new research opportunities on growth and development in specialized regions, countries, and territories, as well as at a sectorial level, mainly for agriculture and mining. Furthermore, other research proposals could be aimed at analyzing spillovers from related industries and knowledge flows within NR industries.

RESUMEN

El desarrollo y el bienestar de los ciudadanos forman parte de las principales preocupaciones que enfrentan los responsables políticos en la actualidad, en la mayoría de los países. Con el fin de lograr estos objetivos, académicos e investigadores han elaborado diversas teorías y modelos que ofrecen información sobre los factores clave que determinan el desarrollo. Desde la Teoría neoclásica, que explica el crecimiento como una función determinada por el capital y el trabajo (Sala-i-Martin, 2000; Weil, 2006), hasta la Nueva teoría del crecimiento y la Teoría evolutiva del crecimiento, las cuales exploran nuevas formas de lograr el progreso, una serie de trabajos teóricos y empíricos se han realizado en esta dirección, con el propósito de proveer diferentes claves para el avance de las economías. En particular, las propuestas nacidas desde la teoría evolutiva muestran cómo el conocimiento, dentro de escenarios globalizados y cambiantes, podría soportar nuevas trayectorias de crecimiento gracias a la generación continua de innovaciones, como planteó Schumpeter (1947) décadas atrás.

Autores desde diferentes perspectivas han destacado la importancia del conocimiento y la tecnología para el progreso de los países, sectores y empresas, ya que provee nuevos mecanismos para la creación de riquezas, más allá de las convencionales vías ofrecidas por las más tradicionales teorías (Dosi, 1988; Freeeman, 1995; David y Foray, 2002). Las evidencias muestran que el conocimiento y la innovación permiten romper el determinismo económico, lograr incrementos marginales crecientes, interrumpir los procesos estáticos, y evitar las restricciones al crecimiento de la visión neoclásica. Además, el conocimiento puede también sostener un proceso de innovación permanente, impulsar la convergencia de los países rezagados con aquellos más prósperos, promover cambios en los mercados, permitir el surgimiento de nuevas industrias, y reactivar sectores económicos tradicionales, todo lo cual se logra a través de procesos dinámicos, multi-causales y con dependencia bidireccional (Castellacci y Natera, 2013), los que a menudo tienen resultados impredecibles. Para aprovechar estas nuevas oportunidades, algunas economías han seguido las orientaciones entregadas por organizaciones internacionales, invirtiendo en intangibles y estableciendo estrategias para impulsar nuevas industrias basadas en el conocimiento, transformando así sus economías. Como resultado de estas decisiones, diversas historias de éxito se pueden encontrar, como son los ejemplos de EE.UU., Corea del Sur, Taiwán, Singapur y Japón (Wright, 1990; OCDE, 2010; Felipe et al., 2012).

Aunque esta nueva perspectiva ha contribuido efectivamente al desarrollo de los países, sobre todo en economías más intensivas en el conocimiento y la tecnología, este enfoque no ha sido aplicado ampliamente en la resolución de los problemas que presentan las industrias primarias, y en particular aquellas especializadas en la explotación de los recursos naturales (RN). En efecto, estas actividades económicas han sido generalmente menos estudiadas bajo un enfoque basado en el conocimiento. Los trabajos relacionados con estas economías han tomado generalmente en cuenta una visión más convencional, y los resultados señalan que estos recursos pueden causar impactos negativos en la economía, el medio ambiente y la sociedad, efectos que han sido denominados en la literatura como "*la maldición de los recursos naturales*". De este modo, las recomendaciones para estos casos han estado orientadas a fomentar la necesaria transformación de sus estructuras económicas por otras basadas en industrias intensivas en conocimiento y tecnología (Rosser, 2006; Smith, 2007; Ville y Wicken, 2012). Sin embargo, en las últimas décadas algunas evidencias comienzan a mostrar cómo los factores de naturaleza inmaterial podrían ofrecer nuevas alternativas a estas naciones, las cuales permitirían mejorar el desempeño de los sectores basados en RN, mediante la incorporación de los intangibles como pilar del crecimiento. Para alcanzar este propósito, estos países deberían invertir más en capital humano, innovación y tecnología, y a la vez fortalecer sus instituciones (Ferranti et al., 2002; Bravo-Ortega y De Gregorio, 2007; Hauser et al., 2011).

Esta Tesis aborda precisamente estos tópicos, con el fin de identificar los elementos clave que podrían sostener el crecimiento en el largo plazo en aquellos países especializados en RN, más allá del rol que tienen los factores tradicionales de producción, y de esta forma contribuir al diseño de estrategias para evitar la maldición de los RN sin tener que abandonar estas industrias. Por lo tanto, una de las principales novedades de esta investigación es el estudio del efecto de los recursos naturales en el crecimiento, tomando los activos intangibles como elementos clave de este proceso. Los argumentos teóricos que sustentan esta propuesta, se encuentran en la Teoría evolutiva del crecimiento y en el marco conceptual de la Economía del conocimiento, los que se conjugan a través de un análisis que integra ambas perspectivas. Estos marcos analíticos proporcionan una vía más flexible, integral, multinivel e interconectada para comprender el crecimiento de los países, incluyendo no sólo los factores tecnológicos y físicos, sino también los elementos institucionales y de contexto que afectan el crecimiento, lo que proporciona un abanico más amplio de alternativas para la construcción de políticas de desarrollo.

De esa forma, el objetivo principal de esta Tesis es identificar el efecto de los principales determinantes del crecimiento económico de Chile, tomado como base una perspectiva que combina los principios de la economía del conocimiento y la especialización productiva en los recursos naturales. Por su parte, los objetivos específicos son: (1) caracterizar el rol de los intangibles en la actual economía del conocimiento, las principales líneas de trabajo y las herramientas de gestión en el ámbito nacional; (2) identificar los factores clave del desarrollo económico de aquellos países con exitosas economías basadas en los recursos naturales, teniendo en cuenta un enfoque evolutivo; (3) identificar los determinantes de la brecha del PIB de las economías basadas en RN, las que además estarían afectando la eficiencia técnica y el gap tecnológico; y (4) conocer las dimensiones y pilares fundamentales del crecimiento de Chile, como así también su evolución. Aunque Chile es el objetivo último de este estudio, un análisis más amplio es llevado a cabo con el fin de proporcionar una más extensa comprensión de los hallazgos, de forma tal que también sean útiles para otros países con estructuras productivas similares. Chile es utilizado así como un caso representativo de economías especializadas en recursos primarios y con un destacado desempeño económico, lo que motiva a detectar una posible nueva trayectoria de desarrollo. Además, este estudio ofrece algunas claves sobre las causas que podrían explicar la desaceleración económica observada en los últimos años en este país, la cual ha sido interpretada como signos de la maldición de los RN y de la trampa del ingreso medio (Pérez, 2012; Traub, 2013).

Para lograr estos propósitos, esta investigación se realizó a través de tres estudios interconectados, utilizando a su vez diferentes y complementarias metodologías analíticas. El primer trabajo está relacionado con los intangibles y el Capital intelectual (CI), el cual intenta conocer la importancia que tienen para la creación de riqueza en las naciones, cómo medirlos y gestionarlos. Para cumplir con este objetivo, se realizó una revisión sistemática de la literatura, en conjunto a un análisis de conglomerados y otro de correlación, para comparar los principales modelos existentes para la evaluación del CI. A continuación, un segundo trabajo fue realizado para identificar las dimensiones clave del crecimiento en economías especializadas en RN, a través de la estimación de modelos empíricos de crecimiento, para lo cual se utilizaron datos de panel, estimando tanto modelos estáticos como dinámicos. Estos modelos incluyeron tanto variables convencionales (capital, trabajo y RN) como aquellas de carácter intangible (tecnología, capital humano, internacionalización e instituciones) con el fin de integrar los diferentes marcos analíticos. Finalmente, un tercer trabajo, esta vez centrado en el caso Chile, fue impulsado para conocer la dinámica del gap en estos

países especializados en RN, y en particular de Chile. Para ello, se emplearon tres metodologías analíticas, combinadas de una forma complementaria. La primera fue una estimación de un modelo del gap del PIB per cápita mediante el uso de datos de panel; la segunda correspondió a un análisis de la metafrontera estocástica de producción para conocer la brecha tecnológica y la eficiencia técnica, y la última fue un estudio de convergencia. El supuesto general es que las trayectorias de desarrollo son específicas de cada país y que se puede soportar en el sistema productivo original, utilizando como clave la inversión en intangibles en los sectores primarios para agregar valor a las exportaciones y diversificar los negocios dentro de la misma industria. Además, se espera que aquellos efectos positivos en el crecimiento derivados del conocimiento y la innovación, sean factibles no solo para las industrias de alta tecnología y sectores basados en ciencia, sino que también lo sean para cualquier tipo de sector y campo de actividad.

Para la revisión sistemática de la literatura se utilizó información proveniente de tres importantes bases de datos académicas (Web of Knowledge, Science Direct y Econlit) y de los cinco journals que más artículos publican sobre los intangibles de acuerdo con Serenko y Bontis (2009). Por su parte, los datos para las estimaciones de los modelos y los análisis de convergencia y gap se obtuvieron desde reconocidas bases datos internacionales (UNCTAD, WDI del BM y CANA). La muestra total empleada para estos análisis se conformó por 133 países, para el período 1996-2008[2]. Los países se agruparon siguiendo los objetivos de cada análisis. De esta forma, se formaron dos grupos de países especializados en recursos naturales. Uno de ellos, denominado NR SPECIALIZED, integra a las economías cuyas exportaciones de RN representan más del 50 % del total de las exportaciones; el segundo grupo, llamado SELECTED, es el resultado de un análisis de conglomerados o clúster, e incluye a países cuyas economías están también basadas en actividades productivas primarias y además poseen un ingreso (PIB per cápita) alto o medio-alto, según el criterio de clasificación del Banco Mundial. El grupo SELECTED, está integrado por Argentina, Australia, Canadá, Chile, Colombia, Kazajstán, México, Perú, Rusia y Sudáfrica. El resto de agrupaciones de países que son utilizados en los contrastes son el de la OCDE y la OPEP.

[2] Algunos análisis se realizaron considerando un período más largo de tiempo, el cual se especifica en cada capítulo.

Los resultados de la revisión de la literatura sobre el capital intelectual confirman la importancia de los intangibles para el crecimiento, la competitividad, la creación de riqueza, el desarrollo y el bienestar en una nación (Bontis, 2004; Corrado et al., 2009; Lin y Edvinsson, 2011). A pesar del reconocido rol estratégico para las economías, los estudios sobre el CI en el ámbito macro son aún recientes, no hay un marco analítico ampliamente aceptado, y existe una gran dispersión de la información, todo lo cual dificulta su comprensión.

Con el fin de evaluar y gestionar el CI de los países se han desarrollado diversos modelos, los cuales difieren de aquellos diseñados para medir los intangibles de las empresas, aunque mantienen, directa o indirectamente, sus componentes básicos: capital humano, capital estructural y capital relacional. En este ámbito macro, fueron identificadas dos líneas principales de trabajo, una más cercana al estudio del CI de las empresas, impulsada principalmente por académicos, y otra desarrollada por organizaciones internacionales y escuelas de negocios, más orientada a la medición del desarrollo, la capacidad de innovación y la competitividad de las naciones, utilizando los intangibles como parte de las variables explicativas. Estos dos grupos difieren en su base conceptual, la metodología y sus objetivos. A pesar de estas diferencias, las clasificaciones de países reportadas tienden a converger, lo que indicaría que hay diversas vías para contabilizar los intangibles de los países que proporcionan información similar, pero requieren parcialmente diferentes insumos (indicadores) y capacidad analítica. Por lo tanto, para la gestión de los intangibles en el ámbito nacional, los responsables políticos podrían utilizar cualquiera de los modelos analizados, excepto el HDI, pues éste incluye intangibles que no reflejan con exactitud la capacidad de crecimiento de un país, como es el caso de los indicadores de salud de la población.

Por su parte, el análisis de los determinantes del producto de los países basados en RN, mostró que estos recursos podrían tener un impacto positivo sobre el PIB, si los factores tradicionales de producción (capital y trabajo) se combinan adecuadamente con intangibles (apertura, atracción de inversión extranjera directa-, buenas instituciones y capacidad de creación tecnológica medida como concesión de patentes), como propone la Economía del conocimiento. Estos hallazgos confirman que los RN son importantes para el crecimiento en algunos países (SELECTED), mientras que en otros, como en el caso de las naciones más desarrolladas (OECD) o de aquellas que forman parte de la OPEP, su impacto no es determinante para el desarrollo e incluso tienden a afectar negativamente. Además, los recursos renovables

y no renovables no muestran iguales impactos. La actividad agrícola, por ejemplo, no afectó significativamente el producto de los países del grupo SELECTED, mientras que en el resto de las muestras su influencia fue negativa. Por su parte la minería fue sólo significativa y positiva en los países del grupo SELECTED, mientras que el petróleo lo fue en todos los casos analizados.

El análisis empírico también reveló la importancia de la dimensión internacional como canal para acceder a tecnologías y conocimientos extranjeros a través de la inversión extranjera directa. Además, un efecto positivo de la capacidad de innovación local y la generación de tecnologías también se han identificado como pilares de la senda de desarrollo de éstos países especializados. Esto indicaría que no sólo las capacidades de absorción, sino también de innovación, son esenciales en estas economías, las cuales serían claves para mantener el desarrollo y el aumento de la productividad en el largo plazo. Por su parte, las instituciones también fueron identificadas como un factor significativo para el crecimiento para estas especializadas economías, ya que facilitan el control de las adversas presiones derivadas de la explotación de los recursos naturales y favorecen un adecuado clima para la inversión.

De los resultados obtenidos, se puede inferir que la opción adoptada por los países exitosos basados en los RN es diferente de aquella seguida por los miembros de la OPEP o de otras economías especializadas en RN. Los primeros, han sido capaces de superar las dificultades derivadas de las fluctuaciones en los precios de las materias primas y las presiones sociales y económicas internas, aprovechando estrategias de largo plazo orientadas por la Economía del conocimiento y la globalización, como también lo han hecho las naciones más desarrolladas, describiendo así una nueva senda de desarrollo. Dicha senda asume los recursos primarios como un pilar de la economía, y la inversión en intangibles dentro de este sector, como una clave para agregar valor y diversificar los productos y sus exportaciones, sin tener que abandonar dichas industrias.

El caso de Chile confirma una vez más que las economías basadas en los RN pueden enfrentar con éxito los potenciales efectos negativos de la exploración de estas dotaciones físicas, por medio de estrategias que combinen los principios económicos tradicionales con aquellos que aporta el marco de la Economía del conocimiento y la teoría evolutiva. Para estos países, la promoción de la inversión en activos físicos (capital), la apertura internacional, la inversión extranjera directa, y las capacidades de innovación son cruciales para la definición de estrategias de crecimiento y el cierre de la brecha con las economías más avanzadas.

A pesar que los datos muestran que la economía chilena ha reducido la brecha que la separa de los líderes, y que a su vez las reformas y políticas aplicadas durante las últimas tres décadas han tenido un gran éxito en los campos institucionales, la educación, las inversiones y el comercio internacional, también muestra algunas debilidades importantes. En este sentido, es extremadamente relevante fortalecer la creación de capacidades tecnológicas locales, no sólo como medio para mejorar la capacidad de absorción, sino también para la creación endógena de conocimientos en aquellos sectores directamente vinculados a la explotación de los RN, ya sea tanto en disciplinas trasversales (por ejemplo TICs, nanotecnología, robótica, etc.) como en áreas directamente relacionadas al sistema productivo (por ejemplo biotecnología, teledetección, inocuidad, conservación medioambiental, etc.), de forma tal de ir agregando valor a los productos exportados y diversificarlos. Paralelamente, es imprescindible contar con buenas instituciones. Particularmente Chile debe mejorar la efectividad del gobierno, la capacidad regulatoria y poner más atención en el control de la corrupción. Otra de las áreas que requiere una pronta acción es la reducción de la desigualdad social, pues Chile presenta uno de los peores índices de la región y también de la naciones que forman parte de la OECD, tanto por razones de igualdad, como también para reducir los riesgos de potenciales estallidos sociales que afecten los pilares actuales de la economía, como es el caso del favorable entorno para la inversión local y extranjera, y la eficiencia en los procesos productivos y exportadores.

Por tanto, son imperiosas políticas para incrementar el gasto en I+D (público y privado), asociado a los sectores clave y en completa consonancia el empresariado; mejorar la calidad de la educación y fortalecer el acceso al nivel universitario, como respuesta a la mayor demanda por capacidades locales. Mientras que en el plano social, más esfuerzo se necesitan para lograr reducir la brecha salarial, por medio de mecanismos que a su vez contribuyan con la actividad productiva en los sectores basados en RN. En este sentido, nuevamente una mayor y mejor educación son un mecanismo largamente demostrado como herramienta para alcanzar este propósito, como así también el acceso a los bienes públicos básicos.

Aun cuando los resultados y hallazgos son consistentes, esta investigación también presenta algunas limitaciones que son comunes a este tipo de trabajos, a pesar de las precauciones tomadas en los análisis y en la revisión de la literatura. Las debilidades más importantes están relacionadas con los datos y los proxis utilizados para evaluar los intangible variables. Sin embargo, los resultados son robustos y ampliamente respaldados por la literatura. Adicionalmente, otra debilidad se deriva del enfoque

macro utilizado, quedando abiertas diversas áreas de investigación para conocer en detalle (nivel micro y meso) los procesos que conducen al desarrollo de las economías especializadas en RN.

Finalmente, los hallazgos han abierto nuevas oportunidades de investigación sobre el crecimiento y desarrollo de las regiones, países y territorios especializados en RN, así como en el ámbito sectorial, sobre todo en agricultura y minería. Además, otras propuestas de investigación podrían ser dirigidas a analizar los efectos de derrame tecnológico (spillovers) desde sectores relacionados a las industrias primarias, como así también a conocer en más detalle los flujos de conocimientos dentro de las industrias basadas en RN.

INTRODUCTION

Development is one of the most important concerns of citizens, policy makers, scholars, international organizations, entrepreneurs and civil associations seeking to improve quality of life. In striving for this goal, nations face a great challenge that has been placed at the center of economic discussion because there is no single right answer, and the way to achieve sustainable development is still not entirely known. The reason is that changes in the environmental and country-specific characteristics, such as culture, social rules and structures, physical endowments, institutions, historic legacy, and geostrategic situation and geographic location, define a complex puzzle in dealing with development strategies.

Several emerging theories and development models have been proposed in an effort to identify ways to achieve better welfare and convergence with advanced economies. The fact is that some nations have followed good practice recommendations and have implemented guidelines resulting from models, and they have caught up, while others have designed their own trajectory and have fallen behind.

This situation put pressure on policy makers who require suitable information to guide their nations toward development and to avoid failure. Literature can help in this regard, but the emergence of new contexts, advances in knowledge and specific conditions offer new challenges to policy makers and scholars, and therefore more research is needed in both traditional and emerging issues related to development.

For economies specialized in natural resources (NR), this fact is even more complex (Sachs and Warner, 2001; Lederman and Maloney, 2007), because several issues may impact negatively on development, as described in the literature. However, some evidence shows that a new growth path, based on knowledge, is plausible if certain conditions converge. For this reason, this work attempts to contribute to fill the knowledge gap, focusing on development and economic growth in countries with economies heavily based on natural resources, taking the foundations of the Knowledge economy (David and Foray, 2002) as the main conceptual framework.

Hence, the most relevant question is about the possibilities of development for NR-based economies in the Knowledge economy framework. In particular, this Thesis analyzes the factors determining growth within an analytical framework that integrates the traditional view of production factors (Sala-i-Martin, 2000) with a more

knowledge-oriented perspective, in order to provide a set of bases for policy making to support long-term progress. The importance of this study is grounded in the need to offer a new analytical framework for these countries, because traditional approaches have failed to solve old problems deriving from the exploitation of natural resources (Rosser, 2006; Manzano, 2012; and Pérez, 2012), among which are industrialization, social conflict, corruption, pollution, and increased social spending beyond rational criteria (Gylfason and Zoega, 2006; Sala-i-Martin and Subramanian, 2013). Furthermore, systemic studies on development and natural resources are scarce, and very few of them address these topics together from an evolutionary approach. In addition, this research tries to find clues for sustainable growth, based on the evidence observed in successful nations that have taken a different trajectory to that generally proposed by scholars and policy makers, who recommend moving to more knowledge-intensive sectors and giving up resource industries.

The outstanding case of Chile reinforces this analysis, because some authors have insinuated that the middle-income trap and the natural resources curse would be the crucial bottlenecks for developing countries (Sachs and Vial, 2001; Ohno, 2009; Felipe et al., 2012). The search for alternatives providing an escape from this destiny makes this work all the more attractive and useful.

The questions surrounding policy makers and citizens discussed in this work are: Why must economies based on natural resources (i.e. Chile) invest part of their income in innovation and other intangible assets, instead of increasing their social spending? To which industrial policies should they devote greater efforts? This research also attempts to collaborate with strategic decisions that encourage long-term growth and improve quality of life, not only in Chile, but also more generally in other natural resource based nations as well.

In order to fulfill its stated aims, this Thesis is developed through three empirical works along with a review of the literature on key fundamental topics that support this research. The first seeks to identify advances in the study of Intellectual capital (IC) and how to manage this conceptual framework in analytical research. In addition, an in-depth comparison of the main available models to measure IC at country level is performed in order to clarify its components and mechanisms for evaluating and managing intangibles. By incorporating the results of this first step, the second work deals with the determinants of growth in NR-specialized economies, using empirical models. Finally, taking into account the results of the two steps above, a third evaluation is addressed to analyze the case of Chile, a developing and NR-specialized

economy with a successful development trajectory, undertaking the analysis as an integral and evolving process. This work seeks to offer some clues to solve the slowing growth observed in Chile over the last years, and to provide insights regarding future steps to support the development in the long run, which could be useful for other developing and specialized economies.

This Thesis is composed of six chapters. The first includes the research questions, hypotheses and a description of methodology. The second presents a literature review of the main theoretical bases for this research, from the Neoclassical growth theory to the knowledge economy framework, also incorporating the main arguments behind the relationship between natural resources and growth. Chapter III contains an analysis of intangibles based on a systematic literature review. In Chapter IV, an empirical research is carried out on the key determinants of development in economies dominated by NR. The ensuing chapter (Chapter V) analyzes the case of Chile, and finally, Chapter VI summarizes the main conclusions, policy implications, limitations to this work and future research opportunities.

INTRODUCCION

El desarrollo ha sido una de las preocupaciones más importantes de los responsables de las políticas, académicos, organizaciones internacionales, empresarios y la sociedad en su conjunto, quienes buscan alcanzar una mejor calidad de vida. Para lograr este objetivo, las naciones se enfrentan a grandes retos, pues no hay una sola respuesta correcta, e incluso, no es del todo conocida la mejor forma de lograr un desarrollo sostenible. Lo anterior es consecuencia, entre otros causas, de los permanentes cambios en el entorno y a las características específicas de cada país, como son la cultura, las normas, las estructuras sociales, las dotaciones físicas, las instituciones, las condición geoestratégica y la situación geográfica, todo lo cual define un complejo puzle al cual deben enfrentarse los países para la elaboración e implementación de sus estrategias de desarrollo.

Diversas teorías, así como también una serie de nuevos marcos conceptuales sobre el crecimiento y el desarrollo, se han elaborados con el fin de lograr la convergencia con las economías más avanzadas y así alcanzar un mejor bienestar. En efecto, algunos países han seguido las recomendaciones ofrecidas por las naciones líderes y organismos internacionales, poniendo en práctica las directrices resultantes de los modelos de crecimiento, lo cual ha permitido solo en algunos casos avanzar y reducir efectivamente la brecha económica, mientras que otras naciones han preferido diseñar sus propias trayectorias, alejadas de los postulados con más consenso, dando resultados muy diversos, lo que en definitiva dificulta la definición de recomendaciones libre de riesgo a partir de estas evidencias.

Esta situación genera incertidumbre y a la vez presión sobre los responsables de las políticas, quienes requieren adecuada información para guiar sus naciones hacia el desarrollo, evitando el fracaso. En este sentido, las evidencias contenidas en la literatura pueden colaborar con este propósito, sin embargo, la emergencia de nuevos contextos, el avance del conocimiento y las cambiantes condiciones, que además son específicas de cada caso, ofrecen nuevos retos a los académicos y gobernantes. Por lo anterior, se torna imperioso llevar a cabo estudios que ayuden a resolver estas cuestiones, tomado en cuenta tanto los tradicionales desafíos sobre el desarrollo, como así también aquellas interrogantes que surgen a raíz de los diversos cambios que experimenta la sociedad.

En el caso de las economías especializadas en la explotación de los recursos naturales (RN), esta situación es aún más compleja (Sachs y Warner, 2001; Lederman y Maloney, 2007), ya que existe una alta propensión a que estos sectores impacten negativamente en el desarrollo, como argumenta la literatura. A pesar de ello, algunas evidencias mostrarían que una nueva senda de crecimiento, basada en el conocimiento, es plausible si una serie de condiciones convergen. Esta Tesis aborda precisamente esta cuestión, como forma de contribuir al conocimiento de las claves que estarían detrás de estas evidencias, centrándose en el crecimiento económico y desarrollo de aquellas economías altamente especializadas en sectores basados en los recursos naturales, tomando en cuenta para ello el marco conceptual de la Economía del conocimiento (David y Foray, 2002).

La interrogante clave estaría por tanto relacionada con cuáles son las reales posibilidades de desarrollo que tienen estos países en el marco de la Economía del conocimiento. En particular, esta Tesis analiza los factores que determinan el crecimiento de estas naciones, utilizando un marco analítico que integra la visión tradicional de los factores productivos (Sala-i-Martin, 2000), con una perspectiva más enfocada en el rol de los activos intangibles, con el fin de proveer un conjunto de bases para la formulación de políticas para impulsar el progreso en el largo plazo. La importancia de este estudio radica en la necesidad de ofrecer un nuevo marco analítico para estos países, ya que las teorías más convencionales no han logrado resolver viejos problemas derivados de la explotación de los recursos naturales (Rosser, 2006; Manzano, 2012; and Pérez, 2012), entre los cuales se encuentran la desindustrialización, los conflictos sociales, corrupción, contaminación, y aumento del gasto público por sobre criterios racionales (Gylfason y Zoega, 2006; Sala-i-Martin y Subramanian, 2013). Además, los estudios sobre los recursos naturales y su efecto en el desarrollo desde una perspectiva evolutiva no son tan abundantes como se desearía, persistiendo una perspectiva de carácter más tradicional. Asimismo, esta investigación trata de encontrar algunas claves sobre el crecimiento sostenible, teniendo como base la evidencia observada en las naciones exitosas que han logrado una trayectoria diferente a la habitualmente propuesta por académicos y responsables políticos, quienes recomiendan una transformación industrial hacia sectores más intensivos en conocimiento, renunciando a las industrias basadas en recursos naturales.

El sobresaliente caso de Chile refuerza este análisis, pues a partir de este caso de estudio se aborda un análisis que intenta mostrar las vías que podrían seguir los países

con economías especializadas en RN para evitar la trampa del ingreso medio y la maldición de los recursos naturales, restricciones que obstaculizan el crecimiento de estos países en desarrollo (Sachs and Vial, 2001; Ohno, 2009; Felipe et al., 2012). La búsqueda de alternativas para sortear estas restricciones hace aún más atractivo y útil este trabajo. De esta forma, entre las preguntas que son parte de este trabajo y que a la vez rodean a los responsables políticos, y ciudadanos en general, están: ¿Por qué las economías basadas en los recursos naturales (como por ejemplo Chile) deben invertir parte de las rentas en innovación y otros activos intangibles, en vez de destinarlo totalmente al gasto público social? y ¿Dónde la política industrial debiera poner más esfuerzos en este tipo de economías? En definitiva, esta investigación trata de colaborar con las decisiones estratégicas que fomentan el crecimiento a largo plazo, y a su vez, mejoran la calidad de vida de los habitantes, no sólo para el caso de Chile, sino también para otras naciones con alta concentración de industrias basadas en los RN.

Para dar respuestas a estas interrogantes, la Tesis se desarrolla a través de tres trabajos empíricos junto con una revisión de la literatura sobre aquellos elementos conceptuales que dan soporte a esta investigación. El primero está orientado a identificar los avances en el conocimiento sobre el Capital intelectual (CI) y las formas de evaluar y gestionar los intangibles. Además, se realiza una comparación en profundidad de los principales modelos disponibles para medir el CI en el ámbito de los países, con el fin de identificar sus componentes y mecanismos de evaluación y gestión. Posteriormente, e incorporando los resultados de este primer estudio, el segundo trabajo se ocupa de los factores determinantes del crecimiento en aquellas economías altamente especializadas en RN, mediante la estimación de modelos empíricos. Por último, y teniendo en cuenta los resultados de los dos análisis previos y utilizando como base un enfoque integral y evolutivo, un tercer estudio es dirigido para analizar en detalle el caso de Chile, un país en desarrollo con una economía altamente especializada en RN, que ha mostrado una exitosa trayectoria en las últimas tres décadas. Este último estudio trata de encontrar respuestas a los signos de desaceleración del crecimiento observados en Chile en los últimos años, y proporcionar así, información sobre los pasos futuros que debieran darse para reactivar el dinamismo y avanzar en su desarrollo, todo lo cual podría ser también útil para otras economías con similares características.

Esta tesis está estructura en seis capítulos. El primero incluye las preguntas de investigación, hipótesis y una breve descripción de la metodología. La segunda sección

presenta una revisión de la literatura sobre las principales bases teóricas que sustentan esta investigación, partiendo desde la Teoría neoclásica del crecimiento hasta el marco conceptual de la Economía del conocimiento, incorporando también los principales argumentos sobre la relación entre los recursos naturales y el crecimiento. En el Capítulo III lleva a cabo un estudio de los intangibles, basado en una revisión sistemática de la literatura. En el Capítulo IV presenta una investigación empírica sobre los determinantes del desarrollo en economías basadas en los recursos naturales. En el Capítulo V se analiza el caso de Chile, y por último, el Capítulo VI resume las principales conclusiones, implicaciones de políticas, limitaciones del trabajo y las principales oportunidades para futuras investigaciones derivadas de este trabajo.

Chapter I. OBJECTIVES AND MAIN RESEARCH QUESTIONS

This chapter presents the main aspects that contribute to define the Thesis. First, it is justified the relevance of research, based on key literature relating to the topics involved in this study, defining the objectives, hypotheses and research questions. Furthermore, it offers an overview of Chile's economy, characterizing its economic structure and performance, and introducing the current problems affecting its development. Secondly, it describes the methodology used to address the research questions and contrast the hypotheses, and finally, the thesis structure is presented.

1.1. Relevance of research

Economic growth and development have historically been two interconnected objectives that governments and citizens have sought to improve their welfare. However, for many countries, this has been an unreachable challenge, because of the complexity of this task, the difficulties involved in managing productive resources, the diversity of interests and the changing contexts. For this reason, and from many perspectives, scholars have attempted to identify the factors that determine the development and the dynamics of this process, with the purpose of assisting policy makers in drafting and implementing policies.

Empirical evidence shows several cases of economies that have taken off by implementing successful strategies to manage their resources (some examples in Wright, 1990; Frankel, 2010; Sæther et al., 2011; Ville and Wicken, 2012), but it is difficult to detect a single set of best practices that can be imitated by all countries in order to achieve a better performance, as the country-specific factors, environmental conditions and other exogenous constraints force this process to be adjusted in each case (Nelson, 2008), which is defined as multi and two-way causal (Castellacci and Natera, 2013), dynamics, and often with unpredictable results. Thus, emerging new questions should be addressed at a national level and for specific economies, as this study suggests.

Economic specialization is a formula that has been adopted by several countries to increase wealth and welfare; however, many cases of failure are reported in the literature, mainly as a result of inadequate policies and strategies implemented on the basis of traditional approaches (Frankel, 2010; van der Ploeg, 2011). Despite the above

facts, physical resource endowments have also been a fundamental pillar of development in some countries. Cases such as the United States of America, Norway, Australia, Sweden, Chile and Canada confirm that natural resources can be a lever for growth. Most of these successful economies have chosen to transform their traditional economic activities, becoming more knowledge-intensive actors, but doubt remains about whether it is feasible to grow without having to make this change, and strengthening the natural resource-based sectors instead. It is relevant, therefore, to identify the key aspects driving the economic performance of successful NR economies, for which we require a broader analytical framework that will help to explain this phenomenon.

To understand these divergent results, the analysis must be done under a broad scope in terms of the causes behind the facts and the performance of both traditional and new factors. Taking a quick look at economic history, it is possible to recognize changes in the relative importance of different production factors, and how this transformation has been accelerating over time, constantly creating new uncertainties, options, and challenges for policy makers. In fact, after an era dominated by agriculture and related services in Medieval times and the Renaissance, when land and labor became the most important factors for economic progress, the industrial era arrived, allowing production processes to be intensified through new machines, technologies, equipment and organizational systems, becoming physical capital the most important factor supporting countries' income growth. In the nineteenth and twentieth centuries, capital dominated the attention of economists who focused mainly on neoclassical economic models that explained growth in terms of capital and labor, and even labor productivity was determined by the capital accumulation process (Sala-i-Martin, 2000; Weil, 2006). From the latter part of the twentieth century, new assets, characterized by their intangible nature, began to be important for development, both at macro level and firm level; hence, studies on the relationships between agents, human capital (as endogenous element), technology and knowledge were on the research agendas, mirroring the path followed by some economies (Corrado et al., 2009).

Just as these transformations have been taking place, macroeconomic studies have also been evolving to adjust conventional growth theories, and to develop new analytical frameworks, placing intangible assets the cornerstone of the economy, introducing endogenous and systemic perspectives to the models, and opening up new questions and opportunities for countries. This new approach, called Evolutionary

growth theory (Nelson and Winter, 1974), is grounded on the Knowledge economy concept and provides new tools to understand and predict economic performance of countries in which innovation is the pillar of sustainable growth, knowledge being assumed as a complex entity, and the environmental conditions for decision-making are always changing in a complex process of co-evolution and transformation (Nelson and Winter, 1982; Dosi, 1988; Castellacci and Natera, 2013).

This framework not only offers new opportunities to knowledge-intensive industries, but also for countries based on traditional resources, thus requiring the reformulation of the development concept because the key aspect for progress is in immaterial assets. The questions posed here include the following: How should physical and intangible resources be combined to overcome development barriers in resource-based countries? What options do lagging countries have in the Knowledge economy and how to manage them? What are the factors affecting development in NR-based economies?

This thesis deals with these problems from the knowledge economy perspective (Foray, 2004), since the more traditional approaches fail to offer enough answers regarding how to grow when the economies are dominated by NR-industries. Instead, they propose structural changes as a way to achieve progress (Smith, 2007; Piesse and Thirtle, 2010; Felipe et al., 2012). According to the new literature, the factors liable to support NR-based sectors and drive countries toward development of NR based sectors are knowledge, technology, strong institutions, greater investment in human capital and more openness policies (Ferranti et al., 2002; Frankel, 2010; Van der Ploeg, 2011). However, production factors and their relationships are not yet clear enough and more theoretical and empirical contributions are required to assist policy decisions. This fact opens up new ways for resource-based countries and is, therefore, one of the most important motivations of this research, in order to understand the development trajectories of such economies in the knowledge era, and also to be able to provide policy recommendations.

In order to address this issue, this doctoral Thesis combines two main topics involved in country development studies. The first is related to new approaches available for analyzing economic growth, particularly the Technological gap theory (Fagerberg, 1987; Verspagen, 1993) and the Intellectual capital framework (Foray, 2004), while the second topic is the relationship between NR and growth, which is tackled by integrating the new approaches of growth, such as the Evolutionary growth and Technology gap theories, with the more traditional frameworks.

Regarding the first, Technological gap studies are more abundant in the literature than those referred to Intellectual capital, and offer an adequate analytic framework and theoretical foundation to study and understand countries' growth differences based on innovation and imitation processes as main drivers (Fagerberg and Verspagen, 2002; Castellacci and Álvarez, 2006; Nelson, 2008). On the other hand, works on IC at macro level are recent, there is no widely accepted analytic framework and considerable dispersion of information is observed, even though scholars and policy makers recognize the importance of intangibles as the pillars of competitiveness, wealth creation, development, and welfare (Bontis, 2004; Corrado et al., 2009; Lin and Edvinsson, 2011). In addition, IC allows a more flexible, articulate, multilevel, and comprehensive analysis including not only technology factors but also social and other contextual elements. This motivates further, a detailed study in the advance of knowledge in Intellectual capital, in order to identify ways of incorporating these principles into the empirical analysis, and also to contribute to building the conceptual framework and harmonization of measurement tools.

The second area of research in this Thesis are natural resources and their impact on growth, using, as a novelty, the evolutionary approach proposed, among others, by Smulders (2005), Pérez (2008) and van der Ploeg (2011), to try to identify successful development paths and key factors. The empirical work is performed with evidence reported by countries largely based on NR and with an outstanding economic behavior. The literature, which addresses these questions from a more traditional perspective, contributes with a large discussion on the causes of failures and successes, but often takes into account production factors as exogenous variables. Moreover, many of the studies refer to natural resources as a curse, using a static vision, and their results are not completely clear, although the majority point out that NR are a negative factor to growth (Sachs and Warner, 1995, 2001; Smulders, 2005; Frankel, 2010).

Thus, we ran a dynamic model to determine the factors involved in countries' income, for economies based on natural resources, taking the neoclassical production function as a starting point and then including variables of intangibles and endogenous processes.

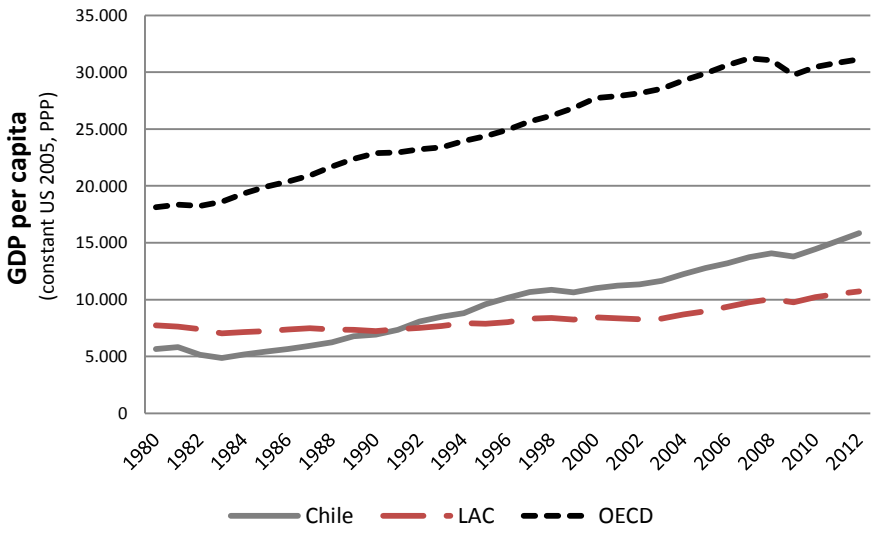
Finally, a gap analysis is conducted integrating the Technology gap and Intellectual capital frameworks into the case study of Chile. The analysis combines NR and complementary and fundamental elements that define a sustainable development path, from the Knowledge economy perspective. This Thesis is envisaged as a

contribution to solving problems related to growth in NR-specialized countries and the new challenges resulting from globalization and the knowledge era. Moreover, the analysis of the Chilean convergence trajectory seeks to serve two main purposes; the first, to take this country as a representative case to address factors determining convergence in these specialized economies; and the second, to tackle the problem of long-term growth in Chile and its dependence on resource industries.

1.2. Chile: A developing country based on natural resources

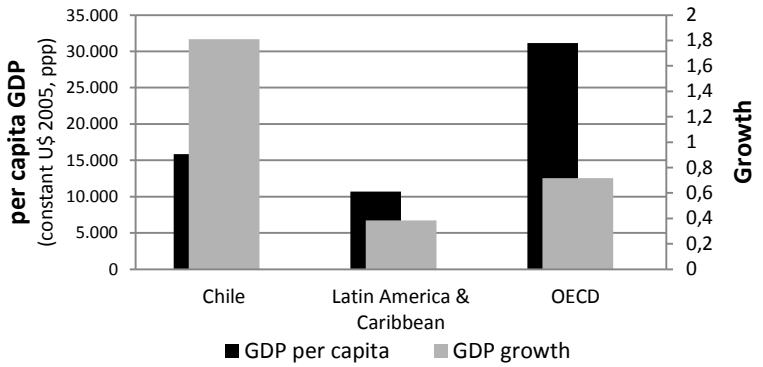
Chile is a small country located on the southwestern edge of South America, with 756,096 square kilometers and a population of less than 17 million (INE, 2012). In the last three decades, this nation has stood out for its economic progress and has been considered as an example to the region (Rosser, 2006; Frankel, 2010). According to the World Bank (2013), Chile has recently been classified as a high income economy, reaching a per capita GDP in 2012 of US$15,848, equivalent to 1.8 times higher than in 1980 and the highest growth rate among Latin American countries, as well as among OECD members (Graphs I.1 and I.2).

Graph I.1. Per capita GDP of Chile, Latin America & Caribbean (LAC), and OECD. 1980 - 2010



Source: data from WDI by World Bank

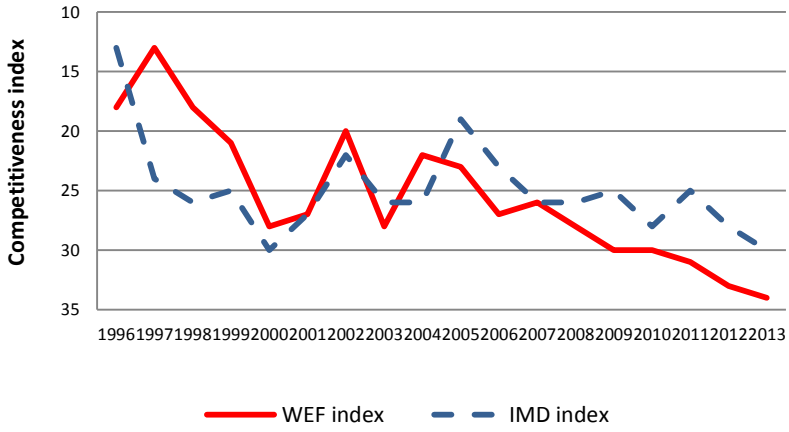
Graph I.2. Economic growth of Chile, Latin America & Caribbean and OECD. Between 1980 and 2010



Source: data from WDI by World Bank

Chile is the most competitive economy in Latin America, thanks to its strong institutional setup, efficient government, macroeconomic stability, and great openness to foreign trade (WEF, 2013). However, income is still far behind the most developed nations, and some signs of middle income trap (MIT) have been identified in the last decade (Pérez, 2012; Traub, 2013). This can be observed in the WEF and IMD competitiveness indexes (Graph I.3), while authors such as Eyzaguirre et al. (2005) have detected structural problems related to unequal income distribution, insufficient human capital and innovation, and poor quality in education.

Graph I.3. Competitiveness indexes of Chile.



Source: data from WEF and IMD

1.2.1. Main facts of economic development in the last 40 years

Scholars and policy makers agree that Chile took off economically from the 70s, after implementing deep reforms, taking place an international orientation and opening through a reduction of protection at multilateral level, followed by a strategic policy of bilateral free-trade agreements, which also attracted Foreign Direct Investment (Meller et al., 1996; Álvarez and Fuentes, 2006; Pérez, 2012).

Previously, Chile had implemented an industrial policy characterized by import substitutions, focusing efforts on manufacturing like other countries in the region, which was inconsistent with the country's comparative advantages in natural resources. After trade liberalization, these activities failed due to their lack of competitiveness in the international scenario, which forced reconversion towards the production of goods for international markets, where the country had comparative advantages (Eyzaquirre et al., 2005).

In the following decades the economy focused on exports, mainly in NR industries (agriculture, forestry, mining, fishing, etc.), owing to the small size of local market, its comparative advantages, the large foreign demand for commodities and international recommendations emerged from the Washington Consensus (among these proposals were: openness, trade liberalization, market deregulation, reduction of direct subsidies and redirection of public spending to health, education, etc.) (Albala-Bertrand, 2006). During the 80s, further economic reforms were carried out including, most notably, bank privatization, liberalization of interest rates, pension system reforms, fiscal super-plus rule, and privatization of public services and infrastructure (Corbo et al., 2005), all of which became the pillars of its current competitiveness (WEF, 2013). However, natural monopolies, now managed by the private sector, were not properly regulated and public goods and social infrastructures were not adequately provided (Eyzaguirre et al., 2005). In addition, constitutional changes to strengthen governance and the development of economic institutions, mostly regulatory and anti-trust, were also being applied.

Concerning the context, even though Chile was governed by a dictatorial regime between 1973 and 1990, there was implicit social agreement and satisfaction with economic policies (O'Ryan and Soliman, 1996), with the exception of manufacturing industries that were affected by trade liberalization. On the other hand, international relationships were improving and commerce with important markets, mainly with USA and Europe, progressed.

Since the early 1990s, along with the return to democracy, four main policy areas at the microeconomic level were prioritized: infrastructure, human capital, productive development (R&D and support to SMEs), and institutions (García, 2006). In fact, a comprehensive plan to improve infrastructures such as roads, ports, telecommunications and electricity was implemented thanks to private investments (local and foreign). In addition, the Government promoted measures to increase schooling (mainly at the primary and secondary levels) and other social benefits to reduce inequality (Eyzaguirre et al., 2005).

In that decade Chile's institutions underwent important changes, but one of the most relevant was the restoration of democracy, which consolidated political stability. This new context also increased transparency, accountability and freedom, and reduced violence, positively affecting the environment for business and FDI (Perez, 2012). Since the mid-1980s, success in international markets –with a concentration of production in a few sectors– and high commodity prices prepared the ground for future growth (Crawford et al., 2010).

The economic and institutional changes that began decades ago continued during the 2000s and later, with more attention paid to social and institutional issues, such as income distribution, social protection, education, civil rights, and justice. Local confidence in economic policies increased and new NR-related business arose as a result of international demand, macro and micro stability, low production cost factors and a suitable local system to support exports (Pérez, 2012).

Although the social environment in the country was stable, there were some additional concerns, since international competition affected economic performance. Further, citizens began to claim more and better public services, mainly education, health, social protection and pension system, along with the improvement of working conditions. This new scenario, in addition to the entry of new competitors (mainly emerging countries) onto markets, new environmental regulations, higher input costs, demand changes, new substitutes[3], and currency appreciation, caused the decline of Chilean competitiveness. Fortunately, and in general terms, during the last decade the price of commodities has shown high levels, offsetting the negative effects of the loss of competitiveness.

[3] E.g. fiber optics replaced copper (main export of Chile) in many applications.

Despite the favorable price of commodities and high profits, Chile has failed to diversify its exports or base its economy on innovation, due to the lack of a stable and strong policy in that direction and low levels of human capital and innovative capacity (Crawford et al., 2010).

To improve competitiveness, the National Innovation Council (NIC) was created in 2005 to propose a strategy of innovation, considered as the most important driver of competitiveness, because Chile showed (and shows) poor productive diversification and reduced added value on its main exports, affecting growth in the long-term perspective (Crawford et al., 2010). To finance this strategy, a royalty on mineral (copper) extraction was applied, plus a tax credit law launched to promote private investment in R&D (CNIC, 2010; Pérez, 2012). This strategy strove to eliminate the main bottlenecks identified in the innovation system[4]: low investment in R&D (public and private), reduced links between demand and local supply technology, scarcity of advanced human capital[5], fragmented and unfocused instruments to foster R&D, and low levels of interrelation and coordination between agents (CNIC, 2010). Conversely, IS of Chile has a high degree of international collaboration (OECD, 2007), which is related to openness policies and catching-up strategies, and the private sector is highly dynamic and proactive in the search for technologies.

Although reforms have brought advances[6], the economy continues to lose momentum as the WEF (2013) and IMD (2013) competitiveness reports confirm, while GDP growth can be explained by the high price of raw materials (Pérez, 2012) rather than productivity[7]. To solve this situation, some specialists insist on applying policies based on a traditional approach that emphasizes investments in tangible assets, considering technology and knowledge as exogenous factors that can be obtained elsewhere in the world, and with a State in charge of solving market failures and promoting entrepreneurs' activities. However, these policies could intensify the structural problems because, when countries converge toward the leaders, innovation capabilities become more important than catching up or other strategies based on foreign technologies and physical assets (Porter, 1990; Verspagen, 1993; Castellacci, 2002). In the case of Chile, development has been based on adapting and adopting

[4] More details of Chile's IS can be found in CNIC (2010 y 2013), OECD (2007), among others. An extended list of indicators can be reviewed in OECD StatExtracts (http://stats.oecd.org).
[5] This situation is directly related to the lack of opportunities for access to tertiary education and the lack of quality in education (Eyzaguirre et al., 2005; CNIC, 2010).
[6] For example, between 2007 and 2010, investment in R&D increased by 45% (OECD, 2014).
[7] According to Magendzo and Villena (2012), since the mid-2000s the TFP of Chile has grown less than in previous periods.

foreign knowledge, rather than endogenous innovation, which threatens its transition to a knowledge-based economy (WEF, 2013).

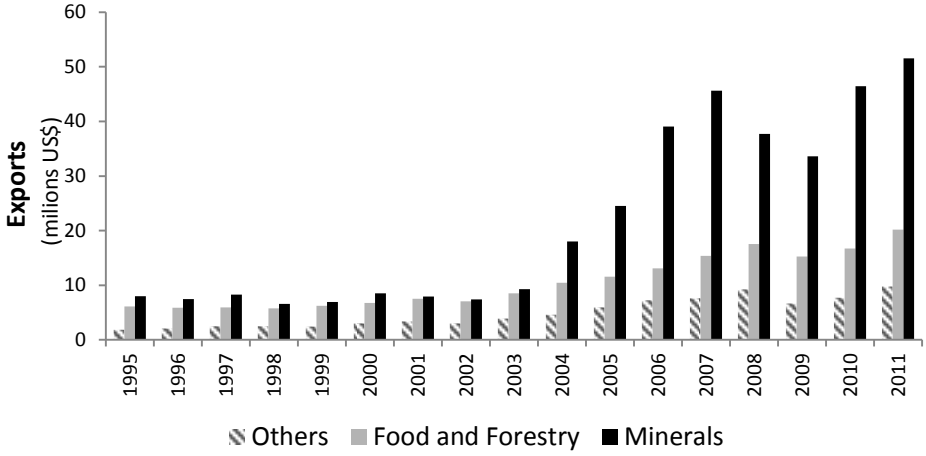
1.2.2. Economic structure of Chile

The Chilean economy has a strong presence of natural resource industries, chiefly mining, foods (agriculture and fishery) and forestry (CNIC, 2010; Maloney, 2007), which are oriented toward foreign markets, mainly as raw materials (Graph I.4). According to UNCTAD (2013), NR exports represent more than 80% of total country exports, with mining responsible for more than 60% in recent years, while renewable resources have reached a share of around 25% in the same period. These data clearly describe an economic structure dominated by NR, and therefore growth policies should take into account this productive specialization as a key to development.

The export orientation of Chile's NR industry is the result of reforms and policies carried out since the 70s, appropriate production strategies based on comparative advantages, and a strong international demand (Eyzaguirre et al., 2005; CNIC, 2010). Besides, in the last decade, the rise of China and the boom in raw materials prices have given a fresh impulse to the concentration in commodity production (Perez, 2012).

In relation to exploiting nonrenewable resources, Chile has a geographic and product concentration. In fact, after the rise and fall of the nitrate industry at the end of the 19th and the early 20th centuries, which accounted for more than 70% of total exports and over 50% of public revenues (Meller, 1996; Claude, 1997), copper extraction became the most important economic activity and GDP determinant, as a consequence of large endowments and foreign capitals and technologies. In the 1970s private copper companies were nationalized, creating the National Copper Corporation of Chile (CODELCO), which is today the main copper producer in the world and controls around 10% of the world's reserves of this metal (CODELCO, 2013). Later, investment opportunities were opened up to foreign capital through mining concessions, with a view to increasing production (Lagos and Blanco, 2010; Arias et al., 2012). Currently, foreign owners handle around two-thirds of total national production, and take advantage of the political, economic, social and legal stability of Chile, large endowments and strong international demand.

Graph I.4. Exports of Chile between 1995 and 2011



Source: data from UNCTAD, 2013

Besides copper, other minerals have been gaining in importance, such as potassium nitrate, sodium nitrate, lithium, iodine, and molybdenum, but have not reached the same importance as copper; however, they offer a positive long-term scenario for this sector (Wright and Czelusta, 2007). Moreover, the high international price of copper and other minerals has offset the increased production costs, and part of the profits is being invested in technology, mainly as an exogenous process.

The mining sector is integrated vertically, and currently there are many subcontracts, with a pattern of the spatial division of labor characterized by the functional specialization (Lagos and Blanco, 2010). This industry is capital-intensive, and technology is a key factor to achieve high productivity and economies of scale. The main suppliers of technologies and knowledge are the foreign sector due to the low capacity of domestic companies for innovation and the weak local knowledge transference, focusing efforts on adapting those developed outside the country rather than creating new ones (Maloney, 2007; Arias et al., 2012).

Current strategies in the Chilean mining sector aim to address the reduction of negative environmental effects of exploitation; improving technologies related to exploration, extraction and management to increase productivity and identify new deposits; and promoting supplier development as a way to develop and incorporate technologies and innovations (CNIC, 2013, Fundación Chile, 2014). In addition, the concern for copper substitutes is encouraging the creation of new uses for this metal, in order to reduce risk and added value to products. Nevertheless, endogenous innovation efforts still seem to be scarce and limited to this purpose.

In addition to non-renewable NR, Chile is internationally known for its forestry and food production (Pérez, 2012; Maloney, 2007). The forestry activity represents around 3.1% of GDP and 7% of exports (CORMA, 2013), and is made up of native forests and new plantations (mainly pines and eucalyptus). This sector is highly concentrated in large and domestic companies who have incorporated foreign technology and developed innovation capabilities through collaborative R&D activities with public and private research centers. Although the Chilean forestry industries not only produce raw materials, but also added value products such as doors and windows, wooden toys, newsprint, and furniture (Pérez, 2012), success still depends on the commodity prices. Indeed, unlike other traditional forestry countries, such as Sweden, Australia, New Zealand, and Canada, Chile has not developed enough technologies and still depends on foreign knowledge. In fact, these countries have gone further and currently mainly produce value-added products (e.g. furniture, toys, components, etc.), environmental services, and technologies and knowledge developed from the detected needs of NR industries.

Forestry has taken advantage of sectorial policies such as Decree Law No. 701 (1974) and Law No. 19561 (1998) that created diverse incentives (CONAF, 2014), a stable context to business, large international demand and an excellent environmental condition for forestry production. In addition, infrastructures and regulations have been encouraged to support and adapt this industry to international requirements. In the same direction, the private sector has adopted both national and international rules in different fields (environmental, social, production management, etc.), and they have incorporated the highest international standards. At present, among the main concerns are the relationships with indigenous communities, environment regulations, and productivity, establishing several strategies to face these challenges, including R&D efforts and a large network, and joint ventures with suppliers and communities (CORMA, 2013).

The food sector is another example of Chile's productive specialization in renewable NR. In recent years this industry has become the second-largest currency earner, with sales in excess of US$12 billion, and it is expected to reach US$20 billion in 2015, placing Chile among the top-ten food producing countries (ProChile, 2013). Behind these results, several strategies can be found. Probably one of the first steps to achieve this result was the capture of foreign technologies, initiated in 1960, with government intervention to create state agencies for the promotion of development strategies and investment in human capital and infrastructure (Pérez, 2012). Unlike forestry, the food

industry has been driven by small and medium producers distributed along the country, with the exception of salmon production where large multinational companies (MNC) have taken over control (Katz et al., 2011). The technology bases within this sector have principally come from abroad. Suppliers have played an important role as promoters of innovation, providing new technologies and knowledge, while universities and research centers have mainly tested and adapted foreign inventions. Complementarily, local capabilities have been improved, and important advances can be observed in human capital, infrastructure and R&D, as a consequence of private and public investments. Several projects are currently being conducted to create own technologies in a wide range of disciplines, such as genetics, biotechnology, processes, conservation, primary production, transportation, etc., to support long-term development and transform Chile into a *World Food Powerhouse*[8]**.**

Comparatively, in the food industry Chile has a similar level of development, or better, than that of the main world producers (USA, Europe, Brazil, China)[9], and its products are appreciated in international markets. In terms of sophistication, Chile concentrates on the production and export of fruit, wine, salmon, seed and white meats, activities characterized by their great complexity compared with other agricultural products such as cereals, soybean and oilseed. In general, their production and export systems require high technological and processing levels, adding value to products (Katz, 2011).

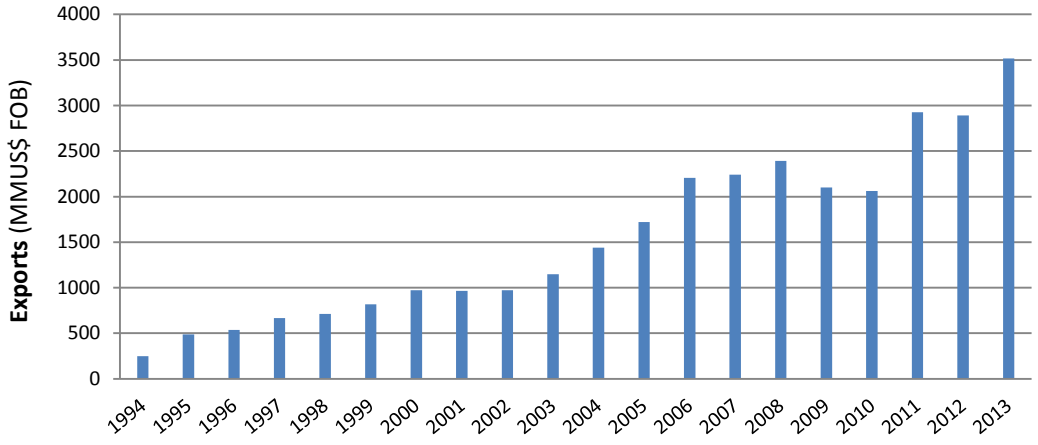
Following successful experiences in developed countries, several actions aiming to foster knowledge-based development have been implemented in these sectors (CNIC, 2010). However, this strategy is recent and the most relevant results will probably occur in the future, although efforts are still small compared to those of competitors.

It is important to consider that wine, salmon or fruit production has some important differences affecting competitiveness and potential development. In the case of wine, this industry has strong vertical links and a large international network in marketing, technology and production. The major challenges facing the Chilean wine sector are: to improve quality (and price), and to adapt production systems and products to new environmental and consumer tendencies (Consorcio vinos de Chile, 2014; Wines of Chile, 2014).

[8] Strategy of Chilean food sector.
[9] http://faostat.fao.org/

Salmon production[10], geographically concentrated in the south of country, has grown rapidly since the 90s (Graph I.5) thanks to local and foreign investments, international technologies and public support in infrastructure, entrepreneurship, openness, and FDI attraction. This activity has impacted regional development (mainly in the Los Lagos region) transforming the local economy. However, a critical problem emerged in Chile in the 2000s when an outbreak of ISA (infectious salmon anemia) virus –a consequence of rapid growth in production, the high physical concentration of farms and a weak regulatory and institutional framework (Katz, 2011; Bustos, 2012)– caused a 70% drop in production[11], equivalent to 600 million dollars, and the loss of about 17,000 jobs. To remedy this situation, the State implemented new regulations and controls, while companies modified their production systems and moved (partially) their farms. Scholars and policy makers agree that to avoid future problems and achieve sustainable development, the industry requires better regulation, proactive enterprises, and increased investment in R&D, which may help not only to improve productivity but also prevent further production difficulties (CNIC, 2010; Katz, 2011; Bustos, 2012).

Graph I.5. Chilean exports of salmon and trout



Source: SalmonChile (2014) and UNCTAD (2006)

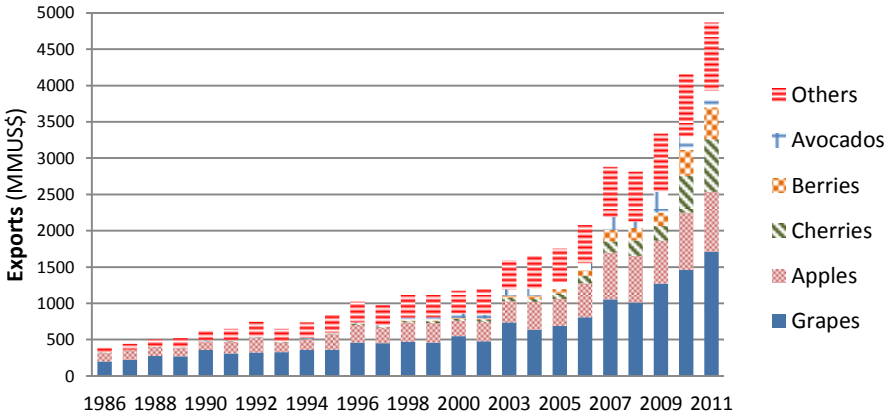
Regarding the production and export of fruit (Graph I.6), Chile has developed a greater knowledge base than in other NR activities. The first public efforts to adopt foreign technology and develop human capital were in the 60s and 70s, and were followed by several private initiatives to produce a diversity of fruit (apple, table grape, cherry,

[10] The "salmon industry" of Chile includes two main species: salmon and trout.
[11] This value is related to salmon.

berries, etc.). The success of these exports was the result of favorable environmental conditions, public support, private entrepreneurships, large international demand and foreign knowledge. In addition, producers and public organizations made the decision to invest in innovation, firstly adapting and subsequently creating local knowledge.

Unlike salmon production, fruit growing is spread throughout the country. The majority of producers are small farmers, who have strong links with local communities generating a lot of temporary and permanent employments. In general, a cluster structure can be observed with multiple interconnections and a dynamic activity among suppliers. Currently, the main challenges are to improve the bases for innovation, address new environmental regulations, diversify markets, increase productivity and reduce production costs, mainly energy and labor (CNIC, 2010; Retamales and Sepúlveda, 2011). In this direction, the new innovation strategy has created public/private partnerships to build a common agenda and increase investment in R&D (in biotechnology, genetics and other innovative technologies). Nevertheless, R&D efforts remain insufficient to meet these objectives, while major competitors advance faster.

Graph I.6. Fruit exports of Chile. Main species.



Source: Own elaboration from FAOSTAT (2014) data

Despite the successful development of NR industries, several doubts persist related to how sustainable this growth can be, because symptoms of Dutch disease (García, 2006), middle income trap (Bustos, 2012; Traub, 2013; WEF, 2013), and enclave productive structures have been identified by scholars, who agree on the need to improve both social and innovation capabilities (Maloney and Rodríguez-Clare, 2007; Pérez, 2012), since international inflows of knowledge and technologies are only a complementary source of growth, but not sufficient in themselves, all the more so

when the leader countries are only a small margin away (Verspagen 1993; Castellacci, 2006b; Sæther et al., 2011). According to the literature, this fear could be resolved through two main solutions, which may be complementary. Based on the experience of industrialized nations, such as USA, UK and Sweden, some authors (Wright, 1990; Smith 2007; Ville and Wicken, 2012) propose an industrial transformation and productive diversification reinvesting NR income in more knowledge-intensive sectors, but this alternative is not immune to social conflict, economic crisis and failure. More recent evidence, such as in the case of Canada (Smith, 2007; Felipe et al., 2012), Australia (Smith, 2007; Ville and Wichen, 2012) or Norway (Sæther et al., 2011; Ville and Wichen, 2012) shows that progress is possible on the basis of natural resources, as Gylfason and Zoega (2006), Smith (2007) and Pérez (2008) have also argued, and the key may be found in the Evolutionary growth theory. This latter alternative indicates that investment in intangibles in NR sectors could improve competitiveness and drive new and more knowledge-intensive business through a diversification within the industry (Blomström and Kobbo, 2007; Sæther et al., 2011).

This window of opportunity is explored in this thesis, analyzing key growth factors for natural resource based economies, taking a close-up look at the case of Chile, which clearly exemplifies this type of industrial specialization. In addition, the economic slow-down observed in Chile over recent years is another motivation to identify the causes and potential solutions of this bottleneck, taking into account the opportunities offered by the Knowledge economy.

1.3. Objectives and Hypotheses

The Evolutionary growth theory has opened up opportunities to understand and support new waves of development, focusing more on the relationships between agents and on intangibles assets than on the predictable interactions between actors and traditional production factors (Verspagen, 1991; Nelson, 2008). There is also a window of opportunity for traditional industries, specifically for sectors specialized in natural resources, as evidence and empirical studies are showing.

Chile, a country largely endowed with NR and an outstanding economic performance since the 1980s, but with worrying signs of deterioration in recent years, is the ultimate object of this work, in an endeavor to identify some clues to assist middle-income and NR-based countries to face the challenge of long-term growth, and to collaborate with policy makers to avoid the negative effects of NR on their economies.

Therefore, the overall aim is *to* identify the effects of the main determinants of economic growth on the development process of Chile, from a perspective that combines the knowledge economy principles and specialization in natural resources, in order to determine the key factors and the convergence trajectory, and to assist growth policies at the national and supranational levels. In particular, this work seeks to determine whether factors deriving from the Knowledge economy can support the long-run development of a country based on natural resources, such as Chile, without having to completely move to new industries. The underlying idea is that intangible assets are more important determinants of growth than physical factors (natural resources and capital) (Lin and Edvinsson, 2008; van der Ploeg, 2011), and hence, NR dominated economies could reach a high and sustainable level of income by investing in intangible assets, as the most developed nations have shown in recent history (Lin and Edvinsson, 2011).

We expect the positive effect of the knowledge factors, such as technological capability, relationships and human capital, to improve the productivity of natural resources based industries, avoiding negative impacts on income as described in the specialized literature. In the specific case of Chile, this should be reflected in the convergence process, while the signs of economic decline can be observed in one or more key factors. Moreover, empirical information from successful NR-based countries may reveal the elements that define the progress and the convergence path of these specialized economies.

The relevance of intangibles[12] to sustainable development, the lack of a theoretical framework, the novelty of their study, the high dispersion of information, and the many measurement tools to evaluate intangibles, all lead to the first specific objective of this research: *to characterize the role of intangibles in the knowledge economy, the main work lines and management tools at a macro level*. To achieve this, a systematic review (Tranfield et al., 2003; Greenhalgh et al., 2004) of the literature on intellectual capital at a macro level has been carried out, and an analysis of assessment models created to evaluate and manage countries' intangibles. This objective is addressed by the following research questions: *What are the major advances in the knowledge of intangibles and the IC of countries? What are the main differences and similarities among models to evaluate IC at a country level? What are the main policy implications of the results of analysis?*

[12] Following Lev et al. (2005), the terms Intellectual capital and intangibles or intangible assets are used interchangeably in this Thesis.

The second specific objective is *to identify the factors that support economic development in successful countries with economies based on natural resources, considered from an evolutionary approach*. The assumption behind this is that intangibles could exert a positive influence on growth in countries specialized in NR, which is supported in the existing literature on evolutionary economy (Nelson and Winter, 1982; Castellacci, 2007a), raising an analytical framework that could be applied to NR-specialized economies, as some scholars suggest indirectly (Smulders, 2005; Pérez, 2008; van der Ploeg, 2011). Moreover, researchers' discussions on the differences between renewable and non-renewable natural resources and their importance in sustainable development lead to a diversity of contributions depending on the exploitation strategies applied and on context (Barbier, 2003; Manzano, 2012). However, there is a consensus on the problems deriving from this economic activity as suggested by Sachs and Vial (2002), Smulders (2005), and Stavins (2011). Thus, for this aim, the first hypothesis is as follows: *natural resources can positively affect growth in economies based on primary industries, but with different impacts depending on whether they are renewable or non-renewable resources* (Hypothesis 1).

According to the literature, the potential role of intangibles differs across countries, when considering the relative levels of development, since in developed countries the main source of knowledge is own-generation, which impacts positively on growth through different forms of innovation, while in developing economies the acquisition of foreign knowledge is still one of the main alternatives for catching up and progress (Castellacci and Álvarez, 2006; Silva and Teixeira, 2011). For this aim, therefore, the second hypothesis is that *intangibles exert a positive influence on growth in economies based on natural resources, as happens in developed countries* (Hypothesis 2). The assumption behind is that intangibles are important even in countries dominated by low-tech industries, such as NR sectors, and hence NR can positively impact on growth if knowledge assets are involved.

To contrast these hypotheses, an empirical analysis is conducted in order to explain the income of NR-based countries under an evolutionary approach. The estimated models were performed taking into account a set of variables selected according to the Technological gap theory (Fagerberg, 1987; Verspagen, 1993), the System of national innovation (Lundvall, 1992; Freeman, 1995), and IC frameworks (Edvinsson, 2003; Marr, 2005), along with a more traditional growth perspective (Sala-i-Martin, 2000). With data from international databases, the analyses were conducted using panel data methodology, which allows considering individual country effects and endogenous

relationships (Arellano and Bover, 1995; Castellacci, 2008b). In addition, descriptive information of variables is previously introduced, in order to characterize the differences between groups of economies.

For the case study of Chile, two specific objectives were established. The first is *to identify the determinants of GDP gap in economies based on NR,* that affect the technical efficiency and catching up processes. This aim is especially relevant for the possibilities of middle-income countries (MIC) with productive structures dominated by traditional and low-tech industries, a reason that justifies the election of Chile as target economy in this study. The second objective is *to determine the key dimensions and pillars of growth of Chile and their dynamics*, to detect the relevant fields in which policies and strategies must focus to improve development in the long run. Knowing the characteristics of the gap between Chile and leader countries with similar economic structures, and its dynamics, is especially important for the orientation of innovation policies that include NR specialization within the Knowledge economy framework. The general assumption is that more efforts should be made to improve local capacities to innovate in NR sectors, creating own technologies and knowledge, which in turn would improve competitiveness and raise the added value of exports.

This analysis is conducted by applying complementary analytical tools: Stochastic metafrontier production function, convergence analysis, and lineal regression with Panel data methodology, in order to answer the research questions: *What variables affect the GDP gap in economies based on NR?* W*hat are the key dimensions of Chilean convergence when an approach based on the knowledge economy is adopted?*

This structured analysis offers a holistic perspective, where a large historical serial data, along with comparisons and production frontier determination, provides information about the challenges for future policies and entrepreneurial decisions, based on benchmarking techniques and econometric models.

The Table below (Table I.1) summarizes the objectives, research questions, hypotheses, and the methodology used in the Thesis. More details on methodology can be found in the corresponding chapter of each work.

Table I.1. Objectives, methodology and products

Objective		Research question	Hypothesis	Methodology	Products
General	**Specific**				
To identify the main determinants of economic growth and the development process of Chile, from a perspective that combines the knowledge economy principles and natural resources	To characterize the role of intangibles in the knowledge economy, the main work lines and management tools at a macro level	What are the major advances in the knowledge of intangibles and the IC of countries? What are the main differences and similarities among models to evaluate IC at a country level? What are the main policy implications of the results of analysis?		• Cluster analysis • Correlation analysis	• A literature review on IC • A comparative analysis of assessment models of IC
	to identify the factors that support economic development in successful countries with economies based on natural resources, considered from an evolutionary approach		Natural resources can positively affect growth in economies based on primary industries, but with different impacts depending on whether they are renewable or non-renewable resources Intangibles exert a positive influence on growth in economies based on natural resources, as happens in developed countries	• Econometric model. Linear regression using Panel data.	• An analysis of key factors supporting growth of NR based countries
	To identify the determinants of GDP gap in economies based on NR, that affect the technical efficiency and catching up processes	What variables affect the GDP gap in economies based on NR?		• Econometric model. Linear regression using Panel data (Dynamic and static).	•An analysis on key factors of gap reduction of NR-based countries; and of gap dynamics of Chile
	To determine the key dimensions and pillars of growth of Chile and their dynamics	What are the key dimensions of Chilean convergence when an approach based on the Knowledge economy is adopted?		• Econometric model. Linear regression using Panel data. • Gap convergence analysis • Model estimation based on stochastic metafrontier production function	

To perform the work, two main sets of data sources were used. For the systematic literature review, data were obtained from three scientific databases highly recognized in academic spheres: Web of Knowledge, Science Direct, and Econlit; as well as the five major journals publishing papers related to Intellectual Capital according to Serenko and Bontis (2009): The Journal of Knowledge Management, The Journal of Intellectual Capital, Knowledge Management Research and Practice, The International Journal of Knowledge Management, and The Learning Organization. Additionally, literature cited in the identified journals was also reviewed, from which emerged further information related mainly to IC measurement models developed by international organizations. Thus, a wide range of data sources were consulted to ensure that the majority of formally published information was included.

The information for the quantitative analysis of the model was obtained from published international country reports (Table I.2). In order to use standardized data, the analysis was performed taking into account the rankings of each report.

Table I.2. List of models and sources used to quantitative analysis

Model	Data source
Intellectual Capital Navigator (ICN)	Lin and Edvinsson (2008)
Intellectual Capital Index (ICI)	Weziak (2007)
Value-Added Intellectual Coefficient (VAIC™)	Pulic (2003)
Intellectual Capital Monitor (ICM)	Andriessen and Stam (2005)
Intellectual capital dynamic value (IC-dVAL®)	Bounfour (2003)
Integral Analysis (INTAN)	Alfaro et al. (2011)
Knowledge Assessment Methodology (KAM)	World Bank (2012)
Global Innovation Index (GII)	Dutta (2011)
Global Competitiveness Index (GCI)	WEF (2010)
World Competitiveness Index (WCI)	IMD (2008)
Human Development Index (HDI)	UNDP (2010)
Innovation Union Scoreboard (IUS)	European Commission (2011)
Innovation Capacity Index (INNCI)	López-Claros (2011)

Source: own elaboration

The second set of data was used to perform model estimations and gap analysis. It was obtained from three international databases: World Development Indicators by World Bank[13], UNCTAD[14], and CANA[15]. These information sources contain a large volume of

[13] More details can be obtained from http://data.worldbank.org/
[14] More details can be obtained from http://unctad.org/en/pages/Statistics.aspx

time series data, spanning more than 40 years for a long list of countries, which allow running evaluations with panel data techniques. However, not all countries, databases, or variables have the same information available, and consequently the study was conducted selecting those countries and time periods with suitable information.

The sample is composed of 133 nations for the period from 1996 to 2008[16]. Countries were grouped in accordance with the objectives of each analysis. Two groups of countries based on NR were made. One of them, called NR SPECIALIZED, integrates the economies whose exports of NR represent more than 50% of total exports; the second group, called SELECTED, is result of a cluster analysis, and includes countries whose economies are also based on primary production activities and additionally have a high or medium-high income (per capita GDP), according to the WB classification. This group (SELECTED) consists of: Argentina, Australia, Canada, Chile, Colombia, Kazakhstan, Mexico, Peru, Russia, and South Africa. The rest of groups corresponded to OECD and OPEC, used as contrasts.

1.4. Thesis structure

Chapter II, the next section of this Thesis, provides an overview of the main theories and conceptual frameworks that give support to this research. In particular, the following section reviews the growth and development theories, from the neoclassical proposal to more recent frameworks related to development: the New growth and Evolutionary growth theories. The main perspectives of the latter theory are examined in detail, focusing on the ideas that conceive knowledge and technology as main progress drivers. In addition, the relationship between natural resources and growth is reviewed, paying special attention to the causes and potential impact of these resources on development, under a long-term vision, as well as the alternatives to escape what the literature has called the '*natural resource curse*' and the 'middle income trap' (Sachs and Warner, 2001; Kharas and Kohli, 2011). These topics are fundamental in conducting econometric analysis and in defining the hypothesis and research questions, considering the opportunities offered by the Knowledge economy.

The third chapter presents a systematic review of the literature on intellectual capital at a macro level, trying to clarify the importance of immaterial assets on development

[15] More details can be obtained from https://portal.ucm.es/web/grinei/cana-data
[16] Some analyses and discussions were conducted for a longer period, which is specified in each section.

and how to measure them, highlighting advances made in the study of intangibles and their relationships. In addition, a quantitative and qualitative analysis of assessment models is provided in that section, as well as a comparative study between them, which identifies conceptual lines and contributes to the construction of the theory. Chapter III also provides some policy recommendations, not only related to the importance of intangibles for country development, but also to determining which models can be applied to managing IC. The conclusions drawn are then used in the following chapters, incorporating the findings about intangibles in the econometric analysis..

Chapter IV identifies the key factors that determine the growth of successful countries based on natural resources through empirical and econometric analysis. The estimation of models begins with a traditional economic approach including variables most related to neoclassical production function. Then, technological and internationalization factors are incorporated, and finally, institutions are included as an indicator of social capital and context. The chapter closes with a dynamic evaluation as a way to verify the robustness of findings. The findings of this section provide a fundamental support for future development policies in resource-based countries, clearly showing that intangibles and an internationalization process are the pillars for specialized economies.

Chapter V gives an account of the gap analysis performed for the case of Chile, which takes into account the findings reached in previous chapters. This section offers a brief description of Chile's economic trajectory and its productive specialization, highlighting its economic advances and strong dependency on NR. The analytical evaluation is conducted by stochastic metafrontier analysis, that contribute to know the technical efficiency and technological gap of countries with similar specialization patterns as Chile, resulting in three main findings determining future policy implications: opportunities from technology catching-up; chances to improve via reorganization of available resources; and the innovation efforts required.

In the second part of Chapter V, an empirical model is performed to determine the factors that affect gap-closing in economies based on natural resources. The results obtained are then included in the last target evaluation in this chapter: the gap analysis of Chile. This gap analysis takes as frontier, or leader economy, Australia and Canada, developed countries with large resource endowments. The analysis also includes USA, an economy usually considered as leader in this type of work, and NR based in the past.

Complementing the factors identified by the models, other variables frequently used in international reports and national innovation system studies are incorporated, in order to have more elements to discuss policy recommendations. Finally, all these results permit the identification of strengths and weaknesses in Chile's development path, the effects of public policies applied, and the challenges to address.

Therefore, from a more theoretical content in Chapters II and III, through a cross country analysis in Chapter IV, the experimental part of this thesis arrives at a specific case study (Chapter V) integrating the results in each step.

In the last section (Chapter VII) a summary is given of the most remarkable findings, conclusions, policy implications and the main limitations of the study. In addition, a set of future research lines are proposed, in order to contribute with knowledge to the long-term development of specialized economies that are facing the development challenge without leaving their traditional sectors, but rather by investing in these industries to enhance their added value through intangibles and innovation, and building bridges with other more knowledge-intensive sectors.

Chapter II. LITERATURE REVIEW

2.1. Introduction

One of the most important targets for countries is to encourage development as a way to improve citizens' quality of life, by implementing policies to promote economic growth, social services, and adequate income distribution. Although development and growth are not the same, there is broad consensus on the importance of the economic dimension to advance on the development path. In fact, the most common evaluation methods for development include income as a factor of progress, and an example of this are country studies which take into account this essential variable in the explanation of development.

Diverse political, philosophical, and even religious orientations have been used in economic thought to answer open questions about the best path to achieve development. From Adam Smith to Karl Marx, including the proposals of John Keynes and Milton Friedman, a great discussion has been maintained, and still remains, regarding how to improve welfare, because in this complex, multi-dimensional and dynamic task multiple factors interact to define the outcome of the process. To guide countries toward development, new theories and approaches are being proposed to provide new analytic frameworks that offer creative solutions, which pay special attention to interconnections between actors, knowledge creation and knowledge flows in globalized scenarios and system dynamics (David and Foray, 2002; Foray, 2004; Nonaka et al., 2006).

Productive specialization is another crucial component of this complex scenario. Many countries have based their development on physical resources, carrying out a process of industrial specialization and productive concentration in commodities, as a consequence of large resource endowments and the lack of knowledge capabilities. This strategy has improved production efficiency and, in several cases, competitiveness, but export basket has been reduced, and this directly affects countries' ability to adapt to external shocks. In particular, countries with natural resource based economies are severely affected by economic cycles and have considerable problems overcoming crises and raw material booms (Lederman and Maloney, 2007). However, new approaches on development could contribute to solving the problem of NR based industries because they incorporate more dimensions and dynamism to the system, opening up additional trajectories for growth.

A brief description of new frameworks and approaches on growth and development is offered in this chapter, as well as their connection with the most traditional proposals, providing the theoretical support to this Thesis. The main strengths and weaknesses of each perspective are also presented here, to address the research under an integrated vision. The first part introduces the New growth theory and the Evolutionary growth theory, and the key elements that support the traditional perspectives. The second part presents the basis of the Knowledge economy, and the main frameworks developed: the Innovation system approach, the Technology gap theory, and the Intellectual capital framework, as well as some constraints to growth discussed in the literature. The third section includes a summary of the literature on natural resources (NR) and development taking into account countries' productive specialization and the different analytical perspectives. Special attention is paid to the causes explaining the results and impacts of NR exploitation, as a way to address the empirical work carried out in this Thesis and to build some policy recommendations.

2.2. Economic growth and development

Concern for development has always been a central issue for policy makers and scholars. To address the challenging goal of sustainable progress, growth theories have emerged and evolved in order to explain economic changes, the factors involved, and how they affect nations' income. Current theoretical models provide information on the factors that determine growth and the links between the elements that are part of the development process; however, new constraints may arise due to the endogenous and systemic nature of development and the impact of new determinants in the knowledge era (Bontis, 2004; Edvinsson and Kivikas, 2004).

Even though development and economic growth are two different concepts, albeit related, the latter is an essential component of development. In fact, the United Nations assesses human development by an indicator made up health, education and income (Malik, 2013). The issue here is that education and health depend, or at least in part, on income (private or public), since these services require economic resources to be provided. Thus, the economic dimension is a core element of development that defines the potential welfare level reached by each country, especially in developing countries.

The more traditional approaches have linked growth and development with the level of production factors available, but evidence shows that the cumulative and dynamic

nature of these elements, the different ways of integration, new and complementary factors, and the structural efforts that countries must perform to cross the threshold of each development stage, make up a very complex puzzle. From different angles, authors such as Porter (1990), Verspagen (1991) and Lin and Edvinsson, (2011), have indicated that exploiting comparative advantages without appropriate investment in knowledge capabilities, could lead to severe development problems because countries' progress must necessarily move to more innovative bases of competitive advantage, reflecting that physical assets are not enough to support long-term development.

Thus, countries with systemic failures or insufficient resources may encounter huge difficulties in their advance toward a higher economic standard. In fact, economies with poor efforts in education, institutions, R&D, and innovation may be affected by the middle income trap (MIT). In particular MIT, described as the failure to transition from middle income to high income economy, has been widely studied because it is one of the biggest challenges that developing countries must tackle in order to be part of the developed world. According to Griffith (2011), the causes of MIT are related to rising production costs and, more widely, to a decline in competitiveness, which could be a result of anchoring the economy to traditional industries and production factors, rather than intangible assets, innovation, and knowledge intensive sectors, as some new theories and frameworks propose. Indeed, the literature reports several cases of countries in the middle income trap, such as Brazil, Morocco, Philippines, Romania, Tunisia, Uruguay, and Venezuela (Felipe et al., 2012; Kharas and Kohli, 2011), whose economies have fallen as consequence of inappropriate policies and strategies, mainly related to innovation activities and institutional factors, essential elements for the change of development phase (Pérez, 2012).

To overcome MIT, countries should carry out aggressive actions in order to acquire capabilities to develop and implement appropriate industrial policies, and increase investment in intangibles to stimulate innovation processes (Ohno, 2012). Economies that have overcome the barrier of middle income to high income have a more diversified, sophisticated, and non-standard export basket (Felipe et al., 2012). Thus, one of the keys for avoiding MIT and for converging with leading economies may lie in institutional reforms and innovation capabilities, promoting continuous technology updates to bring added value and diversification to exports.

In order to lead a country towards development, the literature provides theoretical and empirical proposals to understand growth and assist in the definition of policies

and business activities to improve welfare. These theories have evolved, incorporating elements arising from the new approaches, as well as the complex interrelationships and processes. The evolution and the emergence of new frameworks have not been linear and several influences can be found from very diverse points of view, including political, social, economic, philosophical, environmental, and business-related. These approaches have reacted to new scenarios offering answers to open questions related to sustainable long-term development, thus providing new opportunities for traditional industries and least developed countries.

2.2.1. Neoclassical theory

One of the first answers to understanding development was the **Neoclassical Economic Theory**, which is based on labor and capital as determinants of countries' products and predicts growth as the result of an accumulative process. Diminishing marginal returns from production factors restrict long-term growth possibilities and, therefore, economies walked to the steady state (Sala-i-Martin, 2000; Castellacci, 2007a). In addition to labor and capital, pioneering contributions by Solow (1956) demonstrated that technical progress was also part of the explanation of growth, and this became the most important component. The incorporation of technical progress in the Neoclassical growth model allowed a partial solution to long-term growth restriction, and explains growth reasonably well, since it is a source of productivity (Nelson and Winter, 1982). However, technology was considered as an exogenous variable characterized as a public good; consequently, economies were expected to converge in the long run without explaining differences between countries.

Despite these important advances, the assumption of convergence contrasted with the evidence that showed how some countries have fallen behind, while others actually converged (Verspagen, 1993; Fagerberg, 1997; Castellacci, 2007b) making it clear that technology flows between countries had limitations and an endogenous process might exist affecting the principles of perfect competition (Barro and Sala-i-Martín, 2009).

Later works, such as those of Lucas (1988), Romer (1990), Rebelo (1991), and Aghion and Howitt (1992), took into account technology and knowledge as endogenous variables, providing an answer to increasing marginal returns from production factors. This principle was part of the **New Growth Theory**, which opens new opportunities to comprehend and boost growth, since domestic efforts to create knowledge and technologies turned into an essential pillar of development (Dosi and Nelson, 2010).

This Endogenous growth theory postulates that innovation is produced within the system, and is subject to economic incentives (Mokyr, 2010).

According to Fagerberg et al. (2010), differences in economic development across countries should be assumed as the result of these differences in endogenous knowledge accumulation. As Castellacci (2007a) indicated, this theory considers technological knowledge as a non-rival and partly appropriable economic good, provided mainly by the research sector, within an economy that tends towards a steady state of balanced growth, which may differ across countries.

The exceptional interest in resolving these issues related to growth rate differences between economies, and understanding the causes explaining the evidence, led to the study of **Convergence**, promoting a new line of research to address development problems through identifying mechanisms to reduce the gap between countries. Estimations of convergence speeds across countries were performed to provide information on the share of capital in the production function (Sala-i-Martín, 1996). Empirical results showed that the convergence rate was lower than the potential, probably due to an improper estimation of the technology effect, since it was based mainly on technological diffusion, through which most advanced economies shared technical progress with the least developed, by imitation (Barro and Sala-i-Martín, 2009). Empirical evidence on convergence allowed the identification of explanatory variables of growth, which according to Li and Liu (2005) were investment, population growth, initial per capita GDP and human capital. These findings were consistent with previous works based on more traditional perspectives on growth, but new and stronger relevance was given to human capabilities, resulting in a new dimension for the analysis of 'conditional convergence'.

Under the New growth theory perspective, Daude (2010) argued that low convergence was the result of reduced growth rates observed in many countries, which could be explained by **Total Factor Productivity** (TFP), defined as the efficiency with which production factors are combined. Over the last decades, the study of TFP became one of the main topics for scholars and international organizations seeking answers to growth problems. Under this approach, technical progress is part of the explanation of changes in TFP, which is affected by human capital, technological gap, knowledge, R&D and innovation (Nelson and Winter, 1982; Hulten, 2001; Gancia and Zilibotti, 2005). However, TFP failed to explain how technical change occurs (Esposti and Pierani, 2000).

The neoclassical perspective argues that one way to improve TFP is by increasing the stock of human capital through education and training, on the assumption that the most highly skilled workers will carry out more productive activities and with higher added value, increasing the total product (Sala-i-Martín, 2000; Weil, 2006). Thus, extensive studies on **Human Capital** (HC) led to a new framework specifically concerned with this resource, in order to find clues to enhance growth.

Following traditional views, many development strategies have been proposed, both at micro and macro level. During the 80s and 90s, several proposals were focused on promoting investment in health and education to improve human capital, measures that were part of the Washington Consensus recommendations for developing countries (Woo, 2004). However, HC is not only a productive asset, but also involves a series of intangible characteristics that require another analytical perspective to efficiently promote development and should not be seen merely as an explanatory element of TFP. Authors such as Schultz (1961) and Becker (1993) noted that human capital was accumulative and directly related to growth, and it was probably the core of economic development, beyond its effect on TFP, which began to open interesting perspectives for this new productive resource based on knowledge, accumulative processes, and with an evolutionary and endogenous nature.

In a complementary and still more dynamic perspective, Schumpeter (1947) described how 'creative responses', also called innovations, determined the success of an economy, industry or firm, since changes that generated benefits became the cornerstone of the development process. Thus, innovation and knowledge creation were incorporated to empirical growth models in order to explain country differences (Metcalfe and Georghiou, 1997; David and Foray, 2002). In addition, and at micro level, the **Resources and Capabilities** theory (R&C) pointed out that internal factors, beyond labor or capital, could also drive growth, since different combinations of these resources might result in diverse outputs determining a firm's progress. As wealth creation largely depends on the capabilities of human capital, applied strategies, and other intangible factors (Penrose, 1955; Teece et al., 1997), new perspectives were opened up for understanding development, where knowledge was placed at the center of the discussion, giving rise to the **Knowledge Economy**.

Although these approaches and theories on development have been closely linked to the economic aspect, it is widely accepted nowadays that development is a multidimensional concept and involves a larger number of dimensions (Kuznets, 1973; Alonso, 2006; Pieterse, 2010). This renewed vision of development that began to be

built mainly after the Second World War was the result of social, political and geostrategic changes. The new world order, dominated by the winning powers, pressed for the **Modernization** of the most backward economies as a way to grow and prosper, because modern countries were considered synonymous with development (Tipps, 1973; So, 1990). According to Rostow (1963), to achieve a higher standard of development countries had to go through several consecutive stages, emphasizing the importance of capital accumulation, sectorial transformation and technological modernization. However, this perspective of development by modernization failed to provide a real solution to poverty and underdevelopment in most backward countries (Reyes, 2009). Despite this new focus, an economic perspective on development was maintained, but political and social interests were added.

Authors such as Prebisch and Cabañas (1949) and Singer (1950) described this new scenario, named Dependency, as a set of interdependent relationships between poor and rich countries (periphery and center). The central idea of the **Dependency** theory is that poor countries should provide the basic and cheap resources (natural resources and labor), while developed nations offered technology and advanced goods in a vertical relationship of dominance maintained through a variety of mechanisms (controls, financial, politics, cooperation, education, culture, military, etc.). Seeking to offer poor countries a different path, scholars such as Singer (1950), Cardoso and Falleto (1979), and Prebisch (1986) proposed new economic and industrial policies focused on promoting and supporting local industries (manufacturers) and import substitution affecting domestic production and development, to break the historical trajectory, dependency and deterministic center-periphery relationship, also called Latin American structuralism (Bustelo, 1999). Thus, industrialization was considered to be a way toward development (Ocampo, 2008), characterized by structural change as a process by which economies move from being based on agriculture or extractive industries to other more technology-intensive activities, as Rosenstein-Rodan (1943, 1957) explained in the “Big Push” theory.

Recommendations based on the Dependency theory were related to internal measures in a national context and failed to recognize and incorporate the real role of the international dimension as a whole (Reyes, 2009). This situation gave rise to social and political conflicts in many developing countries, and new perspectives on development emerged, highlighting the theory of **World Systems** (Wallerstein, 2005) and, later, **Globalization** (Archibugi and Michie, 1995; Ocampo, 2004; Rodrik, 2011), that not only took into account the influence of international commerce and other economic issues

over local development, but also changes in culture, technology, traditions, policies, relationships, etc., and their effects on welfare and integration. In contrast, other countries made the decision to adopt more centralized and closed systems, but nowadays they have tended to open their borders and integrate into global systems.

The recognition of additional developmental factors beyond economic ones evolved, and today the topics of gender, democratization, human capital, governance, empowerment, culture, communication, equality, health, the environment and globalization are part of development agenda. In fact, a holistic approach to development is not only multidimensional but also multilevel, because local, regional, national, supranational and global contexts affect this process (Sen, 1998; Peet and Hartwick, 2009; Pieterse, 2010). Moreover, Rodrik (2000) indicated that high quality growth also depends on institutions, since they determine the results of the effort in development factors, which led to further extending the analytical framework for development.

Despite the fact that this new vision of development takes into account a large number of variables and perspectives, which are interdependent and dynamic, economic scope remains a central component in the discussion, and this factor may be behind other elements, mainly in developing countries that have not crossed the economic threshold to satisfy basic needs. As Peet and Hartwick (2009) pointed out, development means making a better life for everyone, which implies meeting their basic needs, and hence there is no doubt that economic performance is affecting development, just as development impacts on economic behavior. On the same line, Alonso (2006) pointed out that although development includes economic growth, development must be socially equitable.

Currently, the development frameworks of **Human Development** (Sen, 1998; Alonso, 2006; UNDP, 2010) and **Sustainable Development** (Pezzey, 1992) have come to the fore and are currently considered as the basis for establishing growth policies. These approaches also bring economic factors into the analysis because this dimension is crucial to meet economic, educational, environmental, food, or health needs, mainly for poor and underdevelopment countries. The current concept of development includes, at least, the economic, social, technological and environmental fields in a global framework. All these factors are considered in the present study, highlighting those related to economic variables because all current theories agree that these aspects are essential to development (Alonso, 2006; Peet and Hartwick, 2009) and highly relevant to NR-based countries. In particular, the knowledge economy

framework incorporates several dimensions to the analysis and offers a more comprehensive approach to development from the field of economics, because it assumes that knowledge is the engine of progress and that innovation is a tool for wealth creation (Lin and Edvinsson, 2008).

2.2.2. The Knowledge Economy

In the last three centuries, the main source of national wealth has transitioned from natural resources (mainly land and labor), through generated tangible assets (buildings, machinery and equipment), to intangible goods (Dunning, 2000; Schiuma et al., 2008, Corrado et al, 2009). Thus, the **Knowledge Economy** (KE), defined as an economy based on production, distribution, and use of knowledge and information (OECD, 1996), has been gaining importance and is being consolidated as a more appropriate framework to understand countries' development.

This new approach allows for a better understanding of differences in growth between countries since it places knowledge and knowledge accumulation as central elements of development. Moreover, in KE, intangibles are more important than physical assets and, similarly, the exploitation of technologies becomes more significant than raw materials production or low-cost labor for nations' competitiveness (Dunning, 2000; Edvinsson and Kivikas, 2004; Corrado et al., 2009). In such an economy, sustainable competitive advantage must derive from the creative, innovative and sophisticated use of knowledge and intellectual assets, which are the key strategic factors (Passerini, 2007; Mokyr, 2010). In this approach, education and training policies are more important than in the neoclassical theory, since the creation and adaptation of knowledge essentially requires a high level of human capital (Castellacci, 2006b).

This conceptual framework underscores the importance of intangible capital as the basis for sustainable wealth creation, where information and knowledge flow and generate feedback, thus increasing knowledge and establishing networks that promote new ideas (Mokyr, 2005). The new knowledge thus generated is incorporated into the production of goods and services, resulting in innovations that drive continuous process improvements (David and Foray, 2002; Foray, 2004). Knowledge can be created and incorporated into traditional activities, resulting in new opportunities for low-tech and resource-based industries, diversifying, adding value, and reinventing these sectors.

Under KE principles and following Schumpeter's ideas, several economists have paid particular attention to innovation, technology, and knowledge as key factors of development. Although these three elements are not the same, they are alike in nature –intangible– and strongly related, because knowledge is an input and also an output of the innovation process (Edquist and Björn, 1997; Carlsson, 2006; Singh, 2008), while technology can be defined as a form of knowledge, as well as a set of codified knowledge, created through an accumulative process (Dosi and Nelson, 2010).

Many perspectives have been used to study the processes of knowledge creation, knowledge diffusion, and innovation as a means to contribute to growth within nations, industries, and firms. As a result of the observed dynamics and relevance of knowledge, scholars built a theoretical framework named **Evolutionary Theory**[17], in which innovation is the core of growth and knowledge is understood as a complex entity that cannot be analyzed in purely economic terms, since it is often tacit, interactive, systemic, breaks the stability, continually upsets equilibrium, and is embodied in people and organizations as part of their culture (Nelson and Winter, 1982; Morcillo, 2006). According to this theory, there is no theoretical optimum and the economy is in permanent disequilibrium, since the possibilities for economic action are always changing through a complex process of co-evolution and transformation in which dynamic relationships between technological, economic and institutional changes play a determinant role (Dosi and Nelson, 2010; Castellacci and Natera, 2013).

Innovation System

Following the evolutionary principle, studies on **Innovation Systems** (IS) have become very popular in the last decades. This novel concept has provided a new and complementary explanation of development, where innovation and learning are behind competitiveness and growth (Lundvall, 2007). In formal terms, Lundvall (1992) defined IS as a set of actors and relationships that interact in the production, diffusion and use of knowledge. With different emphasis on each element, other authors, such as Nelson (1993), Freeman (1995), and Metcalfe and Georghiou (1997), also refer to institutions, agents, technology, and interactions as the pillars of innovation systems.

Under this framework, technical progress and innovation are conceptualized as a continuous process carried out through a network of private and public actors, who

[17] Also called neo-Schumpeterian theory (Nelson and Winter, 1982; Barcenilla and Lozano, 2000).

are permanently producing, distributing and applying knowledge (Freeman, 1995; Edquist and Björn, 1997; Lundvall, 2007). The knowledge created through this network is used to develop new and/or better products, services, and strategies that support countries' development and firms' performance in the long term (Dosi, 1988; OCDE, 2005).

Depending on territorial scope, IS can be analyzed within a country's borders (*National Innovation System*-NIS) or at a regional level (*Regional Innovation System*-RIS), whereas, if it involves only one economic sector, it can be understood as a *Sectorial Innovation System* (SIS). Likewise, IS can been defined both in broad terms and under a stricter perspective depending on the components included, but authors such as Lundvall (1992), Freeman (1995) and Edquist and Björn (1997) agree that there are two sets of elements involved in IS: (1) public and private agents; (2) relationships and institutions, the latter understood as the framework governing relations. Although the type and number of actors depend on the extension of the scope under analysis, nowadays the consensus is that firms, public organizations, and science and education sectors, at least, make up an IS.

The study of IS pays special attention to the relationship between actors, the role of the state, and those responsible for coordinating and stimulating agents through long-term industrial and economic policies (Freeman, 1995), unlike most traditional growth theories characterized by a less sector-oriented strategy and more focused on solving market failures than on the process direction (Albala-Bertrand, 1999).

From an IS perspective, the accumulation and creation of knowledge can be facilitated or prevented depending on the characteristics of the IS itself (Carlsson, 2006). Castellacci and Natera (2013) showed how the dynamics of innovation systems are driven by the co-evolution of two dimensions: innovative capability and absorptive capacity, where the role of human capital, relationships and institutions become critical for country development. These competences to innovate and to absorb knowledge depend on human capital and its interconnections, where education and training policies, along with the dynamics of the environment, are key agents to conducting a virtuous circle of innovation.

While imitation may also be assumed as a way to grow, innovation is even more critical for this purpose as the local capacities and domestic knowledge become more essential to support sustainable growth (Freeeman, 1995; Castellacci, 2002). Assuming the advantages and opportunities of innovation, advanced economies have fostered IS

by applying policies to stimulate the relationships among agents and strengthen weaker actors, which has generated positive results in several economies. In addition, some developing countries have also paid attention to the dynamic process of IS as a way to achieve development by encouraging the innovation system through policies focused on education, technology, links and innovation culture (Freeman, 1995; Erika and Watu, 2010).

However, some doubts remain regarding the effectiveness and efficiency with which this approach can be applied, as some qualitative and subjective elements are difficult to measure, and may be interpreted too broadly (Asheim and Coenen, 2005; Sharif 2006). Moreover, there are still open questions about the real possibilities of driving the innovation system within a country in an increasingly globalized world, where supranational or foreign decisions may affect local perspectives and new structures for knowledge creation are emerging (Carlsson, 2006). Thus, current works on IS are incorporating the international dimension as a route to collaborative innovation, as well as to catch up on foreign technologies and knowledge by means of international learning and imitation activities (Castellacci and Natera, 2013).

Technological Gap

As technology and knowledge are main factors to explaining differences in growth rates across countries (Verspagen, 1993; Fagerberg, 1997; Castellacci, 2008b) and learning more about the creation and transfer of technology, a research line has emerged to analyze development paths: the **Technological Gap** approach. This complementary and empirical framework brings evident implications for scholars, who have sought to understand the convergence process of countries, and their pillars and limitations, from a dynamic outlook, since small differences in growth rates could lead to huge differences in welfare (Giménez y Sanaú, 2007).

The technological gap approach is based on international trade theory, and explains the economic differences between countries as the result of innovations carried out by a leader economy that enjoys monopolistic benefits until followers imitate it (Gandolfo, 1998) and the abilities of countries to exploit the international diffusion of technologies, called *absorptive capacity* (Cohen and Levinthal, 1990). Thus, while innovation may lead to divergence between countries, imitation tends to close the gap in technological capabilities, leading to convergence (Fagerberg and Verspagen, 2002).

These two forces, innovation and imitation, appear to be opposites, but countries can take advantage of both strategies, absorbing foreign technologies and expanding the technology frontier through the generation of knowledge and innovation. Both imitation and innovation require local efforts in order to achieve essential absorptive capacities and innovation capabilities to close the gap. In fact, the imitation process is carried out through the international diffusion of technologies, which is not an automatic and effortless path, since countries need domestic capacities to select, imitate, adopt, and adapt foreign knowledge (Nelson, 2007; Verspagen, 1993), which could have heavy costs for individuals and society, and forces the implementation of long-term strategies (Abramovitz, 1986).

According to this theory, the local conditions for absorbing foreign knowledge, also named *social capabilities* (Abramovitz, 1986), involve the human capital, institutions, equipment and infrastructure that define a country's potential for catching-up and productivity advance (Fagerberg, 1987; Verspagen, 1993; Castellacci, 2002). Thus, international acquisition of knowledge may be conducted mainly by importing goods and equipment with incorporated technology, international commerce of technologies (patents and licenses), and knowledge flows between subsidiaries and headquarters of multinational companies as result of Foreign Direct Investment (FDI) processes (Keller, 2004). Such diffusion of knowledge across economies opens up opportunities to advance faster using the leaders' technologies, which depend not only on local capacities, but also on barriers to international flows, such as protection systems, local and international regulations, and the technology gap itself, since a greater proximity to leader economies reduces the options to catch up (Dosi et al., 1990; Verspagen, 1993; Castellacci, 2002).

However, the technology gap can never be closed completely by imitation alone, especially when countries are near the technological frontier. In this regard Castellacci (2008b), Porter (1990), and Ville and Wicken (2012) have indicated that in early stages of convergence, where the gap is wide, imitation is one of the main channels for economic improvement, while in advanced stages innovation becomes the most important economic driver. As total convergence is not reached by means of catching up alone, backward countries should increase domestic research efforts up to a level comparable with advanced countries, since the post catching-up phase, characteristic of more developed economies, is mainly supported by research and development (R&D) and other innovation related activities (Porter, 1990; Verspagen; 1993).

The gap between countries not only shifts as a consequence of the decisions following catch-up, but also as a result of differences in growth rates of the knowledge stock between leaders and less developed countries. According to Verspagen (1991) and Nelson (2007), this latter group may create and accumulate knowledge faster if they enjoy better institutions and well-trained human capital. The accumulative nature of these variables gives advantages to leading economies, but the limited opportunities to imitate due to proximity to the frontier cause a contrary effect and therefore, convergence can occur if appropriate development strategies are applied.

Following the technology gap perspective, economic growth may be understood as the result of three sets of factors: international technological spillover; new technologies developed by domestic innovation capabilities; and social and institutional factors that determine the potential of this process (Abramovitz, 1986; Verspagen, 1993; Castellacci and Álvarez, 2006). All these interconnected factors define a dynamic and complex context where local factors and national strategies become crucial to supporting sustainable growth.

Many studies on economic development have not only shown that countries can follow different trajectories using imitation and innovation as tools for progress, but also how some countries share similar patterns, resulting in convergence clubs (Verspagen, 1993; Castellacci, 2008b). These clubs are mainly defined on the basis of their innovative capabilities and absorptive capacities, confirming the hypothesis that the capacity to absorb and adapt international technologies and local innovations are key factors to explain differences in growth (Castellacci and Álvarez, 2006; Fagerberg et al., 2007). These results showed that convergence clubs were the result of endogenous factors beyond those of exogenous technology and capital flows, as described in Baumol (1986).

There is remarkable evidence that shows how some countries, such as Korea and Taiwan, have become developed economies by taking foreign technologies, investing in human capital, improving their institutions and economic structures, and using their comparative advantages (Verspagen, 1993; Nelson, 2007; Ohno, 2009). Others, such as Japan and Singapore, have gone beyond managing their intangibles, developing innovations, specializing in knowledge-intensive sectors, and achieving a higher economic standard (Wright, 1990; OECD, 2010; Felipe et al., 2012). These facts confirm the importance of domestic capabilities, long-term policies and knowledge for country development.

Intellectual Capital

Rooted in Evolutionary theory, the **Intellectual Capital** (IC) framework turns its attention to intangible assets that affect growth, and not only technology as the technology gap theory predicts. Furthermore, this framework allows a more flexible analysis, articulated, multilevel and comprehensive, with special attention on relationships, institutions and other contextual elements. Studies on IC are based on the idea that intangibles are the most important factors in nations' wealth creation (Dunning, 2000; Bounfour and Edvinsoon, 2005; Lin and Edvinsson, 2008).

The first works in this field were addressed at the firm level, in order to explain the differences observed between the book and market value of companies, as well as to provide more precise information to stakeholders and shareholders, as intangibles are the basis of competitive advantages of companies (Petty and Guthrie, 2000; Augier and Teece, 2008). At micro level, Cañibano et al. (2002) describe IC as the combination of organizational resources and activities, including human, entrepreneurial, and relational assets. IC includes knowledge, experience, workers' skills, R&D, organizational routines, procedures, systems, databases, intellectual property rights and resources linked to the external relations of companies.

Since intangible assets are as important for the productivity and competitiveness of countries as they are for firms, works on intellectual capital at a national level have been emerging to assist policy makers in implementing successful strategies for long-term growth. Although IC is recognized as a very important factor affecting countries' development, it only became evident in the 1990s (López et al., 2011), with increasing concern among policy makers about intangibles, not only to adapt economies to new contexts, but also for the relevancy of IC in future national performance (Lin and Edvinsson, 2011). The first work on IC at macro level was *Welfare and Security* by Caroline Stenfelt-Dunn, in 1996 (Edvinsson and Stenfelt, 1999). Some years earlier, this topic was also discussed during the meeting "Managing the IC of the Nation, Managing Knowledge Assets into the 21st Century", and later Edvinsson presented his seminal work based on the Skandia Navigator Model (Gallardo and Castilla, 2007). Despite the advances in the last decade, studies referring to IC at a country level are just beginning, they are limited, and there is not yet a generally accepted methodology to measure it (López and Nevado, 2008; Makarov, 2010; Lin and Edvinsson, 2011).

Following the seminal work of Edvinsson (2003), IC is made up of Human Capital (HC), which is embedded in people and is basically developed through education and

training, and Structural Capital (SC) which is referred to Intangibles containing stored codified knowledge. To these two components, several authors add Relational Capital (RC) (Weziak, 2007; Choong, 2008; Ramírez, 2010) comprising the relationships within a country and abroad (Andriessen and Stam, 2005, Weziak, 2007). Another important element of IC is Renewal Capital (RwC), which emerges from studies of IC at national level, and refers to the capabilities and current investments for achieving future economic growth, reflecting the innovative capability of a country (Weziak, 2007, Lin and Edvinsson, 2008). Some authors, such as Bontis (2004) and Lin and Edvinsson (2008), consider this as being part of structural capital, while Weziak (2007) includes RwC independently of human and structural capital.

The diversity of available IC measurement models, which use different methodologies and indicators, make comparisons and comparative analyses to close the gap, as well as the selection and implementation of these assessment tools, a more complex task. In addition, not all economic and intangible drivers can be included within IC, making it even more difficult to identify IC directly related to economic impacts (Ståhle and Bounfour, 2008). These weaknesses raise questions that need to be solved in order to advance in the understanding and management of IC, mainly how to properly assess IC for inclusion in macro-level studies.

Despite the novelty of IC research topics and the problems inherent to their evaluation, important findings have been achieved. Evidence shows that investment in intangibles has grown faster than in tangible assets in the last decades, and empirical and conceptual studies have been building the conceptual basis of IC at a country level. Empirical results have confirmed that IC is an important source of wealth creation for countries and their organizations (Corrado et al., 2009; Nakamura, 2010), and have identified a direct relationship between intangibles and welfare, competitive advantages, competitiveness, and development (Ghiţiu-Brătescu et al., 2010; Makarov, 2010). Ståhle and Ståhle (2006) have also highlighted that these interconnections are changing and complex because they are based on the processes of knowledge creation and diffusion, characterized as highly dynamic by the Knowledge economy.

Tomé (2004) points out that the reduced socioeconomic level of the most backward countries is directly related to their low IC level; this is also demonstrated by López et al. (2011), who found that the differences between rich and poor countries increased when intangibles were included in the economic evaluation, while Lin and Edvinsson (2011) related the most important impacts of the current economic crisis with the lower IC accumulated by peripheral European countries.

Intangibles assessments are enabling a greater understanding of the causes of growth and differences between countries through knowledge of their IC (Ferranti et al., 2002; Lin and Edvinsson, 2011). The comparative analyses provide information on leaders' best practices in order to imitate them, as proposed by the Technology gap theory. Ståhle and Bounfour (2008) pointed out that the dynamics of IC offer new insights into how IC is effectively linked to national growth, reason why variables reflecting this perspective should be used.

However, literature on IC also shows that not all intangible assets are important for growth. Therefore, scholars have selected just a few to try to characterize and manage the development of economies. Indeed, development paths depend on different intangibles at each growth stage, as described by the Technological gap theory. In this regard, Ståhle and Ståhle (2006) explain that intangibles are more important for developed countries than for the most backward economies, since the most advanced nations require more knowledge creation to expand the technology frontier, have more knowledge-intensive industries and they face the most complex development challenges (Tomé, 2004).

Integrating the main perspectives

The growth theory has always been evolving and improving its forecasts by incorporating elements to tackle new socio-economic scenarios. Policy makers have also been taking into account these changes, and have applied better practices resulting in considerable economic progress, such as those observed in Nordic countries and some economies of Southeast Asia. However, there is no consensus on a single recipe for how to grow (Rodrik, 2011), and governments may follow different paths to achieve development since diverse country factors, constraints and objectives can be pursued. In order to compare the perspectives on human capital, knowledge and technology, of each of the different theories and frameworks, the Table below (Table II.1) shows a summary of the main visions in each conceptual approach. This Table interprets and classifies the theories and frameworks, but the reality is much more complex and several overlaps can be found. Some study lines can also be discussed from different perspectives, such as the Human Capital and Convergence approaches, which are also analyzed within the Knowledge economy framework if an evolutionary view is assumed.

Table II.1. Main perspectives on human capital, technology and knowledge of theories and conceptual frameworks

Framework		Approach	Conceptualization			Differences in countries' growth
			human capital	*Technology*	*knowledge*	
Neoclassical theory	Neoclassical model	Traditional perspective	• Labor productivity • Labor availability • Exogenous	• Exogenous • Public good nature • Define the production function	• Exogenous • Public good nature • Incorporated in technology	• Unexplained
	New Growth Theory	Total Factor productivity	• Labor productivity • Mainly exogenous	• Exogenous and endogenous • Key productivity factor • Mainly public good nature	• Exogenous and endogenous • Mainly public good nature	• Partially explained
		Human Capital approach	• Labor productivity • Exogenous and endogenous	• Not directly considered • Exogenous and endogenous (can be an output of HC) • Mainly public good nature	• Mainly endogenous • Embodied in HC	• Partially explained
		Convergence	• Labor productivity • Exogenous and endogenous	• Exogenous and endogenous • Key in conditional convergence • Mainly public good nature	• Endogenous and exogenous • Mainly public good nature	• Partially explained
Knowledge economy		Innovation System	• Key for growth • Endogenous and accumulative • Key for innovation	• Endogenous • Key for growth • Input and output of innovation processes	• Endogenous and accumulative • Key for innovation	• Explained by catching up and innovation processes • Depend on innovative capabilities
		Technological gap	• Endogenous and accumulative • Key for gap reducing (imitation and innovation)	• Endogenous • Key for growth • Key to gap reducing	• Endogenous and accumulative • Key for technology convergence	• Explained by catching up and innovation • Depend on innovative capabilities
		Intellectual capital	• Strategic factor • Endogenous and accumulative	• Endogenous • Mainly as intangible	• Endogenous and accumulative • Pillar of wealth creation	• Explained by intangibles: HC, SC and RC

Source: own elaboration based on referenced literature

The Neoclassical growth theory assumes economy as a system in equilibrium, or in transition to stationary state, with homogeneous and representative agents, and perfectly encodable and predictable, but evidence shows that growth is a process of continuous change, neither deterministic nor predictable (Castellacci, 2006a; Dosi and Nelson, 2010). This theory does not explain adequately the differences between countries' growth, because income divergence is more related to productivity than to human (labor) or physical capital accumulation, as predicted by the neoclassical theory (Verspagen, 1993; Fagerberg et al., 2010). In turn, although the New growth theory considers technology as an endogenous factor and the basis for differences across countries, it also presents weaknesses due to the existence of multi-equilibrium and dynamic interactions, as explained in the evolutionary approach (Álvarez and Botella, 2012; Castellacci, 2002).

Some scholars, moreover, point out that evolutionary approach analysis can be a little theoretical, ambiguous and overly flexible (Sharif, 2006), since the innovation concept is broad, with multiple links, and various types of causalities affect its evaluation (Castellacci, 2008a; Castellacci and Natera, 2013), tending to combine qualitative with quantitative techniques.

Newer theoretical frameworks have resolved several limitations of traditional growth theories, despite which some deficiencies remain. In addition, context changes open up new challenges and opportunities to adjust and understand development and its drivers for the future. More importantly, certain countries' particular characteristics emphasize the importance of comparative studies and individual approaches in order to fit the recommendations and strategies to each case.

Consequently, a reasonable way for new and specific studies is through the integration of conceptual and empirical frameworks resulting from the Evolutionary growth theory and the Knowledge economy approach. The neoclassical perspective is still valid, since NR, capital, and labor remain crucial for many economies, defining their comparative advantages and forming part of national wealth creation (López et al., 2011). Therefore, for empirical objectives it seems appropriate to integrate the endogenous perspective of the New growth theory, the focus on intangibles proposed by the intellectual capital framework, the system vision provided by IS, and the convergence and catching-up conceptualization widely discussed by the Technological gap approach. This comprehensive proposal is not free from difficulties, both conceptually and empirically, so a careful, analytical, step-by-step process should be followed.

2.3. Natural resources and development

Countries' development has been described as a process of change based on industrial structure and specialization patterns of economies (Wright, 1990; Rosser, 2006; Smith, 2007). Before the industrial revolution, nations based economic progress on agriculture, mining, trade and commerce (Mokyr, 2010). With the arrival of great waves of technological advances during the nineteenth century, many countries became dependent on large manufacturing plants. Since the middle of the last century, new technical progress has been made, associated with Information and Communication Technologies (ICT), resulting in prosperous knowledge-intensive sectors, while primary industries have lost importance (Castellacci, 2006b). Following this path, the industrial activity of leading countries moved from traditional capital- and labor-intensive sectors to other more knowledge-based sectors, where innovation and technologies are considered the core of productive activities (Piesse and Thirtle, 2010; Manzano, 2012; Ville and Wicken, 2012).

Despite this natural and fruitful transformation of productive patterns, some countries have maintained their investment in traditional industries and even based their development on natural resources, resulting in a concentrated industrial structure. This industrial pattern, based on a productive specialization in raw materials, has been widely discussed at a national and supranational level, since it brings risks associated with a lower potential for sustainable growth due to the lower added-value of primary products, and their reduced adaptation capacity to external shocks (Álvarez and Fuentes, 2006; WEF, 2013). According to the UCTAD database, in the last decade some emerging countries, such as Brazil, South Africa, Kazakhstan, Russia, Colombia, and Chile, and even some developed ones, among them Australia and Canada, have increased their export concentration. This same trend has been followed by several middle- and low-income economies that are trying to capture the benefits from high raw materials prices in order to finance their strategic agendas (public and private).

As result of this strategy, some economies have failed, and several social, environmental and economic problems have arisen (Sæther et al., 2011), while others have made significant progress, becoming leaders (Pérez, 2008; Barma et al., 2012). To try to explain the reasons for these divergent trajectories, scholars have analyzed a variety of cases and factors that could be driving the results of natural resources exploitation. Likewise, new scenarios resulting from globalization and trade openness bring back opportunities and challenges for those specialized economies largely endowed with NR (Ferranti et al., 2002). These facts motivate new analyses of the

relationship between NR and development, but incorporating an evolutionary perspective because of the relevance of intangibles, causality relationships, interconnections, and knowledge creation and diffusion between actors and sectors. The reason for this is that NR specialization poses risks that can cause a collapse if certain precautions are not taken into account, as it is shown in most of the cases reported in the literature (Cuddington et al. 2007).

Under a Neoclassical perspective, NR are assumed as part of physical capital, also termed natural capital, which along with human capital and the rest of physical capital (infrastructure, equipment), contribute to increasing citizens' welfare (Barbier, 2003; WEF, 2013). As the conventional production function approach predicts, technical progress increases revenue by improving factor productivity, included NR (Wright, 1990; Weil, 2006). In addition, technology can resolve, at least partially, the scarcity and environmental problems related to the overexploitation or depletion of NR (Barbier, 1999; Bretschger, 2005; Van der Ploeg, 2011). Under this approach, states seek to maximize benefits by maintaining the balance between extraction, reserves, and externalities, as can be observed in several mining and oil economies. Nevertheless, this type of management can also lead to a poverty trap (Bravo-Ortega and De Gregorio, 2007).

The traditional economic perspective explains little about the dynamism in the system, its interrelationships, and the mechanisms to govern it. Nor does it clearly show the opportunities to develop sectors based on NR industries, as may result from the Evolutionary theory, since the flow of knowledge to NR-based sectors from the rest of the economy stimulate knowledge creation and local innovation capability (Sæther et al., 2011). Indeed, successful countries with large NR endowments have followed the strategy of promoting new sectors related to commodities, achieving a higher development standard (Manzano, 2012).

To avoid negative effects from NR and achieve positive results, researchers agree that a minimum threshold of HC, institutional quality and openness must be reached, along with the re-investment of NR profits in productive activities (Stijns, 2005; Gylfason and Zoega, 2006; Van der Ploeg, 2011). Recent contributions to the literature recognize the potential of NR-based activities for growth when they are combined with human capital (Bravo-Ortega and De Gregorio, 2007; Iizuka and Soete, 2011) or when there is an intensive use of high technologies, because they are able to create some sort of windows of opportunity for the diversification and development of knowledge-intensive industries (Lederman and Xu, 2007; Lindkvist and Sanchez, 2008; Iizuka and

Soete, 2011). In addition to HC and technology, Hauser et al. (2011) and WEF (2013) point out that the integration of social and institutional factors are also required to achieve positive results in terms of sustainable development.

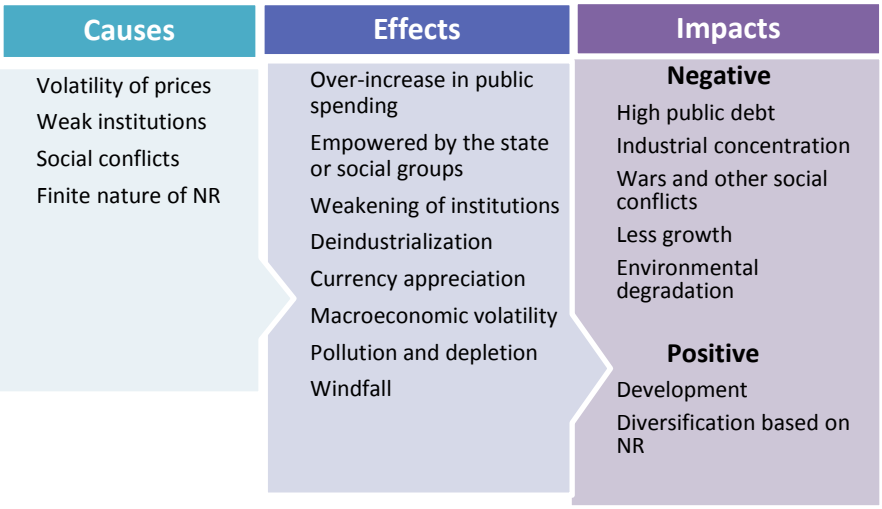
In fact, countries with weak institutions, insufficient investments in human capital, low levels of openness, and limited international flows of capital and knowledge show reduced innovation capabilities and restricted absorptive capacities, tending to achieve the worst results in economic rankings, because perverse incentives from commodity production lock the emergence and expansion of more diversified activities with higher added value (Barbier, 1999; Ferranti et al., 2002).

On the other hand, specialization in NR can also boost productivity, since important economies of scale may be achieved in all levels and activities, and technology could support more efficient production systems and foster complementary, more knowledge-intensive sectors (Ferranti et al., 2002). Thus, the final impact of NR on growth will depend on a variety of factors which act jointly.

Therefore, the effects of NR on the economy vary from country to country and across different episodes in history (Van der Ploeg, 2011), depending on the strategies applied for exploitation and trade, the management of production factors and the nature of the learning process (Barbier, 2003; Manzano, 2012). Likewise, empirical findings have also shown that renewable and non-renewable resources could result in different impacts depending on complementary factors (Stijns, 2005). The Figure below (Figure II.1) shows a simplified list of causes that can help to explain the diverse results of NR exploitation, as well as its effects and impacts.

Scholars and policy makers strive to learn from successful cases of countries with large resource endowments, both in renewables and non-renewables. Because of structural differences between these two types of resources, attention must be paid to certain specific facts and evidence in order to provide suitable recommendations.

Figure II.1. Causes, effects, and impacts related to exploitation of natural resources



Source: Author's elaboration.

In the mining sector, some clues can be found in the analysis of the development paths of leader countries, such as Australia and Canada. In these cases, some particular features have been present improving productivity, available reserves (via better exploration technologies), and environmental, economic and social performance. Indeed, these countries have not only incorporated foreign technologies, but have also created new ones in critical areas such as exploration, extraction, mineral processing, telemining, maintenance, ICT for mining and environmental management (Mudd, 2007). Such advances have made these economies become world leaders, who have intensified their exports of mining-related technologies and overseas investments in mineral exploitation. Thus, from an enclave structure, typical of the mining industry, these economies have built international clusters based on knowledge. Today, they continue to innovate not only in technology, but also in social and environmental NR-related aspects (Solomon et al., 2008), a clear case of vertical and horizontal diversification, adequate long-run policies and good institutions to drive this process.

Apart from these successful cases, other attractive examples of knowledge investment in minerals can be taken from European policies and strategies. In particular, Horizon 2020 [18] defines raw materials as critical resources, promoting the creation of technologies for the production of primary and secondary industries, the development of substitutes, investment in R&D for sustainable production, and the building of a

[18] Horizon 2020 is the European Strategy for Research and Innovation.

knowledge base (European Commission, 2013), all of which offer a wide perspective on how to deal with NR in the knowledge era. Specifically, the raw materials strategies of Finland (Ministry of Employment and Economy, 2013), Denmark (Ministry of Foreign Affairs, 2011) and Norway (Norwegian Ministry of Trade and Industry, 2013), promote investment in knowledge assets in NR industries and horizontal technologies, environmental protection, and social responsibility, underscoring the importance of innovation as the basis for profitable, efficient, and sustainable exploitation.

Although Nordic countries and the USA, an initially NR-based country (Wright, 1990), continue to invest in the NR sector, they have followed a different development path to Australia or Canada, investing income from NR in other sectors, mainly technology-based, and creating new industries and business. In these cases, it was fundamental a clear and long-term industrial policy, a strong institutional framework to deal with the social and political pressures, and a democratic decision-making process. In this regard, Manzano (2006) pointed out that the legal system in USA was the key to the development of the mining sector, because it stimulated investments, regulated production conditions and promoted productivity in a long-run perspective.

Moreover, failure may occur when weak institutions are present, as Rosser (2006) and Van der Ploeg (2011) argued. In fact, corruption, lack of regulations and control, and dictatorial regimens are conditions that increase the likelihood of failure, because NR profits are captured by power groups increasing inequality, which may trigger violence and even wars. In addition, a lack regulation and transparency leads to more social conflicts since increase doubts on use of profits, mining concession processes, evaluation of environmental impacts, etc. This context does not offer attractive scenery for investors, ultimately affecting competitiveness and development.

In the food sector, a similar path can be identified from world leaders. Innovation strategies in food production in North America (USA and Canada) and Europe, among others, show that it is feasible to build a successful food industry investing in knowledge in these sectors, which not only positively affect agricultural productivity, but also permit the creation of new business based on knowledge and related to NR, such as genetics, robotics, processing and software. In this sense, smart specialization can improve the innovation process and accumulate capabilities, promoting knowledge spillovers and technological diversification (European Commission, 2014) in order to build competitive advantages and add value to exports. Furthermore, this sector is showing the ability to create new related industries when they integrate

advanced technologies, such as biotechnology and nanotechnology, into the production system.

All these cases clearly indicate that NR sectors can be the basis for promoting more sophisticated industries, which require an innovation policy oriented to creating capacities and knowledge in these sectors, along with other measures such as investment in productive and scientific infrastructures, stimulation of new business and exports, maintaining macroeconomic stability and an appropriate financial system, promoting openness and strengthening institutions (Ferranti et al., 2002; Eyzaguirre et al., 2005; Frankel, 2010).

Despite agreement among scholars and international organizations that these measures are key tools to avoid the "NR curse", several countries, largely dependent on NR, have not progressed in exploiting their resources due to multiple failures, as described below.

2.3.1. Natural resources-based industries: causes and effects on development

Natural resources have historically been considered as important endowments and economic pillars (WEF, 2013). Between the 1950s and the 1970s NR were mainly seen as a blessing, while since the 1980s this conventional vision changed and a negative image arose (Rosser, 2006). An extensive body of literature emerged on NR and economic growth that sought to determine how to avoid the "resource curse". The findings showed that some properties of NR caused windfalls and promoted growth, especially those related to easy exploitation and economic booms (Manzano, 2012), while others pushed toward economic imbalances and social conflicts bringing negative consequences to development (Stijns, 2005).

Scholars have studied development in countries dominated by NR industries from different perspectives, concerned with negative consequences in the social, environmental and economic scopes. For developed economies, NR appear as a barrier to progress, and the research was focused on identifying the causes of this evidence, summarized as follows:

- Immobile nature and concentrated location. Usually these resources are not distributed uniformly across countries (WTO, 2010) and tend to develop

enclaves (IIzuka et al., 2011; Sæther et al., 2011), which do not generate growth beyond the industrial location.

- Volatile prices and economic booms (Sachs and Warner, 1999; Frankel, 2010) encouraging greater public spending and increasing economic risks.
- Weak links to the wider economy (Buitelaar, 2001; Smith, 2007; Pérez, 2012).
- Relatively easy access and exploitation. A relatively low level of knowledge is required for their production; countries can fall into a rent-seeking without promoting innovation (Maloney, 2007; Figueroa and Calfucura, 2010; Van der Ploeg, 2011).
- Finite nature (WTO, 2010) and, hence, an equilibrium between present and future exploitation is required (Pavitt, 1984; Barma et al., 2012). Moreover, demand may change dramatically as the result of new substitutes (e.g., new fuels, superconductors, etc.) as a consequence of technological advances (Eyzaguirre et al., 2005) or consumer trends.
- Open, competitive, and globalized markets (WTO, 2010), facilitating trade.

These elements, along with specific country factors, define political actions and enterprise decisions that affect institutions, governments, firms, and ultimately growth (Manzano, 2012). The literature has identified several effects of NR on society, ranging from changes in the production structure to social restructuring and modifications in the systems of power. In general, scholars agree that incentives from NR tend to negatively affect economic and social bases of countries. This evidence would justify the need for strong and stable governments and long-term policies to avoid the temptation of easy short-term profits (Sachs and Warner, 1999; Ohno, 2009). In addition, certain social elements tend to define long-standing NR activities that are closely linked to a specific social, cultural and geographical environment, which could affect the adoption of productive changes (Lindkvist and Sánchez, 2008).

In the literature we can find an extensive list of effects caused by NR reserves and exploitation that can be summarized as follows:

- Excess of public debts and adverse terms of trade, as a consequence of excessive optimism in economic booms and high prices of commodities that promote an increase in public spending (Martin, 2007). This situation is more common in countries with weak institutions, especially when there is high corruption, lack of governance, and excessive presence of short-term policies

(Frankel, 2010), generating increased public spending to meet the short-term needs of specific groups.

- Increase of capital stock due to high prices, in the short term, which could affect macroeconomic equilibrium, currency appreciation, and encourage a rise in public spending. This would foster investment in NR industries as a result of rent-seeking, concentrating even more exports and causing deindustrialization (Martin, 2007; Van der Ploeg, 2011).
- Macroeconomic volatility, which adversely affects investment and industrial diversification (Manzano, 2012).
- NR can negatively affect institutions and support social conflicts, as part of perverse economic incentives to resource exploitation (Roos, 1999; Lindkvist and Sánchez, 2008; Van der Ploeg, 2011). In this regard, examples of civil and international wars can be found in recent history, reflecting the desire to control the reserves and exploitation of natural resources in order to finance non-productive activities, even illegal actions. This is more common in countries or regions that do not have strong institutions because corruption, lack of transparency and dictatorial regimes facilitate these adverse contexts.

Both causes and effects are not linear, and several causes can simultaneously converge and result in many effects. In fact, conflicts arising as a result of NR exploitation tend to remain for several decades due to their complexity and diversity of causes, even becoming part of the culture in many societies. In any case, a key aspect behind this situation seems to be the presence of weak institutions, characterized by non-democratic systems of government, lack of control and respect for the laws, weak governance, lack of transparency, and high corruption (Bravo-Ortega and De Gregorio, 2007; Frankel, 2010; Van der Ploeg, 2011).

2.3.2. Impacts of natural resources exploitation

The negative results of NR exploitation, widely described by scholars such as Sachs and Warner (2001), Sala-i-Martín and Subramanian (2003), Smulders (2005), Lederman and Maloney (2007), and Stavins (2011), are not transient, but rather tend to remain in economic and social structures and the development path in the long run.

Although NR impacts can be grouped into categories –economic, social, institutional and environmental– they are interconnected and dependent on each other, through

reverse causality, making them even more complex to manage and requiring long-term policies and good institutions (Ferranti et al., 2002; Rosser, 2006; Van der Ploeg, 2011).

Considering the economic impacts, these have probably been the most studied in the literature. Findings show that NR-based economies grow more slowly than their potential, or fall definitely into recession. Along with excessive public debt, increase in public spending, macroeconomic instability and concentration of exports, several authors have pointed out that Dutch disease[19] is also a consequence of NR exploitation causing currency appreciation and impacting on manufacturing export industries that enter into a deindustrialization process (Manzano, 2012), which can hardly be solved in the medium term.

In fact, high profits from NR as a result of economic booms or strong demand stimulate the production of commodities, which increase the foreign currency in the country; local currency appreciates, and tradable lose competitiveness. In addition, this situation re-orients capital investment and HC to NR industry, negatively impacting other economic activities (Bravo-Ortega and De Gregorio, 2007). If the country does not have a long-term growth policy, and the capacity to implement and control it, deindustrialization will be severe, affecting the whole economy and quality of life. Then, social conflicts could arise from sectors negatively affected by this process.

If production is carried out by private companies, regulations and taxes should interact to improve income distribution and avoid deindustrialization. However, certain taxes on NR extraction could also be inadequate policies because they cause distortion and keep investment below its potential level (Manzano, 2012). Moreover, evidence also indicates that if the state is the owner of firms, social demand or unproductive spending could grow beyond the economy's real possibilities causing a severe crisis (Barbier, 2003; Frankel, 2010), since windfalls from NR may produce myopia among policy makers, causing short-term goals prevail over macroeconomic stability and the welfare of future generations (Roos, 1999; Manzano, 2012).

Therefore, deindustrialization and a huge public debt can be two of the deepest consequences of inadequate control and management of resources, whose impacts are long term and can have a high cost to citizens. This situation would lead to a severe loss of competitiveness, a decline in investment (local and foreign), an increase in

[19] Dutch disease is defined as the deindustrialization process of an economy as result of a currency appreciation when the natural resources rise, making the tradable goods less competitive and decreasing exports, in comparison with other countries (Corden and Neary, 1982).

inflation rates, recession and even armed conflict, as can be observed in some Latin American and African countries with weak institutional frameworks (Collier and Hoeffler, 2004; Roos, 2004). In addition, a greater concentration of NR production due to deindustrialization, increases the risks facing the economy if prices of commodities fall, because the export basket is small and the country has less capacity to move to other economic sectors (Berry, 2008; Frankel, 2010),

Therefore, NR windfalls should be saved to finance counter-cyclical economic policies, create more human capital in transversal and knowledge-based activities, and invest in structural capital, relational capital and infrastructure in strategic industries and support sectors. For this purpose, economic (industrial) institutions should have the capacity to develop and implement policies in this direction, regulate the system, and avoid corruption and social pressures to increase public spending irrationally.

Apart from institutional effects, there may be other social impacts. The relationship between the social dimension and NR is complex and bidirectional, since NR impact the social capital and the social dimension influences the economic performance of resources, resulting in a complex scenario for policy makers. Some authors have pointed out that ethnic, religious or other dissatisfied groups could use natural resources as a source of income to finance illegal acts, extending conflicts, when violence and weak rule of law are present. NR are also considered as the origin of the fights, since conflicting groups try to preserve the property of those profitable endowments (Rosser, 2006). As Ross (2004) indicated, this situation appears more frequently when there are social inequalities and weak institutions, especially insufficient rule of law, high corruption levels and the presence of terrorist activities in the country. In these cases, governments cannot, or sometimes will not, change this path, and the crisis and instability are maintained for decades.

Another important element of social context is human capital. Van der Ploeg (2011) found that NR abundance negatively impacts education, probably because this type of industries requires HC with fewer skills than manufacturing or science-based sectors, discouraging education and training processes. Conversely, HC supports the innovation capability and absorptive capacity that contribute to catching up and innovation processes in these industries; therefore, if private strategies and public policies do not stimulate investment in HC, there will be less opportunities to advance, since catching up and innovation will be negatively impacted (Castellacci, 2006b; Piesse and Thirtle, 2011). As Eyzaguirre et al. (2005) indicated, HC is fundamental for these sectors in order to increase competitiveness, diversify, and add value to exports, but more HC

must also be consistent with the demand for this resource, or the country may lose these capabilities. These same authors also point out that the tasks involved in improving HC, under an innovation strategy, are roles of the State that cannot be replaced by market forces, in a clear reference to the importance of a proactive public innovation policy and a strong institutional framework to overcome perverse incentives and pressure groups.

These two main aspects, social conflicts and low levels of human capital, not only negatively impact on growth, but also affect institutions, social harmony, and governance, as demonstrated by several authors, such as Ferranti et al. (2002), Roos (2004), Rosser, (2006), Van del Ploeg (2011). This social, political and economic instability may persist for decades, as shown by evidence from Latin American and African countries.

Although the evidence indicates a reverse relationship between NR and institutions (WTO, 2010; Manzano, 2012), econometric tests that have attempted to demonstrate this fact have presented empirical problems because institutions' indicators are highly correlated and this negatively affects empirical estimations (Van der Ploeg, 2011). Despite this fact, the evidence is consistent and shows a greater propensity to adversely affect development when the institutional framework is weak and fails to correct market failures or block pressures, because institutions are one of the most important factors to reach a positive result from NR (Frankel, 2010). Indeed, countries with high institutional quality show no curse and reduce the risk of collapse (Rosser, 2006).

Windfalls from NR can also weaken institutions (Roos, 1999) due to perverse incentives to public and private agents, causing corruption, weakening authority, uncertainty, violence, and high financial risks. This leads to a vicious circle, where NR exploitation damages institutions, while weakened institutions adversely affect the economic performance of NR. According to the literature, the negative pressure of NR economic activity would come mainly from economic incentives. If a NR country has good institutions, in terms of transparency, rule of law, accountability, and control of corruption, policies should appropriately conduct public spending, establish a tax system to redistribute income and finance development strategies, and focus public resources from NR on intangible investments (HC, RC, SC, and productive and scientific infrastructure). If, on the contrary, NR revenues are generated under a system with weak institutions, profits are likely to be allocated to increasing the quality of life for specific groups or hierarchies, to finance wars and corruption, or simply provide public

services that are beyond the state's financial capacity without a long-term development strategy, which could increase social expectations, instability, and even social inequality.

This situation is difficult to break and requires significant changes in the countries affected by this perverse process. Therefore, economies with large NR endowments should improve their institutional quality to grow faster and avoid the NR curse (Van der Ploeg, 2011; Manzano, 2012; WEF, 2013), since the key to success is to complement NR wealth with good institutions, human capital, and knowledge (Ferranti et al., 2002). However, there is no unique recipe for "good institutions", because policies and institutions have to be tailored to local circumstances, country by country (Frankel, 2010), but at least some basic elements should be always present, such as political and economic stability, control of corruption, and rule of law. However, the basic institutional conditions are not enough in advanced development stages, as Alonso and Garcimartín (2008) pointed out, and hence more institutional quality is needed in aspects such as democracy, legitimacy and accountability.

Finally, concerning environmental impacts, there are certain externalities that have also been associated to NR exploitation, both from renewable and non-renewable resources. This economic activity could cause negative impacts on the environment and development, if some precautions are not taken into account. Given the finite nature of non-renewable resources, their exploitation reduces the reserves, in turn affecting growth in the long term (WTO, 2010). Moreover, in renewable resources such as forestry and fishery, the extraction rates in many cases are higher than those of self-regeneration, causing scarcity and environmental degradation in several places.

Although this scarcity can be compensated by technical progress in exploration, extraction, and substitution (Van der Ploeg, 2011), which also improves productivity and can reduce pollution (Smulder, 2005; Stavins, 2011), a vicious cycle could begin because lower production costs, as a consequence of innovation, promote extraction, causing a negative impact on price and increasing the demand, and therefore the rate of extraction (WTO, 2010).

To avoid a negative environmental impact, governments and international organizations have been developing and implementing several regulatory standards that are considered as limitations to production by some firms and sectors. Thus, rule of law and regulatory quality are essentials in addressing these pressures, and hence, strong institutions are a key to reduce or eliminate these negative impacts.

Moreover, new technologies, market changes, and environmental awareness are also preventing destructive and polluting practices, and new clean production systems are gaining ground, which is encouraging companies to exploit NR responsibly, in terms of environmental protection.

In brief, natural resources have a potential negative impact on the economy as a result of perverse incentives to increase public and private spending, struggles for the control of these valuable resources, inequality and social conflicts, among other interconnected facts. Even in the absence of these negative conditions, NR can cause macroeconomic imbalances resulting in the deindustrialization of countries (Corden and Neary, 1982). Authors agree that one of the most important aspects that facilitate this adverse process is the presence of weak institutions, characterized by precarious rule of law, high corruption, autocratic presidential regimes, poorly defined and protected property rights, and underdeveloped financial systems (Van der Ploeg, 2011; WTO, 2010), all of which lead to a vicious circle and expose countries to the resource curse (Barma et al., 2012).

Despite potential NR curse, recent findings are showing a new perspective, which would indicate that NR can positively affect GDP if strategic intangibles (human capital and strong institutions) are present in the NR-based industries (Ferranti et al., 2002; Frankel, 2010). This latter situation opens up new opportunities for specialized economies, but requires further studies in order to detect the clues to achieving a positive impact. In addition, current high prices of raw materials and the growing importance of resource extraction in many developing countries is attracting interest for studies related to growth and policy issues around natural resources, because this opportunity could lead to failure unless the appropriate policies are adopted (Barma et al., 2012).

Chapter III. INTELLECTUAL CAPITAL AND DEVELOPMENT

Following scholars and policy makers, who point out that intangibles are the main factors involved in the wealth creation in the current era (Bontis, 2004; Corrado et al., 2009; Nakamura, 2010), the evaluations and their management should be an essential task. However, it is not completely assumed as strategic, at least at the operative level, and only some aspects are considered in public policies and development strategies, due to the advances in the literature on IC are still limited, there is not yet a unique recognized methodology to manage and measure it , and flows of information comes from many different sources, making it complex to understand, harmonize, and put into action the findings (Makarov, 2010; Alfaro et al., 2011; Lin and Edvinsson, 2011).

Therefore, a systematic review of the literature is conduced and its results are shown in this chapter, which is made up by two studies on IC at macro level. The first is concerned with the systematic literature review that seeks to know the advances in the study of this conceptual framework and the main tools to manage countries' intangibles, and the second is an analysis of assessment models that compare them through quantitative and qualitative variables. The conceptual bases supporting these studies are presented only in the first part.

3.1. National Intellectual Capital Assessment Models: A literature review[20]

3.1.1. Introduction

In recent decades intangibles that make up Intellectual Capital (IC) have become the most important resource for wealth creation and national progress (Bounfour and Edvinsoon, 2005; Lin and Edvinsson, 2008 and 2011), even more than the tangibles (Nakamura, 2010). In the current social and economic context, termed the Knowledge economy, knowledge and information are the core competencies (Ghiţiu-Brătescu et al., 2010) of nations pursuing development, above capital (Pulic, 2005) or labor (Dunning, 2000). According to Foray (2004), knowledge is an essential good for the new economy: the Knowledge economy. Empirical works show a strong relationship

[20] Paper published in Journal of Intellectual Capital. Reference*:* Labra, R. & Sánchez, M. P. (2013). National intellectual capital assessment models: A literature review. *Journal of Intellectual Capital, 14*(4), 582-607.

between intangible assets and national economic development (Corrado et al., 2009; López et al., 2011). In addition, intangibles positively affect work productivity (Nakamura, 2010) and provide the future profits of countries and their organizations (Bontis, 2004).

The first studies related to IC were carried out at the level of firms and sought to explain the market value of companies (Cañibano et al., 1999). Later, governments, researchers, and international organizations developed new works to measure and manage IC at macro level, but the works are still scarce, there in not a widely accepted framework, and the information is dispersed.

Thus, this literature review was conducted to identify the advances related to IC at the macro level and obtain an overview of intangibles. The specific objectives of this research are: (1) to identify the main advances in IC studies; (2) to identify the main models developed to measure IC at the country level; and (3) to characterize and compare the models. The research questions are: What advances have been made in the last decade in knowledge about IC at the national level? How is IC measured at the country level? What kind of indicators, variables and components are being used? What are the main differences among models? What can be learned for future policies?

This analysis summarizes the conceptual framework advances and the underlying theories for IC analysis, as well as the most important results obtained in empirical studies. Section fourth introduces the methodology applied to find the more relevant literature published. Subsequently, in the fifth section the main models analyzed to measure IC are presented, along with the characteristics and a first comparison between groups of models. Finally, it is discussed the main results in order to detect the key elements of IC at macro level.

3.1.2. Conceptual framework

The Neoclassical economic model has broadly dominated the study of economic growth and development, and has served as basis for public policies the last century. Under this theory, capital and labor explain national growth and these are characterized by their exogenous nature (Solow, 1956). Studies in the 1950s by Robert Solow, among others, included technological change among the variables explaining growth. Solow (1956) pointed out that capital is not the only factor determining

productivity; other variables are also important, such as research and education. The estimations presented by Solow in 1956 described technological progress as one important factor for countries' economic growth (McQuinn and Whelan, 2007).

At the firm level and in the context of rapid technological change, wealth creation depends on capabilities and entrepreneurial strategies (Teece et al., 1997). According to Penrose (1955) growth potential is determined by the firm's resources, which are both tangible and intangible, the latter being the source of innovation capability (Morcillo, 2006). Currently, intangible resources are the main source of wealth, prosperity, economic growth (Edvinsson and Kivikas, 2004; Corrado et al., 2009) and core competencies (Dunning, 2000; Contractor and Lorange, 2002; Ghiţiu-Brătescu et al., 2010), which has given rise to a new conceptual framework, the knowledge-based economy. Following David and Foray (2002), the Knowledge economy is the result of the creation and interchange of knowledge, where the information and communications technologies sector is a key element, and intangible capital is more important than tangible assets.

The Organization for Economic Co-operation and Development (OECD) defines the knowledge-based economy as an economy directly based on the production, distribution and use of knowledge and information (OECD, 1996). This new economy, as opposed to the neoclassical framework, explains better the differences among countries in growth levels by using the knowledge factor as a key element, together with physical equipment and labor force (David and Foray, 2002). These factors produce new technologies supporting growth (Fagerberg et al., 2007).

The motivation to study knowledge in firms emerges from the differences observed between the book and market value of companies, as well as to provide more precise information to stakeholders (Cañibano et al., 1999) because intangibles are the base of competitive advantages (Petty and Guthrie, 2000).

Intangibles related to business are called intellectual capital (Petty and Guthrie, 2000). Cañibano et al. (2002) describe IC as the combination of organizational resources and activities, including human, entrepreneurial, and relational assets. Part of IC is knowledge, experiences, and workers' skills, R&D, organizational routines, procedures, systems, databases, intellectual property rights and resources linked to the external relations of companies. According to Cañibano et al. (2002), Johanson (2005), and Ståhle and Bounfour (2008), IC is composed of human capital (HC), which is embodied in people; structural capital (SC), which is related to intangibles that contain codified

and stored knowledge; and relational capital (RC), which refers to relationships with customers, suppliers, or partners.

3.1.3. The Intellectual Capital of countries

Intangibles are the most important assets in firms since they improve productivity and competitiveness (Edvinsson, 2003), providing competitive advantages to them (Augier and Teece, 2005). According to Ståhle and Ståhle (2006), the intellectual capital and competitiveness of nations are also strongly related, being both results of available knowledge within countries. Bontis (2004) pointed out that hidden values are lie in individuals, enterprises, institutions, communities and regions, and that adequate management increases national wealth and economic success. Thus, the measurement and management of intangibles improve the adaptation of public policies and the use of good practices, supporting the creation of new and better investment programs, together with adequate incentives to promote development.

Although IC is recognized at the macro level as a very important factor in determining national wealth, it only became evident in the 1990s (López et al., 2011), with increasing concern among policy makers about intangibles, not only to adapt to the new context, but also for the relevancy of IC in the future national performance. The first work on IC at the macro level was “Welfare and Security” by Caroline Stenfelt-Dunn, in 1996 (Edvinsson and Stenfelt, 1999). Some years earlier this topic was also discussed during the meeting “Managing the IC of the Nation, Managing Knowledge Assets into the 21st Century”, held in the USA in 1987. Later Edvinsson presented his seminal work based on the Skandia Navigator Model (Gallardo and Castilla, 2007).

The development of models to evaluate intangibles at a macro level has followed different paths, taking diverse principles into account. Several studies on national intellectual capital have replicated measurements at the micro level (Ståhle et al., 2011) or have taken available macro indicators on intangibles (Bianchi and Labory, 2003). Moving from the firm to the national level is premised on the idea that intangible assets are as important for the productivity and competitiveness of countries as they are for firms. However, the complexity of IC assessment makes it impossible to transplant micro models to the national level (Lin and Edvinsson, 2011), because the evaluation of hidden value for countries is more difficult than for firms (Käpylä et al., 2012).

In recent years, research on National IC has produced several measurement tools to capture IC and its impact at the aggregated level (Salonious and Lönnqvist, 2012). Although there is not yet a recognized macro model or a widely accepted methodology to evaluate national IC, studies about this topic and its economic impact are being used as diagnostic tools to benchmark and analyze national development strategies, and support effective decision-making on national intangible assets (Lin and Edvinsson, 2011; Käpylä et al., 2012).

Many studies have evaluated country-level intangibles as a way to improve economic performance (Lin and Edvinsson, 2011). Among the country studies are: Australia by Gans and Stern (2003) and Gans and Hayes (2008), Austria by Schneider (2007), Finland by Ståhle and Pöyhönene (2005), Israel by Pasher and Shachar (2005), Luxembourg by Alexander (2006), Spain (Madrid) by Pomeda et al. (2002), Poland by Government of Poland (2008), Arab region by Bontis (2004), EU countries by Bounfour (2003) and Weziak (2007), developing countries (Seleim and Bontis, 2013), and Nordic countries by Lin and Edvinsson (2008). Another important work is the evaluation of 40 countries by Lin and Edvinsson (2011) that includes a dynamic analysis for several years.

An important line of work in evaluating IC at the country level began with the work of Edvinsson and Malone in 1997 on the taxonomy of evaluating intangibles at the firm level, including human and structural capital. Today, there are diverse models to measure intangibles at the country level whose results tend to converge. In addition, more attention is being given to comparative studies, particularly those with models that report composite indexes.

In fact, comparative evaluations have shown a close relationship to economic performance, allowing greater understanding of the causes of growth in the knowledge era. Moreover, these evaluations also explain the current economic crises in countries such as Greece, Portugal, Italy, and Spain (Lin et al., 2013), and could help to avoid future economic downturns since IC measurements provide information on the main intangibles that support economic growth. However, IC must be managed to ensure a positive impact, implementing long-term policies due to the accumulative nature of IC, which follows a dynamic evolution. Among the more important IC studies regarding this situation are the works of Lin and Edvinsson (2008, 2011) and Lin et al. (2012, 2013), who strive to offer information that will assist policy-makers to improve intangibles.

3.1.4. Selection of the sample and method of analysis

In accordance with Tranfield et al. (2003) and Greenhalgh et al. (2004) a systematic literature review was conducted on IC at the country level. The search was aimed at academic information in scientific databases: Web of Knowledge, Science Direct, and Econlit; as well as the five major journals publishing papers related to IC (Serenko and Bontis, 2009): The Journal of Knowledge Management (JKM), The Journal of Intellectual Capital (JIC), Knowledge Management Research and Practice (JMR&P), The International Journal of Knowledge Management (IJKM), and The Learning Organization (LO). Complementary and key literature was also included in order to incorporate other types of documents such as reports and management studies.

The review covered January 2000 to December 2012[21], and relevant literature reviews, summaries, or conceptual works related to IC published prior to this period were included. The search keywords were "intellectual capital", intangible, and measur*[22] knowledge, which were combined with three words related to level of analysis: nation*, countr*[23], and macro level. Despite the wide search, only 126 documents were identified using the search keywords.

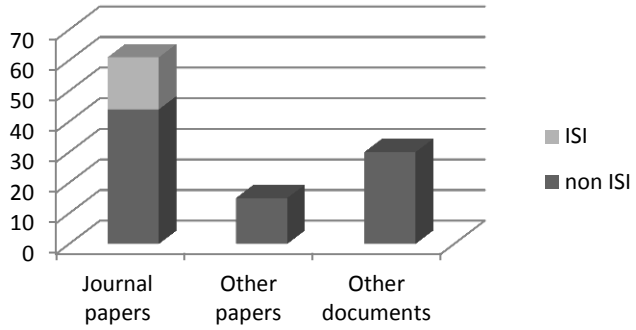
Additionally, literature cited in the identified journals was also reviewed, from which emerged further information developed by international organizations, opening an important line of work.

Finally, a total of 106 documents were analyzed (Graph III.1), 61 of which were journal papers and the rest were working papers, theses, books, reports, and other types of formal publications.

Of the documents selected, 58% are journal papers, of which only 28% are in the Journal Citation Reports (JCR) of Thomson Reuters (ISI papers). This is probably because IC is still a new topic and is not fully accepted, confirming that more efforts are needed to build a more acceptable framework for national intellectual capital.

[21] An extension of the literature review was carried out in order to incorporate information until March 2014. The same tendency related to increased interest in IC studies, and the positive relationship between intangibles and growth, is confirmed in the recent publications.
[22] asterisk means any word with *measur* as word-root
[23] asterisk means any word with *nation* or *countr* as word-root, respectively

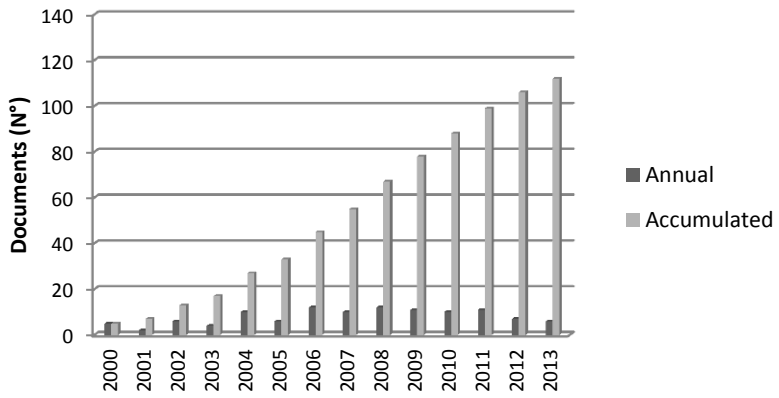
Graph III.1. Total number and type of documents reviewed



Source: author's elaboration

The information shown in Graph III.2 confirms that the study of IC and intangibles at the macro level is still in its first steps, which is consistent with what Ståhle and Ståhle (2006) and Makarov (2010) have indicated. Around 80% of the documents reviewed were published in or after 2005; thus the literature review focuses since 2000.

Graph III.2. Documents identified and selected by year published
(January 2000 – December 2013)

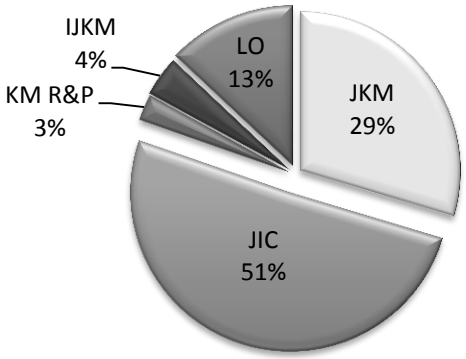


Source: author's elaboration

The majority of the papers found were identified by both the search in scientific databases (WOK, Science Direct, and ECONLIT) and by the review of the five journals (JKM, JIC, JMR&P, IJKM, and LO), which confirms the validity of the search methodology and also ratifies that the selected journals are the most important publications about IC, which coincides with what was pointed out by Serenko and Bontis (2009, 2013).

The Journal of Intellectual Capital had the largest number of papers on IC at the macro level, with around 51% of all the journal papers analyzed (Graph III.3), followed by the Journal of Knowledge Management (29%).

Graph III.3. Percentages of papers found per selected journal



Source: Autor's elaboration

The papers reviewed contain theoretical/descriptive and empirical information about IC at the country level. The most prolific authors are: N. Bontis, L. Edvinsson, C. Lin, G. Schiuma, A. Serenko and P. Ståhle.

The selected information was analyzed to identify advances in the study of national IC and the characteristics of the main models to measure and report the intangibles at the country level. A total of 17 IC assessment models were studied through qualitative and quantitative analysis, including a description of the main aspects of the models. The variables to classify the models used were objectives, types of assets included, components, and methods of aggregating indicators (see Annex 4).

A correlation analysis was carried out with the rankings reported by 13 models (Annex 3). Since the models analyze different numbers of countries, only countries studied by all the models were taken into account to standardize the data, which resulted in a total of 14 countries.

A complementary review focused on scientific literature published between January 2013 and March 2014 was carried out. The recent information also confirm the previous findings related to the positive relationship between intangibles and economic performance (Navarro et al., 2013; Seleim and Bontis, 2013), the novelty of this topic, and the dispersion of models to evaluate IC.

3.1.5. National Intellectual Capital: Main models

The literature presents several models to measure IC at the national level using different methods to identify intangibles. In general, two approaches were identified (Table III.1), confirming the findings of Hervas-Oliver and Dalmau-Porte (2006), and López et al. (2011). One originated in the study of intangibles of private firms and is promoted mainly by academics and their institutions. The second, developed by international organizations and business schools, aims to study competitiveness, innovative capacity and development at the country level. The table below (Table III.1) shows the models selected from the literature review.

Table III.1. Models of measuring intangibles at the country level

Model	Author(s)/Person(s)	Organization
Models developed by researchers (Academic models)		
Intellectual Capital Navigator (ICN)	L. Edvinsson and M. Malone	Lund University
National Intellectual Capital Index (NICI)	N. Bontis	McMaster University, DeGroote Business School.
Intellectual Capital Index (ICI)	D. Weziak	Warsaw School of Economics
Value-Added Intellectual Coefficient (VAIC™)	A. Pulic	University of Zagreb
Intellectual Capital Monitor (ICM)	D. Andriessen and C. Stam	INHOLLAND University. Centre for Research in Intellectual Capital
Intellectual capital dynamic value (IC-dVAL®)	A. Bounfour	University Paris-Sud.
Integral Analysis (INTAN)	V. López, D. Nevado and J. Alfaro.	Universidad de Castilla La Mancha.
State New Economy Index (SNEI)	R. Atkinson	The Information Technology and Innovation Foundation
Models developed by international organizations and international business schools (International organizations' models)		
Knowledge Assessment Methodology (KAM)	World Bank (WB)	
Global Innovation Index (GII)	INSEAD	
Global Competitiveness Index (GCI)	World Economic Forum (WEF)	
World Competitiveness Index (WCI)	International Institute for Management Development (IMD)	
Human Development Index (HDI)	United Nations Development Programme (UNDP).	
Innovation Union Scoreboard (IUS)	European Union (EU)	
Science, Technology and Industry Outlook (S&T I)	Organization for Economic Co-operation and Development (OECD)	
Structural Monitoring System (SMS)	Danish Government (DG)	
Innovation Capacity Index (INNCI)	Editor report 2010-2011: Augusto López-Claros	

Source: Author's elaboration

The first group includes the models derived from the taxonomy presented by Edvinsson and Malone (1997), such as ICN, ICM, and ICI, which seek to identify national IC, using indicators of intangibles that support country growth. These models include HC, SC and the local and international relationships.

International organizations' models simply combine the vision of intangibles with the traditional economic growth approach. The results of these models are far from IC

principles, but the reported rankings are similar to those based on IC, because intangible assets are highly important for both.

Tables III.2 and III.3 show the main characteristics of each evaluation system. While academic models determine IC as an independent factor using indicators of intangibles, the international organizations' models use indicators of intangible and tangible assets to determine competiveness, innovation capability, or development of countries without identifying total IC. These last models are based on macroeconomic and microeconomic principles, including the Knowledge economy framework, and use micro and macroeconomic variables such as market size, credit access and labor and capital costs. Despite the differences among models, there are important commonalities because they share the evaluation of intangible assets.

The models analyzed incorporate intangible assets to determine their indexes and reports. While the academic models obtain their indexes by using indicators of intangibles and tangibles separately, the international organizations' models integrate both indicators. The academic models, in general, also determine human capital, structural capital, and some types of relational capital, such as market capital.

Table III.2. Academic models: Main characteristics

Models	Skandia Navigator			VAIC	ICM	IC-dVAL	INTAN	SNEI
	ICN	ICI	NICI					
Author(s)	L. Edvinsson and M. Malone	D. Weziak	N. Bontis	A. Pulic	D. Andriessen and C. Stam	A. Bounfour	V. López, D. Nevado and J. Alfaro	R. Atkinson
Assessment objective	Wealth	Intellectual Capital	Wealth	Value added and efficiency	Intellectual capital	Intellectual capital	Intellectual capital and wealth	Economic structure of states and comparison to the ideal structure
Main aggregated indicators	IC and Financial Capital	IC	IC and Financial Capital	IC and capital employed (material and financial assets)	Dimension 1: IC; Dimension 2: Assets, investments and effects	Resources, Process, Outputs and Assets	IC (intangibles) and visible wealth	Knowledge-based jobs, globalization, economic dynamism, the digital economy and Innovative capacity
IC components	HC, Process Capital, Market Capital and Renewal Capital	HC, RC, SC and Renewal Capital	HC, Process capital, Market capital and Renewal Capital. Market Capital includes RC components	HC and SC	HC, SC and RC	HC and SC. Additionally, other types of capital can be included, such as innovation, social capital and market capital	Intangible: Visible assets and hidden assets (HC, SC and non-explicit factors)	Not explicit, but deduced: HC, SC, RC, renewal capital, Process Capital and Market Capital
Assets	Intangible and tangible	Intangible	Intangible and tangible, separately	Intangible and tangible, somewhat separately	Intangible and tangible, separately	Intangible and tangible, separately	Intangibles and tangibles in evaluating wealth, only Intangible for IC	Intangible and tangible
Methodology	Each indicator is standardized (scale 0-1). The GDP (ppp) is used, through its logarithm. The data are obtained from the OCDE and IMD. The indexes are calculated by adding the selected indicators (Lin and Edvinsson, 2008)	An IC index is determined. The indicators are added according to the relative importance of each one (Weziak, 2007)	Each indicator is standardized (scale 0-1). The indexes are calculated by adding the selected indicators. The NICI index is calculated as the average of four IC components: Human, Process, Market, and Renewal capital (Bontis, 2004)	Determines two indexes: IC efficiency and IC value added. IC value added is the difference between outputs and inputs. IC efficiency is the addition of human capital efficiency and structural capital efficiency. The efficiency is calculated through the ratio between each component and the total value added (Pulic, 2003)	The Lisbon strategy is used to select the indicators. Three IC indexes are determined, which represent three temporal dimensions of IC: past, present, and future (Andriessen and Stam, 2005)	The indexes are calculated averaging selected indicators from international databases. Each indicator is standardized previously (Bounfour, 2003)	Human capital and structural capital are calculated by adding the selected indicators, named in this model: absolutes indicators. Each indicator is multiplied by a factor reflecting the relative importance, which is obtained through main component analysis (López et al., 2011)	Each indicators used is indicator is multiplied by a factor reflecting the relative importance, which is represented by the correlation with the component analyzed. The total (final) value is obtained by adding the value of each category, and then dividing by the total sum of the sample (Atkinson and Andes, 2008)

Notes: (1) All models in Table III.2, with the exception of SNEI, report national IC through a specific index, without including financial assets; (2) Assets evaluated: type of assets that the models use: tangibles or intangibles. Source: author's elaboration.

Table III.3. International organizations' models: Main characteristics

Models	KAM	GII	GCI	WCI	HDI	S&T I	IUS	SMS	INNIC
Organization	World Bank	INSEAD	World Economic Forum	International Institute for Management Development	United Nations Development Program	OECD	European Union	Danish Government	Editor report 2010-2011: A.López-Claros
Assessment objective	Knowledge	Innovation	Competitiveness	Competitiveness	Human development	Science and innovation performance.	Innovation performance	Prosperity and welfare	Innovation capacity
Main aggregated indicators offered	Knowledge economy	Knowledge economy and macro and microeconomic principles	Macro and microeconomic principles	Macro and microeconomic principles	Human development: social and economic principles.	Knowledge economy	Knowledge economy	Knowledge economy and macro and microeconomic principles	Knowledge economy
Main aggregated indicators	Knowledge Economy Index (KEI) and Knowledge Index (KI)	Innovation input: Institutions, HC and research, Infrastructure, market sophistication and business sophistication. innovation output: scientific outputs and creative outputs	Institutions, Infrastructure, Macroeconomic environment, health and basic education, higher education and training, goods market efficiency, labor market efficiency, financial market development, technological readiness, market size, business sophistication, and Innovation	Economic performance, government and business efficiency	**Life expectancy, knowledge and education and standard of living**	R&D spending, Patents, Scientific articles, Education level, Researchers, Collaboration and firm innovation	Enablers, Firm activities, and Outputs	Welfare and public services; productivity and business conditions; transport, infrastructure and environment; overall conditions	Innovation capacity. In addition determines: HC, training & Social inclusion; Regulation & legal framework; Inst. Environment; and Usage ICT; R&D
IC components	Not explicit, but are deduced: HC, RC, SC, Renewal Capital, Market Capital, and Process Capital	Explicitly only HC. Also are deduced: RC, SC, Renewal Capital, Market Capital, and Process Capital	Not explicit, but are deduced: HC, RC, SC, Renewal Capital, Market Capital, and Process Capital	Not explicit, but are deduced: HC, RC, SC, Renewal Capital, Market Capital, and Process Capital	Not explicit, but are deduced: HC	Not explicit, but are deduced: HC, SC, RC, and Renewal Capital	Not explicit, but are deduced: HC, SC, RC, and Renewal Capital	Not explicit, but deduced: HC, RC, SC, Renewal Capital, Market Capital, and Process Capital	HC explicitly. RC and SC implicitly

Assets	Intangibles and tangibles together	Intangibles and tangibles together	Intangibles and tangibles together	Intangibles and tangibles together	Intangibles and tangibles together	Intangibles and tangibles separately	Intangibles and tangibles somewhat separately	Intangibles and tangibles together	Intangibles and tangibles somewhat separately
Methodology	KEI and KI are calculated by averaging indicators. Each indicator is standardized (scale 1-10) (World Bank, 2012)	GII and two sub-indices are determined: Innovation Input and Innovation Output. The first sub-index included: institutions, human capital and research, infrastructure, market sophistication, and business sophistication. The innovation output index included: scientific outputs and creative outputs. Sub-pillar scores are calculated as the weighted average of individual indicators; pillar scores are calculated as the simple average of the sub-pillar scores (Dutta, 2011; Dutta and Lanvin, 2013)	The data are obtained from international databases and survey. A total of twelve components (pillars) are determined using 112 indicators. The pillars are clustered in Basic requirements (institutions, infrastructure, macroeconomic stability, and health and primary education), Efficiency enhancers (higher education and training, goods market efficiency, labor market efficiency, financial market sophistication, technological readiness, and market size), and Innovation and sophistication factors (business sophistication and innovation (WEF, 2010)	331 indicators are used to determine 20 variables, which are grouped into 4 competitiveness factors. Each factor reports an index (IMD, 2008, 2011 and 2013)	Three main components are included that are calculated using four indicators: life expectancy, knowledge and education (literacy rate -with 2/3 weighting - and gross enrollment ratio – with 1/3 weighting- and standard of living (in GDP ppp). The HDI is calculated as the average of components (UNDP, 2010)	13 indicators are presented without aggregation. The indicators are reported together with EU averages (OECD, 2010)	25 indicators are used to evaluate 8 variables, grouped into three clusters: enablers (human resources and open, excellent and attractive research systems), Firm activities (firm investments, linkages & entrepreneurship, and intellectual assets), and Outputs (innovators and economic effects) The information is reported together with EU averages. In addition, information is presented from non-EU countries of economic importance to Europe (European Commission, 2011).	Each selected indicator is reported, classified by dimension and component. The information is used for benchmarking (Denmark. Finansministerie, 2000)	INNCI and five pillars are determined through 61 indicators. The countries are ranked according to their overall performance. Each pillar has a different weight, which depends on a country's income and level of democracy (López-Claros, 2011)

Note: In general, the models described in Table III.3 use both intangible and tangible indicators, without integrating them.

Source: Author's elaboration

3.1.6. Findings

a. Differences between models at the country and firm levels

The studies with firm models have created a widely accepted taxonomy with three main components: human capital, structural capital, and relational capital (Ståhle and Bounfour, 2008). For the evaluation and management of the IC of the firm, Cañibano et al. (2002) proposed a three-step system: identify the strategic objectives of the firm and its main intangibles, then determine an indicator system, and finally manage and follow-up on those intangibles.

Several studies on national IC have emerged by replicating micro measurement models (Ståhle et al., 2011), such as ICN, IC-dVAL, and VAIC. Among the differences between IC at the firm and national levels are the quantity of information involved and the peculiarities of the entity being studied (López, et al., 2011). In addition, the need for national comparisons requires that the particularities of each country are excluded, and therefore it is not possible to make comparative evaluations when different objectives and strategies are taken into account (Salonious and Lönnqvist, 2012; Käpylä et al., 2012).

Although some models to evaluate IC at the country level are adaptations of models developed for private firms, there are several differences between them that are summarized in Table III.4. The differences between models for firms and countries are mainly related to the purpose and structure. While the evaluation systems for firms consider the strategy or objectives of the companies (Cañibano et al., 2002), using formats according to the sector or type of firm, country models apply a more standard methodology, without differences among countries for easy comparison. The models to evaluate intangibles at the country level report composite indices that permit comparison among countries, while the models for firms tend to give information through a set of indicators.

In general, macro-level assessments not only include intangible assets related to the economic activities of enterprises, but also a number of institutional, social and other contextual elements that reflect the national and supranational development environment that affects business, sectorial performance and personal progress.

Table III.4. Main differences between country and firm-level models

Characteristics	Firm-level models	Country-level models
Origin	To explain differences between market and book values	To improve country growth
Purpose	To report growth capacity of firms	To report the growth capacity of countries
General objective	To determine the IC of private firms	To determine competitiveness, innovative capacity or development
Structure	A common structure is used for all firms, but the indicator systems can differ among firms	A similar evaluation structure is applied to countries
Theoretical base	IC and intangible assets framework	Two lines are observed: IC developed at the firm level and a macroeconomic approach
Narrative	Recommended	Not used. New models try to incorporate this dimension
Composite Indexes	Not commonly used	Highly developed. Permits country comparisons

Source: Author's elaboration

b. Differences between academic models and international organizations' models

Although several tools are available to measure intangibles at the country level, international organizations' models are the most widely used because policy makers are not yet familiar with the concept of IC, even though elements of IC (e.g. competence level, national brand) are highly valued (Salonious and Lönnqvist, 2012). In addition, the composite indexes have been widely accepted by policy makers and academics as they provide an easy way to comparatively understand and manage the IC level of a country (Lin and Edvinsson, 2011). Consequently, academic models that report composite indices, such as ICN, ICI, NICI, and IC-dVAL, have attracted more attention and are beginning to gain popularity.

The main differences between the two approaches are the objectives and the conceptual framework (Table III.5). The academic models seek to determine national IC directly, and some models additionally determine national wealth as a way to predict future performance, while the international organizations' models focus directly on capacity for growth or development without identifying IC or IC components.

Table III.5. Main differences and similarities between academic and international organizations' models

Characteristics		Models	
		Academic models	**International organizations' models**
Main Differences	**Conceptual framework**	Knowledge-based economy	Macro/micro-economy and knowledge-based economy
	General objective	Intellectual capital	Competitiveness, innovation or development.
	Origin	Studies on IC at firm level.	Studies about country-level growth
	Main Index	IC	Each model report different index according to the objectives
	Measurement process	Tangibles and intangibles evaluated separately	Tangibles and intangibles evaluated together
	IC components	Mainly explicit: HC, RC and SC. Some models include renewal capital, market capital, and process capital	Not explicit, only use Intangibles indicators
	Variables	Based in IC framework	Based on the components of competitiveness, innovation and development
	Indicators	Mainly non-financial indicators. Focused on intangible assets	Mainly financial indicators
Main similarities	**Purpose**	Development of the country	
	Final Outputs	Composite indexes	
	Assets	Intangibles and tangibles	

Source: Author's elaboration

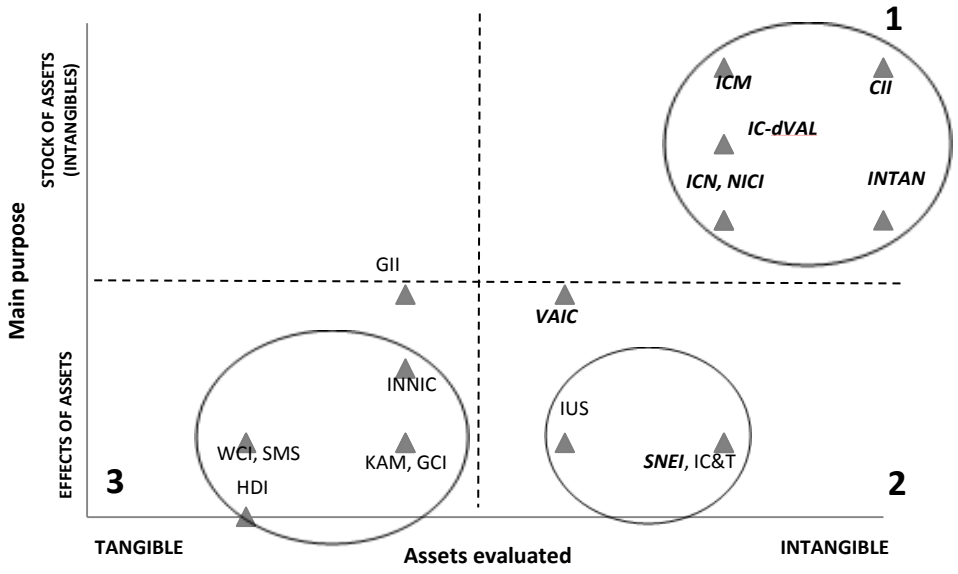
The indicators used for the academic models are principally non-financial, and related to stock and the effects of each resource. In addition, financial indicators are used to provide information about capital or investment in intangibles. In contrast, the international organizations' models have a high proportion of financial indicators. This combination of financial and non-financial indicators in all the models has also been pointed out by Ramírez (2010), who argued that an adequate evaluation system of intangibles includes both types of indicators.

Despite the complexity of assessing intangibles, some models are widely known and accepted, mainly international organizations' models. Nevertheless, there is still no consensus on the evaluation models or the indicators. Thus, countries that want to use these models must adapt them to their specific requirements in order to manage IC. To adapt the standard information and evaluation systems to the current needs of countries, some researchers try to improve models and fit them to specific contexts.

c. Categories and model classification

Given the large number of methods to measure intangibles, it is necessary to select the most adequate alternative. To do this, scholars and policy makers need to know the models, their characteristics, and have a classification that facilitates selection. The following figure (Figure III.1) shows a classification of the models according to two important characteristics: the type of assets evaluated and the purpose of the model. This classification seeks to aid in the selection of the system by policy makers, researchers, business actors and governments.

Figure III.1. Models classified according to objectives, indicators and composition
Italic and bold letters: academic models



Source: Author's elaboration

The index used in the X-axis, was determined through the sum of normalized variables: objectives and IC composition (see annex 4). To the right are the models with methodologies that include more variables of intangibles. In the upper part are the models whose purpose is to know the stock of intangibles rather than the effect or impact.

Sector 1 (top-right) includes the ICM, ICI, IC-dVAL, INTAN, ICN and NICI models, which are more related to the IC taxonomy developed for companies since most of them originated in studies of IC at the firm level (Ståhle et al., 2011). These models mainly use indicators of intangibles and report IC through composite indexes that permit

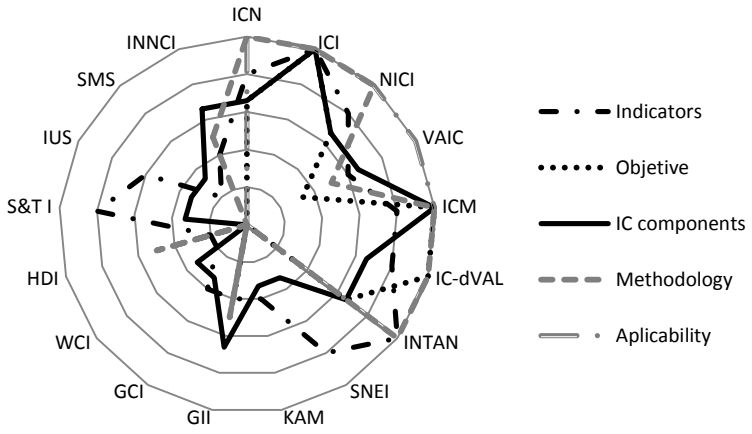
comparisons across countries. However, the application of these models requires sufficient knowledge of IC and its relationship to national development.

The models in Sector 3 aim to determine the effects of intangible and tangible assets, such as competitiveness and development, and their results are easier to understand and apply for policy makers. In general, these models are not directly based on an IC framework and use a more macroeconomic perspective.

At the bottom-right of the figure are IUS, SNEI and S&T I. These models take into account the Knowledge economy framework to define the variables to evaluate, but do not determine the IC of a country as whole. The reports from these measurement tools show the development and economic growth potential of countries based on intangible assets, being widely used for follow-up and management of public policies at national and supranational levels.

Two main groups emerge when the models are analyzed on the basis of their objectives, the type of assets evaluated, methodologies used to aggregate the indicators, and the IC components included (Graph III.4). These groups coincide with the origin of the model (academic and international organizations' models). The main differences between the two model types are related to the aggregation of indicators and the theoretical base.

Graph III.4. Evaluation models of intangibles.



Note: Annex 4 shows the evaluation system used for the evaluation.
Source: Author's elaboration

The ICN, ICI, NICI, ICM, IC-dVAL and INTAN models follow a common pattern and are closer to the IC framework, evaluating IC as a whole and separately from financial capital, while the IUS, S&T I, WCI, GCI, KAM and SNEI models integrate indicators of tangible and intangible assets in each evaluation step. The VAIC model follows a more

financial perspective, and its results are not closely related to the IC framework (Ståhle et al., 2011). On the other hand, the academic models explicitly evaluate the IC, using mainly human capital and structural capital components. Some models, such as NICI, ICN, and ICM, also include relational capital, renewal capital or market capital.

Even though the aggregation of indicators and the intermediate indexes differ among models, their results (country rankings) tend to converge. The similarity of rankings confirms that the models have captured national IC. Hervas-Oliver et al. (2011) found that all the indicators included in prestigious innovation studies had a similar nature (intangible). In general, the rankings provided by the models analyzed include a Nordic country among the top five positions (Table III.6).

Table III.6. Standardized classification of countries (position in ranking)

Models	Countries													
	SE	**DK**	**FI**	**DE**	**UK**	**BE**	**AT**	**NL**	**IE**	**FR**	**PT**	**IT**	**ES**	**GR**
ICN W	1	3	2	6	9	8	5	4	7	10	14	12	11	13
ICI	2	4	1	3	9	7	6	5	10	8	12	14	11	13
VAIC	8	10	11	1	2	7	9	6	14	3	13	4	5	12
ICM A	1	2	3	9	4	8	6	7	5	10	12	14	11	13
IC-dVAL	1	3	4	7	5	10	9	2	6	8	14	12	11	13
INTAN	1	3	6	4	2	9	5	7	10	8	13	12	11	14
KAM KEI	2	1	3	7	5	9	8	4	6	10	13	12	11	14
GII	1	3	2	6	5	9	8	4	7	9	12	13	11	14
GCI	1	5	3	2	6	9	8	4	10	7	12	13	11	14
WCI EP	7	9	11	1	4	6	5	2	8	3	12	13	10	14
HDI	3	8	6	4	13	7	12	2	1	5	14	11	9	10
IUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
INNCI	1	3	2	7	5	9	8	4	6	10	12	12	11	14

Data source: Andriessen and Stam (2005), Weziak (2007), Lin and Edvinsson (2008), European Commission (2011), Dutta (2011), Pulic (2003), López et al. (2011), Bounfour (2003), World Bank (2012), WEF (2010), IMD (2008), UNDP (2010), López-Claros (2011).
Source: Author's elaboration.

The correlation analysis confirms the similarities in the results of the models analyzed, showing that models with partially different inputs produce similar country rankings. Table III.7 shows a generally high, positive, and significant correlation among most of the models, except for the VAIC and WCI (Economic Performance index). These exceptions could be related to the different approaches and methodology used because the VAIC provides the value added by IC and investment (capital), rather than the stock of IC (Pulic, 2003), and the WCI considers the country's competitiveness from a mainly macroeconomic perspective.

Table III.7. Matrix of correlations among rankings (country position) reported by the models

Models	Indexes	ICN		ICI	VAIC		ICM			IC-dVAL	INTAN	KAM		GII	GCI	WCI		HDI	IUS
		Wealth	IC		Added value	Efficiency	Assesst	Invest	Effects			Knowl. Economy	Knowl.			Econ. Perform.	Business Effc.		
ICN	Wealth	1																	
	IC	.996 ***	1																
ICI		.921 ***	.925 ***	1															
VAIC	Added Value	-.042	-.055	.090	1														
	Efficiency	-.077	-.068	-.253	-.429	1													
ICM	Assets	.873 ***	.864 ***	.771 ***	-.152	-.244	1												
	Investments	.824 ***	.820 ***	.895 ***	.081	-.389	.749 ***	1											
	Effects	.622 **	.609 **	.644 **	.503 *	-.538 **	.604 **	618 **	1										
IC-dVAL		.890 ***	.877 ***	.793 ***	.103	-.209	.873 ***	732 ***	807 ***	1									
INTAN		.793 ***	.771 ***	.798 ***	.345	-.473 *	.833 ***	758 ***	807 ***	820 ***	1								
KAM	Knowledge Economy	.921 ***	.916 ***	.824 ***	.007	-.279	.938 ***	793 ***	749 ***	960 ***	846 ***	1							
	Knowledge	.930 ***	.921 ***	.815 ***	.024	-.182	.925 ***	780 ***	754 ***	969 ***	846 ***	.987 ***	1						
GII		.927 ***	.923 ***	.892 ***	.049	-.279	.927 ***	821 ***	754 ***	958 ***	869 ***	.976 ***	.967 ***	1					
GCI		.859 ***	.851 ***	.938 ***	.301	-.358	.754 ***	833 ***	815 ***	868 ***	881 ***	.846 ***	.846 ***	.923 ***	1				
WCI	Economic Performance	.411	.393	.512 *	.591 **	-.587 **	.332	437	780 ***	503 *	613 **	.411	.398	.470 *	640 **	1			
	Business Efficiency	.833 ***	.820 ***	.648 **	-.270	-.138	.890 ***	609 **	578 **	833 ***	653 **	.864 ***	.851 ***	.807 ***	609 **	.393	1		
HDI		.574 **	.560 **	.516 *	.007	.125	.376	451	521 *	622 **	253	.499 *	.530 *	.519 *	534 **	.429	.574 **	1	
IUS		.859 ***	.851 ***	.886 ***	.090	-.407	.873 ***	908 ***	697 ***	793 ***	899 ***	.881 ***	.877 ***	.905 ***	877 ***	.429	.679 ***	.327	1
INNCI		.926 ***	.922 ***	.845 ***	--135	-216	.940 ***	782 ***	715 ***	958 ***	837 ***	.985 ***	.980 ***	.991 ***	872 ***	.400	.836 ***	.513*	.886 ***

*** Significance at 1% level; ** Significance at 5% level; * Significance at 10% level

Source: author's elaboration

3.2. Intellectual Capital of nations: an analysis of assessment models[24]

3.2.1. Introduction

The current economic and social framework has led nations to seek mechanisms to aid them in becoming more adaptable, thus promoting a highly dynamic wealth creation process. At a macro level, we now recognize that intangibles are important because of their capacity to support economic growth (Edvinsson and Kivikas, 2004).

To manage intangibles, there must be a measurement system that allows its description, accounting, and effective follow-up (Edvinsson and Stenfelt, 1999; Ståhle and Bounfour, 2008); this requires a system of variables that helps reflect and manage the hidden wealth of a nation (Bontis, 2004). Various efforts have been made to this end, highlighting studies of intellectual capital (IC) at the firm level that have contributed to developing measurement and reporting models that can be used at a country level (Ståhle et al., 2011). However, the complexity of this assessment makes it difficult to adapt firm-level models to the macro level (Lin and Edvinsson, 2011; Käpylä et al., 2012). Another important and independent line of work by international organizations incorporates intangibles with more traditional measurements to explain country development, competitiveness and innovative capacity.

Therefore, this work analyzes and compares the evaluation systems of national intangibles in order to identify the similitudes and differences and collaborate in the harmonization of these assessment tools. The empirical work also seeks to contribute to the selection of the most suitable model from among the various alternatives for the strategic management of intangibles.

In the next section is introduced the specific mythology used in this research, and then are offered a set of information about models, their characteristics, a qualitative and quantitative comparison, and a classification of the models to ease the management of IC.

[24] Paper submitted (second review) to the journal Knowledge Management Research and Practice (JMRP) on October 2013.

3.2.2. Methodology

The study of models is based on the analysis of the literature selected from a previous systematic literature review related to country-level intangibles, carried out in the above research. The models were analyzed and compared principally by cluster technique. This analytic tool has become popular to assign observations to groups as a way to categorize a sample and identify clusters and their structures (Punj and Stewart, 1983; Kaufman and Rousseeuw, 2009). In this methodology, individuals are classified according to similarities among variables or attributes of interest, evaluating the distance between them, and grouping them according to their degree of similarity (Barcenilla and Lozano, 2000; Mooi and Sarstedt, 2011). There are different ways to measure the distance between observations. In this regard, we have used hierarchical clustering methodology, while the distances were computed by average linkage. Finally, following to Tryfos (1998), we used squared Euclidean option, which is common for this type of analysis.

A total of 17 IC assessment models have been studied. The first cluster (Cluster 1) was addressed using qualitative information from the objectives and components of the 17 models analyzed, with a total of 14 measured variables (see details in Annex 5). For the second cluster analysis was used data from the 13 models that report country rankings. The data were standardized because these measurement tools report on different combinations of countries. Therefore, only countries that are studied in all the models were considered, resulting in a total of 14. With this information (13 models with information for 14 countries) were applied cluster techniques to classify the models based on the reported country rankings (Cluster 2).

Finally, it is performed a third cluster analysis (Cluster 3) of country groupings according to the levels of intangibles reported in the 13 models, with interesting findings that confirm the relevance of country-level IC and its policy implications.

3.2.3. National Intellectual Capital assessment models

The analyzed literature presents various models to measure country-level intangibles. Some models are adaptations of systems developed and applied at the firm level (López and Nevado, 2008; Ståhle et al., 2011), such as Intellectual Capital Navigator by L. Edvinsson and M. Malone, Intellectual Capital Dynamic Value by A. Bounfour, and Value-Added Intellectual Coefficient by A. Pulic. However, there are important

differences between IC models at the firm and national levels due to the peculiarities of the entity under study (López, et al., 2011) and the need to compare countries. Moreover, the evaluation systems applied at a country level tend to provide composites indexes that have been widely accepted as they provide an easy way to comparatively manage the IC of a country (Lin and Edvinsson, 2011).

In general, it is possible to identify two measurements and reporting approaches of the IC of nations (see Table III.5) confirming the findings of Hervas-Oliver and Dalmau-Porte (2007), Alfaro et al. (2011) and López et al. (2011) shown in the previous analysis of this chapter. These two groups of models differ in both their conceptual framework and the methodology to measure intangibles. The main characteristics of these models (Table III.8) provide evidence that academic models are more likely to use the conceptual framework of the Knowledge economy and determine the IC of countries, while the other models integrate intangibles within the micro and macroeconomic principles affecting a country's growth. Despite the differences between them, the evidence and reports indicate a convergence in their results.

Table III.8. Conceptual framework and main measurement objective(s) of the models

Models	**Characteristics**					
	Conceptual framework			**Objective**		
	Knowledge Economy	Macro/ Micro economy principles	Other	IC	Competi-tiveness	Development
Academic models						
ICN	X			X		
ICI	X			X		
NICI	X			X		
VAIC	X			X		
ICM	X			X		X[a]
IC-dVAL	X			X		
INTAN	X			X		
SNEI	X			X		
International organizations' models						
KAM	X				X	X
GII	X	X		X	X[b]	X
GCI		X			X	X
WCI		X			X	X
HDI		X	X[c]			X
S&T I	X					X
IUS	X					X
SMS	X	X			X	X
INNCI	X	X			X	

Notes. a: defined as the Lisbon strategy; b: Innovation, c: Includes social components such as life expectancy.
Source: Author's elaboration

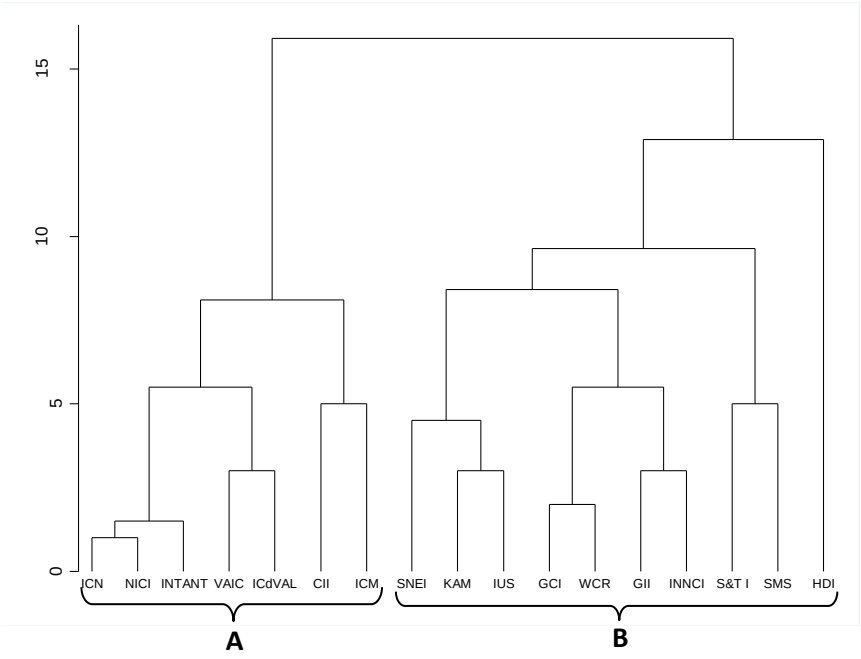
The extensive use of various elements of IC for all models confirms its importance in these indexes since all these factors are related to an economy's behavior (Dutta, 2011) and there is a high degree of interdependence between the IC of a country and

its competitiveness (Ståhle and Ståhle, 2006; WEF, 2013) and national innovation system (Hervas-Oliver et al., 2011). This is why the rankings for IC, competitiveness, and innovation place the richest economies in the top positions.

a. Comparison of models in accordance with their objectives and components

Because of the large number of alternatives to measure intangibles, the selection of the method can be complex. As well, each model requires different inputs (information), much of which are not available in some countries. Facilitating selection of a model is the motive for this study. Cluster 1 (Graph III.5), which uses 14 qualitative variables (Annex 5), confirms that there are two lines of study and evaluation of intangibles and IC at the macro level, one followed mainly by academics and the other primarily by international organizations. The first group (Group A, Graph III.5) is made up of models that have the objective of providing the IC level of a country, while the second group (Group B, Graph III.5) takes into account the values of intangible assets as a way to measure aspects like competitiveness, development, and innovation capacity. One model is in neither group, the Human Development Index (HDI), mainly because it not only includes variables like education and income found in all models, but also health related indicator (life expectancy at birth), which is an intangible not usually taken into account in IC evaluations.

Graph III.5**.** Cluster 1 dendrogram. Model grouped in accordance with objectives and components.



Source: Author's elaboration

Group A models use secondary information from public databases of international organizations. Generally, they explicitly include human capital and structural capital in their measurements and reports and also consider relational capital, labeling this in several ways (such as relational capital, market capital, economic and institutional capital, and globalization). All Group A models determine the IC level of the country by providing specific composite indexes.

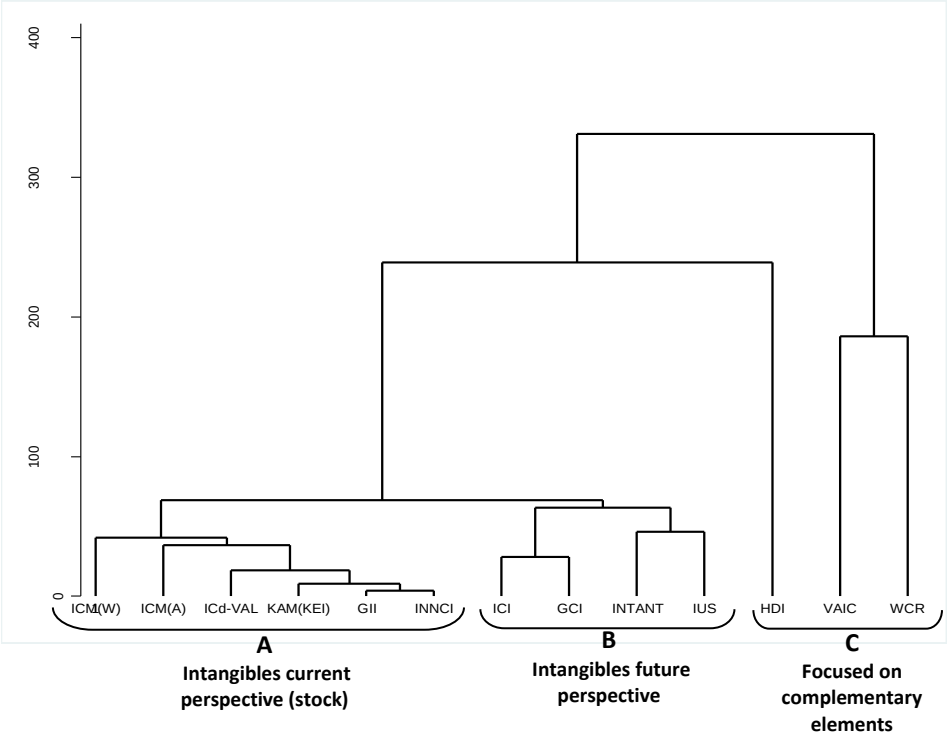
As for the Group B models, all seek to directly or indirectly know the effect of intangible and tangible assets on the development of nations. Their measurements implicitly include elements of human capital, structural capital, and relational capital, but fail to determine them independently as do the Group A models.

b. Comparison between models according to the reported country rankings

This clustering provides a different classification of the models from that obtained by qualitative variables (input indicators), confirming that there are alternative ways to assess country-level intangibles. The cluster analysis of the country rankings (Cluster 2) identified three main model groups. The first (Group A, Graph III.6) is mostly oriented to measuring intangible stocks and reporting the total IC level, knowledge or innovation capacity. The second (Group B) is more concerned with the management of intangibles in a future perspective and providing information about the competitiveness of a country. The last group also deals with an important set of tangible assets, including other social and economic elements such as justice, income distribution, and life expectancy that, along with IC, play important roles in a country's development.

The proximity between methods evaluated through cluster analysis offers an overview of the similarity of the results reported by the models. Our findings show that INNCI, GII, KAM, IC-dVAL, ICM, and ICN obtain very similar country rankings. The main differences are found with the models VAIC, HDI, and WCI, which could hamper comparative studies. These exceptions could be related to the different approaches and methodologies used because VAIC provides the value added by IC and the investment, rather than IC stock (Pulic, 2003), while with the WCI a country's competitiveness is viewed mainly from a macroeconomic perspective.

Graph III.6. Cluster 2 dendrogram. Models grouped according to country rankings



Source: Author's elaboration

These findings answer the research question about differences and similarities of models, and are consistent with those reported in the literature, as several models can produce similar outputs with partially different inputs and methodologies. Indeed, Hervas-Oliver et al. (2011) identified that IC and competitiveness were strongly related, and therefore, different measurement tools can provide similar information.

If we compare the two cluster analyses (Clusters 1 and 2), we observe that models with different methodologies and objectives, such as GII, IC-dVAL, and IC-Navigator, provide similar rankings, because they use similar indicators and variables. Differences arise in terms of how to add the indicators (López et al., 2011) without decisively affecting the results. Likewise, Hervas Oliver et al. (2011) found that all the indicators included in prestigious innovation research had a similar nature (intangible).

Models that are characterized for determining the IC level independently, such as IC-Navigator, IC-Monitor, and National Intellectual Capital, require more knowledge to be implemented and interpreted. On the other hand, models such as Global Competitiveness, Global Innovation, Innovation Capacity, and Innovation Union Scoreboard only take into account the values of intangibles as a way to measure

competitiveness, development, and innovation capacity. They generate information that is easier to understand and apply to development and follow-up policies.

It can therefore be pointed out that there are several models to measure the intangibles of countries. Their rankings of countries are similar but they require different inputs. This provides several alternatives to the user in terms of the required information, the available data, and the type of reporting, benchmarking and management systems to be used.

The analysis has identified differences and similarities among national IC assessment models, finding that methodological differences do not necessarily affect the results, which has important and practical implications for both policy makers and scholars that want to know and manage country-level intangible assets. Thus, it is clear that intangibles are a key and determinant component of development, competitiveness, innovation, and growth of countries, and therefore must be part of any index of evaluation of these variables.

c. Classification of countries based on reports of intangibles

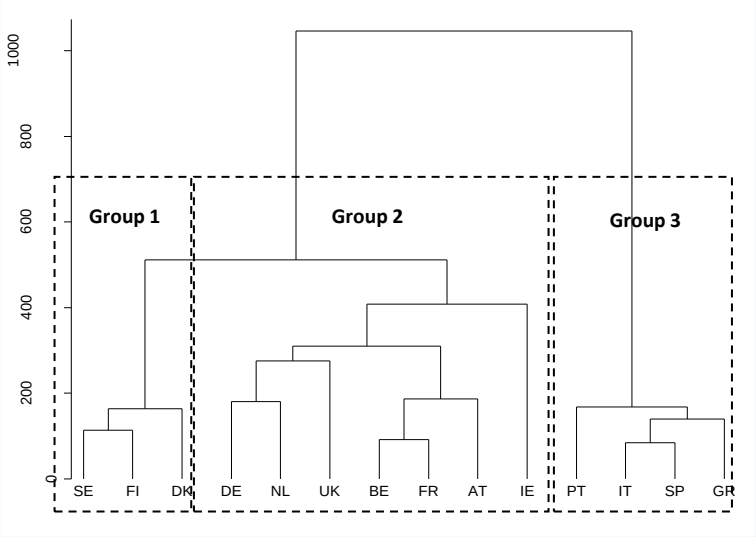
Grouping countries by cluster analysis (cluster 3) based on the reports provided by the 13 analyzed models (Graph III.7) and using the position of countries in rankings as a variable, result in two major groups. One group is made up of Italy, Spain, Greece, and Portugal, known as the peripheral countries of Europe, which, along with Ireland, have had the greatest difficulties in the current economic crisis. This could be a product of the low level of their intangibles, which is in accordance with Lin et al. (2013).

Another set includes two subgroups (Groups 1 and 2, Graph III.7). Group 1 is made up of the Nordic countries included in this work (Denmark, Finland and Sweden) and those generally occupying the first positions in the IC and competitiveness rankings (see Table III.6), which coincide with the results by Hervas Oliver et al. (2011) and Lin and Edvinsson (2011). The other subgroup (Group 2) includes Germany, the Netherlands, Belgium, France, Austria, the United Kingdom, and Ireland. In this group, Ireland exhibits the greatest dissimilarity from the other countries, coinciding with its weak economic performance in recent years.

It seems that the information provided by the models on the intangibles of a nation and their influence on development, competitiveness and innovative capacity allow us

to understand economic performance since IC represents the capacity to create wealth in the long-term. This is because there is a direct relationship between intangibles and economic growth (Ståhle and Ståhle, 2006; Weziak, 2007; Corrado, et al., 2009).

Graph III.7. Cluster 3 dendrogram. Country groups based on country rankings



Source: Author's elaboration

CHAPTER IV. IDENTIFYING THE ROLE OF NATURAL RESOURCES IN KNOWLEDGE-BASED STRATEGIES OF DEVELOPMENT[25]

4.1. Introduction

There is a broad consensus today about the importance of the capability building process, defined by the creation and use of technologies and knowledge, as a driving force of economic growth. This explains why innovation has become a concern for policy actions promoting development and a key factor in overcoming poverty in developing countries (Erika and Watu, 2010). There are diverse efforts of governments to provide capabilities to achieve wealth, better living conditions and long-term sustainable development. The Evolutionary theory predicts that knowledge is at the core of the development process. Nonetheless, some countries have achieved high economic standards even though their economic structures are based on natural resources and predominantly low-tech industries (Sæther et al., 2011). This opens new opportunities for research into the potential role of natural resources in development from a knowledge-based approach that highlights the elements of national innovation systems.

Economic growth is a changing process in which a diversity of factors interacts and this interplay makes it possible to interpret them following a systemic approach (Castellacci, 2007a; Fagerberg and Verspagen, 2002). The idea is that knowledge is not only related to scientific and technological advance but also closely related to the possibilities that the production system and the institutional framework offer for integrating innovation as a main driving force for the advance of countries. Overall, countries can take advantages of the opportunities arising from a knowledge-based economy if they can appropriately manage an industrialization process oriented to the creation of more knowledge-intense activities, the generation and consolidation of intangible assets that favor competitiveness and the reorientation of production toward higher value added goods and services that can be based on their original specialization. This would imply that although structural change in traditional sectors, like resource-based industries, is key, it is not needed to be so radical if the development strategy adopts a systemic approach.

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Much of the available evidence agrees on the existence of a negative relationship between natural resources and economic growth. This view arises from a variety of recurring factors such as weak institutions, deindustrialization and currency appreciation also known as the Dutch disease, the presence of social conflicts, inadequate distribution of human capital among industries, environmental damage, excessive public debt, natural resources depletion, and even negative effects on innovation systems (Sachs and Warner, 1999; Rosser, 2006; Van der Ploeg, 2011). However, some recent works support the idea that economies based on natural resources can reach development by adopting a more systemic strategy that considers potentials complementarities that place knowledge at the core of the process (Gylfason and Zoega, 2006; Iizuka and Soete, 2011).

According to Pavitt's taxonomy (Pavitt, 1984), natural resource-based industries are mainly supplier-dominated in relation to their access to technology, which is why their technological opportunities are low and core technologies are provided by other sectors and mostly by foreigners. However, many authors also argue that human capital may contribute to positive results from the exploitation of natural resources, and this can become a key aspect for the definition of a successful catching up process. Many resource-based countries have been obliged to make serious efforts to develop the necessary absorptive capacities to allow them to benefit from foreign knowledge and technologies. Nonetheless, as the literature suggests, it is plausible to integrate technology and human capital along with physical endowments for a sustained development. This implies an alternative and systemic view that does not necessarily defend the strategy of a radical shift in the national industrial structure in favor of other more knowledge-intensive strategies. A possible combination for the definition of development strategies is to take advantage of the productive diversification and the strengths of national production and innovation systems. This would allow us to identify what is the combination of internal factors and external influences that promote sustained development.

There is a gap in the literature on national innovation systems concerning the factors supporting development in countries with significant natural resource endowments. This work aims to contribute precisely in this respect by providing an integral explanatory framework to understand the development possibilities of natural resource-based economies. The assumption is that development trajectories are country-specific and can be supported in the original productive system. This research focuses on analyzing the combination of factors supporting development in high

performance economies based on natural resources. The theoretical roots of this proposal are found in the knowledge-based economy approach that defends the role of intangible assets as one of the most influential factors for the advance of countries (Bontis, 2004; Lin and Edvinsson, 2008).

Information for the empirical analysis was obtained from international sources such as the WDI, UNCTAD, and CANA (Castellacci and Natera, 2011) databases, for the period 1996 to 2008. The complete sample of countries includes a total of 133 nations. Two groups of countries based on NR were made. One of them, called NR SPECIALIZED, integrates the economies whose exports of NR represent more than 50% of total exports; the second group, called SELECTED, is result of a cluster analysis, and includes countries whose economies are also based on primary production activities and additionally have a high or medium-high income (per capita GDP), according to the WB classification. The rest of groups corresponded to OECD and OPEC, used as contrasts (see Annex 2 for group composition). The applied growth model that has been estimated is defined by the inclusion of a set of traditional regressors (capital, labor and natural resources) together with factors more related to national innovative and absorptive capabilities, the institutional framework and some indicators of internationalization. The estimation is carried out using both static and dynamic Panel data.

The results of this analysis show firstly a positive impact of natural resources on growth in SELECTED countries, while it is not significant in the case of OECD economies or the total sample of countries. Secondly, the relationship between natural resources and growth depends on the type of resources, since the impact of forestry and oil are similar in both SELECTED and OECD countries, while differences arise in agriculture and mining. The impact of agriculture is not negative in the former group (while it is in the latter) and mining has a positive effect on economic performance. Finally, our findings confirm that a knowledge-based approach that combines physical and intangible factors is a suitable framework, based on a national system of innovation, to explain growth not only in advanced countries but also in successful economies dominated by natural resources. The adoption of this perspective and fresh empirical evidence would have interesting implications for the definition of national policy strategies.

The second part of this chapter presents a revision of the main arguments found in the literature, focused on the relationship between natural resources and development. The third section describes the objectives and the working hypotheses and the fourth

section presents the methodology and describes the data. The last section includes the most relevant results from the model estimations along with a discussion thereof.

4.2. Literature background

Achieving sustainable economic growth is one of the most important challenges for any country, along with a more equitable distribution of income and finding appropriate mechanisms to overcome poverty. In this context, innovation is becoming more important in the definition of development strategies (Giménez and Sanaú, 2007; Erika and Watu, 2010; Álvarez and Botella, 2012). Although the diffusion of technologies across countries is one of the main pillars in many traditional growth models (Solow, 1956), most of the pioneering proposals did not explain how innovation and international transfer of knowledge takes place. We had to wait a long time for the changes in the main economists' conception, which was motivated by the evolution of the economic activity and by the sequential transit from the classical prevalence of natural resources and labor in the explanation of the accumulation process, to the establishment of a new paradigm in which physical assets took on a key role, and more recently to a new framework based on the prominence of intangibles (Romer, 1990; David and Foray, 2002; Corrado et al., 2009).

The most updated models include technical change as an endogenous driver of growth and development (Romer, 1990; Aghion and Howitt, 1992; Fagerberg and Srholec, 2008), with the creative ability of agents to introduce novelties to the system (Schumpeter, 1947) and endogenous knowledge accumulation representing key factors in explaining how innovation results are path dependent (Fagerberg et al., 2010). However, as evolutionist economists claim, the main limitations in the present growth framework are due to the existence of dynamic dependences such as interaction, learning and the cyclical components of growth (Castellacci, 2007a). Despite the predictions of many models that underline knowledge generation as a main engine of growth, the process of development can be understood by the interaction of innovation and imitation as two different and complementary forces that can encourage the possibilities of countries for catching-up. In the international context, the former can increase divergence among countries, while the latter reduces the technological gap among countries (Fagerberg and Verspagen, 2002). Thus, the development of absorptive capacities is crucial for innovation and imitation (Fagerberg and Srholec, 2008).

The relevance of foreign technology in development can explain the catching-up process, with openness, trade and FDI being important channels for knowledge acquisition. According to Castellacci (2007b) and Madsen et al. (2010), openness encourages growth and promotes the domestic generation of patents (Romer, 1990) and improvements in education (Cavallaro and Mulino, 2009; Fagerberg, 1994). The importance of FDI and international trade in technological change are well known since they allow the flow of technology and know-how among countries (Roy and Van den Berg, 2006; Narula and Dunning, 2009), which directly affects productive activities. Recent works point out that knowledge not only flows from developed to developing countries but also in the reverse, with potential benefits for richer countries as well (Goldstein and Wells, 2007; Cuervo-Cazurra and Genc, 2008; Gammeltoft et al., 2010).

Institutions also play an important role because they provide an adequate environment for local and foreign investments, making it possible to reduce potential social conflicts and promote new activities related to higher value added businesses. It is realistic to think that good institutions and long-term policies can avoid the negative effects of natural resource exploitation, like civil wars, perverse economic incentives, rent-seeking, and corruption (Rosser, 2006; Van der Ploeg, 2011). Much empirical evidence agrees on the key role played by aspects like human capital, physical capital investments, technology and institutions in the generation of national product (Gimenez and Sanaú, 2007). These assumptions have also some direct implications for improving competitiveness of countries because technological change adopts a complementary character with respect to the most traditional explicative aspects like prices, costs and salaries (Argüelles and Benavides, 2008; Fagerberg et al., 2007; Castellacci, 2008a).

The concept of national innovative capacity developed by Furman et al. (2002), which is defined as the ability of a country to produce and commercialize innovative technology flows over time, provides a framework that is supported by three well-established lines of research: the endogenous growth theory (Romer, 1990); the conceptual approach of national competitive advantages based on the existence of clusters (Porter, 1990); and the research results from the conceptual approach of national systems of innovation (Lundvall, 2007; Nelson and Winter, 1982). The innovative capacity of a country refers to the output of innovations and to a set of determining factors that are crucial to consolidate the process of innovation at the national level. This capacity permits selecting and assimilating foreign technologies and knowledge (Fagerberg et al., 2010) and developing new ones (Argüelles and Benavides,

2008). Thus, the differences in national capacities are due to differences in economic geography (and this can condition the level of inter-firm spillover effects) or to differences in national innovation policies, mainly those oriented to supporting basic research, the legal protection of intellectual property rights, or the education system. The key idea would be that the national innovative capacity is related to, but different from, scientific and technological advance, which implies going beyond those elements that are crucial for the development and commercialization of new technologies.

Even though the literature broadly confirms that countries with high economic standards have transformed their productive structures towards a higher predominance of high-tech sectors (Catalán, 2007), some economies based on natural resources (NR), with predominantly low tech-industries, have had high levels of economic performance by using the opportunities that these sectors can offer (Von Tunzelmann and Acha, 2005). Two main points of view emerge in the NR literature, one focused on the growth effects of NR endowments while the other deals with the intensity or specialization of related industries. Nonetheless, most of the studies under these two perspectives identify an inverse relationship between NR and economic development, more intense when the level of human capital is low (Sachs and Warner, 1995; Bravo-Ortega and De Gregorio, 2007).

Recent contributions to this line of research point out that institutions are one of the most important factors to reach positive results from the exploitation of NR, although, they deal with a common methodological problem associated with the high correlation among several indicators of institutions (Frankel, 2010; Ville and Wicken, 2012). The empirical evidence indicates that countries with a high institutional quality show no curse and have low risk of economic decline (Van der Ploeg, 2011; Rosser, 2006) because a good institutional framework provides a suitable environment for investors and avoid corruption, violence and irrational increase in public spending that affecting macro and micro economy. Other studies show that abundant NR hamper growth when institutions are weak (WTO, 2010). Thus, in presence of a high level of concentration of NR industries and weak institutions, negative effects on macroeconomic stability can be expected (Manzano, 2012). The strong relationship between NR and institutions is also explained by the fact that NR can worsen institutions and contribute to social conflicts as part of the perverse economic incentives linked to resource exploitation (Ross, 1999; Barbier, 1999; Van der Ploeg, 2011). Overall, an extensive body of literature deals with the complexity of the effects that NR have on the advance of countries in fields other than the economy. The reason

is that we are dealing with an endogenous process with reverse causality and interconnected relationships, making it difficult to separate one from the other.

Some scholars have also pointed out a relation of causality driving these negative effects. Some common reasons are: the easy generation of high incomes, which discourages investments in more knowledge-intensive industries; the low growth potential of a fixed production factor; the negative effect of currency appreciation over manufacturing exports and deindustrialization, which is known as Dutch disease; the generation of a mistaken feeling of economic security that discourages investments in other assets (Gylfason and Zoega, 2006); the presence of high levels of corruption and the reduction of the institutional quality (Sachs and Warner, 1999); an inadequate distribution of human capital among industries (Bravo-Ortega and De Gregorio, 2007); negative effects on innovation systems (Fagerberg and Srholec, 2008); and environmental damage (Smulders, 2005; Stavins, 2011).

Nonetheless, some recent pieces of literature recognize the potential of NR-based activities for growth when there is an adequate combination with human capital (HC) (Iizuka and Soete, 2011; Bravo-Ortega and De Gregorio, 2007) or an intensive use of high technologies that can create windows of opportunity for diversification and development (Iizuka and Soete, 2011; Lindkvist and Sanchez, 2008). Moreover, Hauser et al. (2011) indicate that the integration of social factors is also required to achieve positive results in terms of sustainable development. According to Catalán (2007), successful growth in countries based on NR is explained by HC endowments, together with the strength of public institutions, the promotion of S&T public policies and the establishment of technological clusters. Finally, authors that analyzed the differences between renewable and non-renewable resources have pointed to the existence of a positive impact when renewable resources are associated with human capital investments and how this is a key issue to generate sustainable development (Pender, 1998), while Stijns (2005) identifies important differences when the two types of natural resources are considered.

4.3. Objectives and hypotheses

The main objective of this chapter is to develop an integrative framework that combines traditional factors generally present in the explanation of growth with those more closely related to the national systems of innovation perspective. The proposal is to test how plausible would be to conceive the idea that resource-based economies

can reach higher levels of development by following a strategy that combines their predominant specialization in intensive use of natural resources along with the reinforcement of intangible assets.

A specific working objective is to check the effects of different types of natural resources on different groups of countries, developed and resource-based, and to evaluate the aspects that make it possible to clearly identify different trajectories and the key drivers of successful economies. The findings of our empirical work could contribute to the definition of development policies and defining integrated strategies for sustained growth.

The main contribution of this analysis is to provide a framework to understand different patterns of development, including those based on natural resources. Much of the literature confirms the importance of changes in industrial structural in the richest countries to reach development, but our proposal is to identify an alternative way composed of relevant elements of intangible nature for sustainable development, maintaining traditional sectors as pillars of progress. Our findings will also provide new information for policy makers' decisions related to improving development in countries with high natural resource endowments that are lagging behind. The general assumption is that effects that are positive for growth derived from knowledge and innovation are possible not only in high tech and science-based industries, but there are extensive to all types of sectors and fields of activity. In such a case, development strategies based on knowledge should integrate not only R&D related activities, but also the entire production and innovation system, together with institutional aspects, and the influences of the international context.

Our working hypothesis is supported by the literature previously revised, raising an analytical framework built on the national system of innovation approach that could be applied in economies based on natural resources. Among the discussions of scholars about the differences between renewable and non-renewable natural resources and their importance for sustainable development, some contributions argue for a positive contribution of renewable resources when these are combined with human capital (Pender, 1998). Others, such as Stavins (2011), indicate the potential role of technology to reduce the problem of scarcity in the case of non-renewable resources and to increase their productivity, although this could generate over-exploitation, which would reduce economic growth in the end, obliging countries to implement different public policies to mitigate these negative effects (Smulders and Gradus, 1996). Therefore, our first hypothesis is that *natural resources can positively*

affect growth in economies based on primary industries, but with different impacts depending on whether they are renewable or non-renewable resources (Hypothesis 1).

The New growth theory and the evolutionary approach postulate that intangibles are at the core of economic development. As well, in the intellectual capital literature, HC and technology are seen as important aspects in wealth creation (Edvinsson, 2003; Corrado et al., 2009; Dunning, 2009). However, their potential role across countries differs when considering the relative levels of development. In developed countries, the main source of technology is local production, which impacts positively on growth through different forms of innovation, while in developing countries the acquisition of foreign knowledge and technology is still one of the main alternatives for catching up (Castellacci, 2006b; Silva and Teixeira, 2011). According to this, our second hypothesis is that *intangibles exert a positive influence on growth in economies based on natural resources, as happens in developed countries* (Hypothesis 2). The next Table (Table IV.1) summarizes the hypotheses.

Table IV.1. Hypotheses to contrast.

	Hypotheses
Hypothesis 1	natural resources can positively affect growth in economies based on primary industries, but with different impacts depending on whether they are renewable or non-renewable resources
Hypothesis 2	Intangibles exert a positive influence on growth in economies based on natural resources, as happens in developed countries

4.4. Data and methodology

Our empirical analysis is conducted following an applied growth model rooted in the Knowledge economy framework and the Evolutionary theory, integrating a combination of both physical and intangible explanatory factors. The sample is composed of 133 countries for which there are statistical information available for the period of 1996 to 2008. Three main subgroups of countries were considered to estimate the model (details in Annex 2). The first group is OECD economies, which includes the most developed countries. The other two groups are made up by NR-based countries. One, called NR SPECIALIZED, is integrated by economies where NR exports represent more than 50% of total exports, while the other group, named

SELECTED, is result of a cluster analysis[26] and includes countries whose economies are also based on primary production activities and additionally have a high or medium-high income (per capita GDP), according to the World Bank classification. The countries of this latter group are: Argentina, Australia, Canada, Chile, Colombia, Kazakhstan, Mexico[27], Peru, Russia, and South Africa. Other studies (Giménez and Sanaú, 2007; León-Ledesma, 2002; Silva and Teixeira, 2011) have also identified some of these countries as successful nations exploiting their natural resources, as a path to achieving development, which is in agreement with our results. In Annex 10 is presented a brief profile of each SELECTED countries.

The variables included in the empirical model were selected according to the literature review, taking into account the restrictions of the analytical method. We followed the conventional approach used in other applied models of growth conceived through the creative destruction process (Aghion and Howitt, 1992), taking labor and capital (investment) as the main traditional factors. Investment was used as an indicator of capital as in Stijins (2005) and Castellacci (2008b). Two indicators were constructed for the analysis of the effect of natural resources on countries' performance. The first is a Specialization index calculated as the ratio between natural resource exports and total exports. The second is Intensity, defined as the ratio between natural resource exports and GDP, according to Sachs and Warner (1995; 2001). Additionally, other variables related to natural resources (mining, oil, agriculture, and forestry) and intangible assets were incorporated in the analysis. Patents are taken as the indicator of technologicaly and technological capacity, while schooling is adopted as a proxy for human capital. The openness and an indicator of foreign direct investment (inward FDI stock) were selected to proxy international influences. Finally, an indicator of institutions, the institutions index developed according to WB methodology (Kaufmann et al., 2003), was introduced. Table IV.2 shows the definitions and sources of all the variables used in our empirical analysis. The descriptive statistics, presented in Table IV.3, were calculated for the whole sample, and separately for OECD countries, countries specialized in NR and the group of SELECTED countries. Additionally, we also included OPEC countries as a control group because, although they also intensively exploit natural resources, there are notable differences from SELECTED countries in

[26] The cluster analysis was based on economic variables (per capita GDP and growth rate) and natural resources indicators (Agriculture and Minerals).

[27] Mexico is less specialized than the rest of countries of SELECTED group, however the specialization index at the end of the analyzed period is more than 27%.

the level of development, reflected in lower values for indicators like institutions, patents, schooling and FDI.

Table IV.2. Definition of variables and indicators included in the model

Variable	Definition	Source
GDP	Per capita GDP, PPP, at 2005 constant prices (US$)	CANA from Penn World Table
Labor	Labor force, total	WDI
Capital	Investment. Share of per capita GDP (constant prices 2005, PPP) Converted (%)	Penn World Table
Mining	Mineral rents (% of GDP)	WDI
Oil	Oil rents (% of GDP)	WDI
Agriculture	Agriculture, value added (% of GDP)	WDI
Forestry	Forest rents (% of GDP)	WDI
Patents	US Patents granted per country of origin. Number of utility patents granted by USPTO per year and the inventor's country of residence per inhabitant	CANA from USPTO
Schooling	Mean years of schooling. Average number of years of school completed in population over 14	CANA from Barro & Lee and WB
Inward FDI	FDI Inward Stock (%GDP)	UNCTAD
Openness	Openness indicator: (import + export)/per capital GDP ppp	CANA from UNCTAD
Institutions	Index composed of: Rule of law; Corruption control; Voice and Accountability; Political stability and Absence of violence/ terrorism; Government effectiveness; and Regulatory quality	World Bank
NR specialization	NR exports as share of total exports	UNCTAD (exports)
NR intensity	NR exports as share of GDP	UNCTAD (exports), CANA and WDI

Source: Author's elaboration

Table IV.3. Descriptive Statistics: Average values for the period 1996-2008

Variable		All countries		NR SPECIALIZED		SELECTED		OECD		OPEC	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Per capita GDP	(US$ 2005)	10,176	10,471	7,280	9,522	13,236	8,820	23,336	8,024	13,649	15,394
Investment	(%)	22.6	6.9	21.5	6.3	21.7	2.9	23.7	4.2	23.0	7.5
Forest rents	(%)	1.28	2.17	1.59	2.11	0.43	0.38	0.27	0.39	0.41	0.60
Mineral rents	(%)	0.63	2.01	1.08	2.74	2.05	3.11	0.44	1.88	0.09	0.18
Oil rents	(%)	4.77	10.83	8.45	13.86	5.55	7.38	0.72	2.20	31.44	13.03
Agriculture, VA	(%)	15.84	13.92	20.16	13.96	5.90	2.61	3.52	2.28	10.60	11.38
Specialization, NR	(%t)	52.6	30.3	78.5	13.1	62.9	21.4	27.9	22.8	92.1	4.8
Intensity; NR	(%)	15.1	13.0	21.0	13.8	15.1	10.4	8.31	6.82	38.5	16.0
Institutions	(index)	2.49	0.89	2.16	0.75	2.72	0.92	3.69	0.54	1.88	0.59
Inward FDI	(%)	34.9	64.8	28.1	22.1	29.3	12.8	35.2	25.2	24.3	23.5
Patents	(Pat/MM hab-year)	19.3	45.7	6.1	12.1	15.2	33.0	62.5	71.4	2.2	4.4
Openness	(index)	0.68	0.39	0.59	0.26	0.47	0.15	0.67	0.34	0.64	0.20
Schooling	(N° years)	7.44	2.59	6.66	2.51	8.88	1.51	10.14	1.46	6.56	0.56

Source: see Table IV.2. Note: The list of countries and the composition of the groups can be found in Annex 2. Source: Author's elaboration

Although many studies in the literature on growth adopt OLS as a valid method to estimate models, it is well known that one problem with this method in cross-country analysis is the existence of country specific effects, which is why OLS is inconsistent and has an upward bias (Castellacci, 2008b). The use of Panel data methodology has become very popular because it permits to face this problem among other strengths, taking into account fixed effects in cross-country analysis. Nonetheless, it also has some limitations when endogeneity problems are not considered explicitly. From an evolutionary perspective, factors that contribute to a country's development follow a path-dependent trajectory that describes a cumulative process (Dosi, 1988), and this may justify a possible endogenous structure of the model that allows incorporating past effects into present results through the inclusion of instrumental variables and the lagged dependent variable as regressors. Dynamic panel techniques, such as the generalized method of moments (GMM) or differences GMM, solve this problem by treating explanatory variables as endogenous (Arellano and Bond, 1991; Castellacci, 2008b). An extension of GMM, called Difference and System GMM, developed by Arellano and Bover (1995), takes the regressors in levels and differences as instrumental variables, making it possible to use all the available moment conditions and thus providing a better estimation3. However, this last method can generate problems of over-identification due to the proliferation of instruments and consequently imperfect estimations can be obtained (Roodman, 2006; Roodman, 2009). Roodman considered that over-identification is common when there is large number of periods (T) in the sample.

In our analysis we run three estimations with different specifications of the model, using per capita GDP as the dependent variable. Following a traditional growth approach, the first estimation includes capital, labor and natural resources (specialization) as independent variables (Equation IV.1). Accordingly, the general specification would adopt the following form:

$$\mathbf{GDP_{it} = \beta 0 + \beta 1\, K_{it} + \beta 2\, L_{it} + \beta 3\, NR_{it} + \eta_i + \gamma_t + \varepsilon_{it}} \qquad \text{(Equation IV.1)}$$

where:

GDP: ln per capita Gross Domestic Product (GDP)

K: ln Capital, investment

L: ln Labor

NR: Natural resource specialization

The subscript it refers to the country i in period t, η_i and γ_t represent individual and time effects, respectively; ε_{it}: random error term.

In the second specification of the model (Equation IV.2), the diverse types of natural resources are incorporated, (forestry, agriculture, oil, and mining). The objective is to determine whether they have different effects on growth. The equation would adopt the next form:

$$GDP_{it} = \beta 0 + \beta 1K_{it} + \beta 2L_{it} + \beta 3Oil_{it} + \beta 4Ag_{it} + \beta 5F_{it} + \beta 6M_{it} + + \eta_i + \gamma_t + \varepsilon_{it}$$ (Equation IV.2)

where:
GDP: ln per capita Gross Domestic Product (GDP)
K: ln Capital, investment
L: ln Labor
Oil: Oil rents
Ag: Agriculture, value added
F: Forest rents
M: Mineral rents
The subscript it refers to the country i in period t, η_i and γ_t represent individual and time effects, respectively; ε_{it}: random error term.

Finally, the inclusion of intangible variables as repressors, in accordance with the evolutionary approach, leads to Equation IV.3a. The sample of NR SPECIALIZED countries is included to estimate different development paths. To take into account possible endogenous structures of the model, Equation IV.3b was estimated for the target sample (SELECTED). The xtabond2 estimator (Roodman, 2006) was used to introduce dynamics and to take into account the endogenous relationship of the model and the reverse causality of technological factors.

$$GDP_{it} = \beta 0 + \beta 1K_{it} + \beta 2L_{it} + \beta 3NR_{it} + \beta 4Pat_{it} + \beta 5FDIIS_{it} + \beta 6Op_{it} + \beta 7Sch_{it} + \beta 8Insi_{t} + \eta_i + \gamma_t + \varepsilon_{it}$$ (Equation IV.3a)

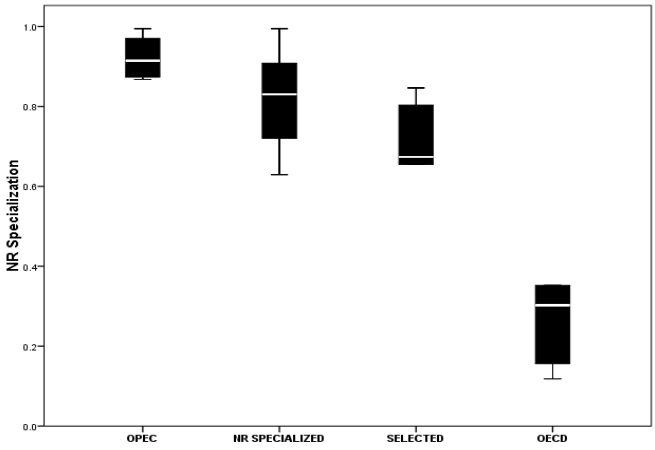
$$GDPit = \beta 0 + \beta 1GDP_{it-1} + \beta 2K_{it} + \beta 3L_{it} + \beta 4NR_{it} + \beta 5Pat_{it} + \beta 6FDIIS_{it} + \beta 7Op_{it} + \beta 8Sch_{it} + \beta 9Ins_{it} + \eta_i + \gamma_t + \varepsilon_{it}$$ (Equation IV.3b)

Where:
GDP: ln per capita Gross Domestic Product (GDP)
K: ln Capital, investment
L: ln Labor
NR: ln Natural resources, specialization
Pat: ln Patents
FDIIS: ln FDI, inwards
Op: ln Openness
Sch: ln Schooling
Ins: Institution index
The subscript it refers to the country i in period t, η_i and γ_t represent individual and time effects, respectively; ε_{it}: random error term.

4.5. Empirical analysis

Studies of the impact of natural resources on national income and economic growth have generally been built making use of diverse proxies for natural resources. The indicators of intensity and specialization are more closely related to resource exploitation than abundance or other indicators of endowments (Sachs and Warner, 1999, 2001; Stijns, 2005). Furthermore, intensity, expressed as the composition of a country's trade, can also be considered an expression of its endowments (Wright, 1990). However, there is no consensus about the most adequate indicators for NR in growth analysis. Some researchers consider that specialization is more a measure of productive structure, while others consider that specialization is an adequate indicator to reflect the economic contribution of NR. Graph IV.1 shows natural resources (specialization) level by country groups. There is an important difference between OECD and other country groups, despite the wide data dispersion. It can also be observed that SELECTED and OPEC countries are more specialized in NR than OECD countries because, as noted above, most of these developed economies have undergone structural transformations that resulted in a higher level of knowledge-intensive activities and industries (Ferranti et al., 2002).

Graph IV.1. Natural resource specialization by country groups: OPEC, NR SPECIALIZED, SELECTED, and OECD for the period 1996-2008

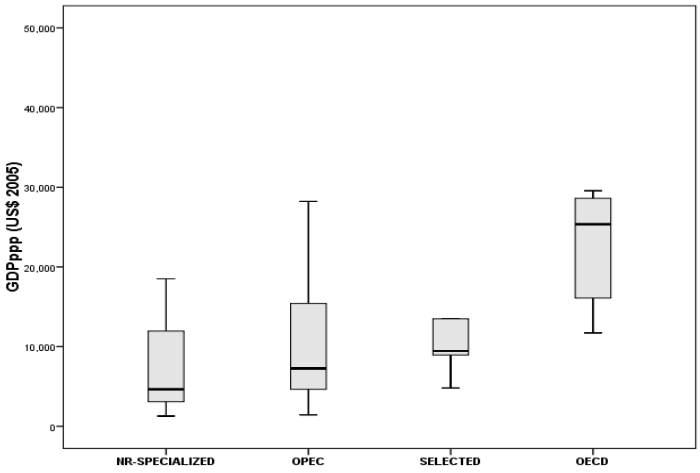


Source: Author's elaboration

OPEC members are the most NR-specialized countries and these economies have a lower per capita GDP than do SELECTED countries (Graph IV.2). Notably the income differences between OPEC and OECD countries are greater than between SELECTED and OECD group, an aspect that can be explained according to the empirical findings

showing the negative effect of natural resources on development. This is mainly related to the insufficient capacity to exploit the international diffusion of technologies -called absorptive capacity- (Cohen and Levinthal, 1990; Castellacci, 2007b), the low level of investment in human capital of these economies (Bravo-Ortega and De Gregorio, 2007), and the presence of weaker institutions (Frankel, 2010).

Graph IV.2. Per capita GDP (US$ 2005) of NR SPECIALIZED, OPEC, SELECTED, and OECD countries for the period of 1996-2008



Source: Author's elaboration

The potential role of natural resources in the development process (Barbier, 1999; Iizuka and Soete, 2011) is more plausible with the adoption of a more systemic perspective that takes into account other complementary factors. To justify this statement, a first step in our analysis is the estimation of the effect of NR specialization on national product, using only traditional factors as exogenous variables. The results confirm that both capital (investment) and labor are positively related to GDP in all cases. Natural resources have only a positive and significant effect on GDP in SELECTED countries, and OPEC[28], which is consistent with our first hypothesis (Table IV.4). The positive development path followed by this group of countries (SELECTED) has been based on natural resources, while for developed countries the "natural factors" are not considered as a determinant of their economic progress. The different results across the sub-samples are probably due to the diversity of countries included in the groups. When the sample is more homogeneous (SELECTED), this relation tends to be clarified. Thus, capital and NR impact positively on growth in countries specialized in natural

[28] When the estimation is performed using random effect.

resources, a result that is consistent with the findings of other authors such as Wright (1990) and Lederman and Maloney (2007), who explained that capital is complementary to NR, and therefore the two factors show similar effects. The main reason for this result could be a positive interaction of natural resources with intangible assets, as we will show later in this work. Similar results can be found in the related literature, such as Bretschger (2005), Bravo-Ortega and De Gregorio (2007), Wright and Czelusta, (2007), and Sæther et al. (2011).

Table IV.4. Effects of physical factors (investments, labor, and natural resources) on per capita GDP

	ALL		SELECTED		OECD		OPEC		OPEC (rand)	
	coef	se	coef	se	coef	se	coef	se	coef	se
Capital (invest)	0.163***	0.05	0.547***	0.15	0.558***	0.20	0.068*	0.04	0.228**	0.11
Labor	1.332***	0.10	1.446***	0.19	2.486***	0.25	1.321***	0.21	0.337*	0.18
NR (specialization)	0.026	0.05	0.505**	0.26	-0.064	0.12	0.259	0.60	1.901*	1.00
cons	-12.43***	1.48	-16.12***	3.00	-31.07***	3.58	-11.89***	3.17	3.15	3.01
Hausman test (chi-sq)	607.2		13.5		473.5		-327.9		-327.9	
Number of observations	1,860		140		462		126		126	
R-sq: within	0.447		0.695		0.644		0.695		0.457	
R-sq: between	0.000		0.048		0.001		0.681		0.666	
R-sq: overall	0.000		0.015		0.000		0.556		0.456	

*Significant at 10%; **Significant at 5%; ***Significant at 1%, Robust standard errors. Fixed effects, except OPEC (random and fixed effects).
Source: Author's elaboration

When considering the different types of natural resources as regressors (Table IV.5), capital and labor are still directly and positively related to growth. Moreover, oil is also an important factor that supports economic development and has a positive and significant effect on GDP in SELECTED, OECD and the entire sample of countries (ALL). Wright (1990), Stijns (2005), and Behbudi et al. (2010) had similar findings, which confirm a positive relationship between oil and economic performance. In contrast, forestry negatively affects economic progress. It is plausible to think that these results are conditioned by environmental factors as described in related literature about scarcity and over-exploitation of natural resources, because technological progress can generate degradation and pollution and this affects long-term development (Stavins, 2011). In addition, restrictions arising from environmental policies can reduce the productive performance and even increase production costs (Blomström and Kobbo, 2007). However, as Ferranti et al. (2002) point out, forestry endowments can be economically productive when a network is created and high technology is

incorporated into the process, while Blomström and Kokko (2007) argue that a successful forestry industry is possible when openness, technology, knowledge and appropriate policies are articulated.

Table IV.5. Effects of capital (investment), labor, and natural resources (agriculture, forestry, minerals, and oil) on per capita GDP

	ALL		SELECTED		OECD	
	coef	se	coef	se	coef	Se
Capital (invest)	0.099**	0.04	0.352***	0.12	0.376**	0.16
Labor	0.945***	0.12	0.961***	0.19	1.332***	0.40
Agriculture	-0.016***	0.00	-0.013	0.01	-0.087***	0.03
Forest	-0.019**	0.01	-0.183**	0.08	-0.193***	0.06
Mineral	0.011	0.01	0.018***	0.00	0.003	0.00
Oil	0.008**	0.00	0.029***	0.01	0.029***	0.01
Cons	-6.11***	1.83	-7.78**	3.20	-11.82*	6.23
Hausman test (chi-sq)	209.4		16.3		68.3	
Number of observations	1,680		139		398	
R-sq: within	0.527		0.808		0.760	
R-sq: between	0.030		0.051		0.002	
R-sq: overall	0.039		0.007		0.005	

*Significant at 10%; **Significant at 5%; ***Significant at 1%. Fixed effects. Robust standard errors. Source: Author's elaboration.

The results of the estimations show that agriculture and mining do not have the same impact on GDP. Agriculture has a negative effect on GDP for the entire sample (ALL) and OECD countries, which agrees with Stijns (2005) and Manzano and Rigobon (2007), who found symptoms of Dutch disease in economic performance caused by this sector. Likewise, Hauser et al. (2011) argued that agriculture is more a way of life than a production system in several countries. However, it can be though that SELECTED countries may have been successful in introducing technology and human capital to agricultural activities, contributing to eliminate the negative effect, which agrees with the findings of Esposti and Pierani (2000), Pérez (2008), and Piesse and Thirtle (2010).

There are no significant effects of mining on GDP in the case of OECD countries, or for the complete sample of countries, while the impact is significant and positive in the SELECTED countries. Again, it is plausible that this effect is related to the incorporation of complementary and intangible factors, such as human, structural and relational capital, which would allow achieving the sustainable development of the sector (Ville and Wicken, 2012) as we will explore further in this chapter.

Thus, resource-based countries show the capacity to neutralize the negative effects of agriculture observed in the complete sample and to obtain positive impacts from mining. This transformation of traditional sectors towards more efficient industries may be related to the incorporation of technological change, although its relative effect is modulated by other factors. Even though technological capacity may improve the relation between NR and economic development, there are still differences in the impacts of renewable and non-renewable resources on GDP, which is also consistent with hypothesis 1.

Beyond the existence of different perspectives to understand the relationship between GDP and its determinants, there is broad consensus about the complexity of the problem. Then, we proceed to another specification of the model that is supported by the predictions of the Evolutionary theory and the Knowledge-based economy framework, arguing that intangibles are important factors in the wealth creation process (Lin and Edvinsson, 2008). The analysis includes technology, human capital, institutions and internationalization indicators as proxies for the elements defining the national systems of innovation and Intellectual capital framework. Table IV.6 shows the results of the new estimations, which considers both tangible and intangible aspects. The models were estimated for SELECTED and NR SPECIALIZED samples, trying to identify differences within NR-based economies. The estimation of the model for the OECD sample is also presented for making a more complete international comparison. It can be noted that natural resources definitively have different behaviors among the country groups. While in SELECTED countries these resources positively affect GDP, in OECD their role is not significant. This finding is consistent with other empirical evidence, as well as with some theoretical contributions that predict that NR can be a positive, negative or neutral factor, depending on how they are managed and the strategies applied (Lederman and Maloney, 2007). Authors such as Wright (1990), Barbier (2003), and Pérez (2008) identified positive impacts of natural resources on economic performance, while others found negative effects or even the absence of a clear relationship between these two variables (Sachs and Warner, 1995; Gylfason and Zoega, 2006; Lederman and Maloney, 2007; Stijns, 2005).

Table IV.6. Panel data analysis of physical and intangibles factors

Variable	NR SPECIALIZED		SELECTED		OECD		NR SPECIALIZED		SELECTED		OECD		NR SPECIALIZED		SELECTED		OECD	
	coef	se	coef	se	coef	se	coef	se	coef	se	coef	se	coef	se	coef	se	coef	se
Capital (invest.)	0.135*	0.07	0.657***	0.11	0.455***	0.13	0.132*	0.07	0.690***	0.11	0.447***	0.14	0.131*	0.07	0.649***	0.13	0.447***	0.13
Labor	1.086***	0.25	1.004***	0.30	1.701***	0.24	1.085***	0.25	0.680**	0.31	1.529***	0.26	1.085***	0.25	0.409***	0.16	1.530***	0.25
NR (specialization)	0.286***	0.10	0.398***	0.15	0.028	0.06	0.301***	0.10	0.305***	0.09	0.036	0.05	0.303***	0.10	0.383***	0.10	0.036	0.05
Patent	0.048	0.03	0.081**	0.04	0.075***	0.03	0.041	0.03	0.055**	0.03	0.045**	0.02	0.040	0.03	0.077***	0.03	0.045**	0.02
Education (schooling)	-0.004	0.31	0.537	0.41	0.965***	0.36	-0.036	0.31	0.538	0.44	0.784**	0.34	-0.039	0.31	0.607	0.41	0.784**	0.34
Openness	0.148**	0.07	0.167**	0.08	0.365***	0.09	0.130*	0.08	0.152*	0.08	0.230**	0.09	0.129*	0.07	0.245**	0.10	0.230**	0.09
FDIIS							0.043	0.04	0.141**	0.05	0.100***	0.03	0.043	0.04	0.150***	0.05	0.100***	0.03
Institutions													0.010	0.11	0.235**	0.11	0.004	0.11
cons	-7.50**	3.51	-9.09**	4.25	-19.44***	3.49	-7.64**	3.53	-4.70	4.38	-17.01***	3.76	-7.66**	3.56	-0.47	2.15	-17.04***	3.75
Hausman test (chi-sq)	84.87***		20.87***		204.82***		84.96***		16.90**		169.97***		131.36***		4.63		56.4***	
R-sq (within)	0.4999		0.7748		0.8028		0.5055		0.8087		0.823		0.5055		0.805		0.823	
R-sq (between)	0.0567		0.0419		0.0022		0.0602		0.1676		0.0009		0.0586		0.8238		0.001	
R-sq (overall)	0.0006		0.0813		0.0037		0.001		0.2506		0.0025		0.0007		0.8191		0.0025	
F (chi2)	16.2***		34.55***		59.93***		15.04***		72.10***		62.15***		15.21***		528.07***		54.44***	
Number of observations	479		128		426		479		128		426		479		128		426	

Note: *** p<0.01, ** p<0.05, * p<0.1. Fixed effects, except the last estimation of SELECTED (random effects). Robust standard errors.
Source: Author's elaboration.

As countries evolve toward more modern paths, other factors gain importance, as is evident with the contribution of intangibles to growth in more developed economies (OECD). These are the cases of economies that have moved from NR-based economy to more knowledge drivers, as Wright (1990) described for USA, Blomström and Kobbo (2007) for Sweden, Smith (2007) for Finland; Sæther et al., 2011; and Ville and Wicken (2012) for Norway, among others case studies.

Among the intangible resources, education has the highest coefficient, reflecting the importance of human capital in economic advancement. On the other hand, in the SELECTED countries innovation capabilities support their development trajectory. Thus, the estimations show that in these economies, as well as in OECD countries, growth is supported by intangibles, along with tangible assets, which confirms our second hypothesis.

An interesting result to mention is the one related to the indicators of openness and FDI, both of which is related to foreign transactions and capital flows. They have a significant and positive impact in both OECD countries and successful countries with economies based on natural resources. In fact, international flows of capital, merchandise, and technology have become a determining factor for the economic takeoff, even denoting the dependence on foreign knowledge acquired through catching up (Ferranti et al., 2002), and the effect of increasing local productivity with foreign technology (Mastromarco and Ghosh, 2009). In the case of NR SPECIALIZED economies, openness is also a significant aspect, which is reasonable if we consider the importance of access to wider markets have for these countries for the commercialization of their products. In such economies there is still a traditional development path that does not necessarily take full advantages of the opportunities offered by the Knowledge economy, which is why the level of openness becomes an essential aspect for expanding demand abroad for their products. In addition, international networks and advanced human capital are key elements to build absorptive capacities, which are critical to catch up and develop innovation capabilities.

These positive effects should not deter consolidating the national system of innovation, not only because of the importance of developing local technologies and improving the domestic absorptive capacities, but also because institutions are revealed as a significant positive factor for this group of economies, aspects that can enhance more sustainable progress (Lederman and Maloney, 2007). In fact, good institutions avoid the corruption, prevent harmful effects of perverse incentives from

NR windfall, reduce potential conflicts (even civil and international wards), favors social and economic stability, permit rationally manage public expenditures and conduct development in a long-term respective. Successful countries based on NR, such as Australia, Norway, Sweden, and Finland have oriented their NR rents to knowledge investments, creating new industries and improved primary sectors by adding value to products (Blomström and Kobbo, 2007; Ville and Wicken, 2012). In addition, the significant coefficient of both local invention (patents) and institutions in SELECTED countries are indicators of the capability building process and illustrate how this could positively affect their catching up process. Our findings confirm that NR-industries offer new possibilities, not only as a consequence of eventual commodity booms, but also by taking into account the opportunities offered by technology and knowledge for what are termed low-tech industries. In fact, these new elements – knowledge and technology - can reduce production costs, promote access to new markets, help in finding new mineral and petroleum deposits, enhance sustainable exploitation of renewable natural resources, improve the quality of existing products and develop new ones, and create new related business based on knowledge into NR industry (diversification within industry).This diversification within industry results in new business and products with more value and reduce risk of commodity crisis and emergence of substitutes. According to the data of concentration of the economies and per capita GDP[29] (Annex 11), diversification is more critical when countries cross the development threshold from middle income to high income

Therefore, it can be argued that NR-based countries are not necessarily obliged to completely change their industrial structures to improve economic performance, but rather it is possible to conceive a sequential building process that encourages a new development path in which a combination of elements based on the national system of innovation adopts intangibles as the core of their development strategy. Thus, if countries invest in strategic intangibles, not only NR-curse will not occur, but rather, economies can expect positive impacts from primary resources.

A promising direction to define actions to enhance development in NR-based economies is to promote investment in technologies and knowledge that allow them to achieve a more positive path of income generation and strengthen institutional frameworks. Although education is not statistically significant in the model's estimation for SELECTED group, we cannot disregard its relevance in the definition of

[29] Economic concentration assessed through the Herfindahl-Hirschmann index and reported by WDI.

development strategies. In fact, a human capital with a higher education is not only more productive, but also allows the construction of higher absorption and innvation capabilities. The result of the estimation is likely due to the type of indicator used as a proxy for education, which mostly reflects the quantity and not the quality of human resources and, moreover, the expected significant effect of human capital on growth is partially captured by the labor indicator.

The results of our analysis also show that in the case of the SELECTED countries natural resources, along with intangible factors, support development and their combined action is an engine of long-term growth. This demonstrates that NR-based countries can reach high economic levels when natural endowments are joined with intangible assets. In accordance with the literature, our findings also confirm that foreign technology and capital have become crucial growth determinants in these economies.

Thus, economic progress in NR based economies must be accompanied by investments in tangibles and intangibles assets, through a process of smart specialization as EU propones (European Commission, 2014), but with the basis in the natural resources. In particular, the institutional advance should go from basic conditions (macroeconomic stability, IPRs, rule of law, etc.) to other with more quality in terms of governance, regulatory capacity, democracy, transparency, and control corruption. Moreover, the technology sources also should transit from international suppliers to endogenous production, achieving a balance between both sources. For this, countries should improve their absorptive capacities and creation, which are based on high qualification of HC.

Finally, to test the potential endogenous process described by scholars and as a test of robustness, we estimated the dynamic panel specifications using the Difference and System GMM method for the sample of SELECTED countries (in Table IV.7). The results do not diverge from previous estimations. On the contrary, they describe the same tendency, as do the static models. However, some variables, like labor and institutions, are not significant, due to the strong effect of lagging GDP, which to some extent captures the cumulative impact of the other variables included in the model. However, this does not mean a negative relationship, but rather the cumulative nature of these variables is reflected in the standard of development.

The coefficient of the lagged dependent variable has the highest value among independent variables, which denotes the path dependence and cumulative process described by both innovation and economic progress, as highlighted by several

researches in the evolutionary tradition. Nonetheless, the high degree of similarity among the results is remarkable and reflects the strong explanatory power of the proposed model that integrates intangibles as an important determinant of growth. Thus, some potential implications for policy makers would be related to improving local capacities and increasing the level of openness of their economies, fostering the flow of knowledge and technologies worldwide. In addition, long-term policies are required to achieve sustainable development because perverse incentives can appear, mainly in the presence of weak institutions.

Table IV.7. Effects of physical, technological and intangibles factors on per capita GDP of SELECTED countries. Estimation of dynamic panel data

	MODEL A		**MODEL B**	
	coef	**se**	**coef**	**Se**
GDP (L1)	0.673***	0.136	0.496*	0.275
Investments	0.249**	0.124	0.357**	0.142
Labor	0.099***	0.024	-0.076	0.422
NR (specialization)	0.047	0.038	0.256*	0.138
Education (schooling)	0.277	0.451	0.526	0.522
Patent	0.058***	0.018	0.094*	0.051
Openness	0.052	0.039	0.188***	0.073
FDIIS	0.136***	0.023	0.122***	0.045
Institutions			0.126	0.136
cons	0.504	0.967	4.592	5.004
Number of observations	60		60	
Number of instruments	10		11	
Arellano-Bond test for Ar(1)	-2.46**		-2.28**	
Arellano- Bond test for Ar(2)	-1.59		-0.81	
Sargan test (chi-sq)	0.91		0.88	

*Significant at 10%; **Significant at 5%; ***Significant at 1%. Two steps. Robust standard errors. Source: Author's elaboration.

CHAPTER V. TECHNOLOGY GAP AND CATCHING UP IN ECONOMIES BASED ON NATURAL RESOURCES. THE CASE OF CHILE[30]

5.1. Introduction

Chile has been successful in the implementation of policies and reforms during past decades with notable results in terms of levering economic standard when compared with other Latin America (LA) countries; however, the weakening of economic progress in the last decade urges the need for changes in the national development strategy. Some of the objectives are the increase of local capabilities that foster added value, the diversification of exports, and the correction of social inequalities (Berry, 2008; Pérez, 2012). The economic specialization of Chile, strongly based on natural resources (NR), adds serious challenges. As the evidence shows, the NR exploitation may negatively affect economic growth due to several social, environmental, and economic factors that would explain the so-called "NR curse" (Ross, 1999; Sachs and Warner, 2001; Van der Ploeg, 2011).

The evolutionary vision of sustainable development is based on knowledge and technology as main drivers of growth (Versapagen, 1993; Nelson, 2007). Accordingly, development strategies within the technology gap tradition confer special importance to both the access to foreign sources of knowledge as well as to local capabilities building process, along with an appropriate institutional context (Castellacci and Álvarez, 2006). Under this view, economic growth is understood as a dynamic process implying several factors of different nature that evolve over time (Fagerberg and Verspagen, 2002; Castellacci, 2007a), and precisely this combination would be essential to understand a country trajectory and the reasons of growth and stagnation, because they are the key elements that would support sustainable development in the long run.

Under this approach, primary assets (capital, labor and NR) and exogenous technology are relevant in early stages of development, but innovation capability is also a determinant for countries in order to advance in a perdurable progress path (Dosi, 1988; Porter, 1990; Verspagen, 1991). This aspect could explain part of the Chilean decline during the 2000s, and it would justify carrying out new and different efforts to reach higher economic standard. Benchmarking and comparison with other economies

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based on a similar productive structure are good tools to identify weaknesses and opportunities that would support the definition of policies. This research tries to identify the current frontier and the possibilities for catching up. For doing this, we first drive a metafrontier analysis and then an analysis of convergence. The analytical results provide knowledge about the gap determinants, as well as general implications for countries dominated by NR industries. Statistical information has been obtained from international sources, such as WDI, UNCTAD, and CANA (Castellacci and Natera, 2011) databases, for the period 1980 to 2011. The sample is composed by a set of ten NR-based countries (called SELECTED), identified by cluster technique, which are characterized by a high and medium-high income according to the World Bank (WB) criteria and economic structures with strong presence of NR (more details of countries' profile in Annex 10). Moreover, the evaluation of convergence is done considering as leaders to USA, a global economic leader and ex-NR based economy (Wright, 1990), and also the NR-specialized leaders of the sample (Australia and Canada), while the dynamic growth analysis is conducted following Fagerberg et al. (2007).

The results suggest that to reduce the income gap, countries specialized in NR should intensify openness and FDI for catching-up, to increase capital investments, and to build innovation capabilities, along with continuing with the exploitation of their NR as development basis. The opportunities for Chile derived from the resource management improvement are scarce because its technical efficiency is close to the frontier. Despite Chile´s economic progress and convergence with the leaders, a wide gap of technological capability still remains and this is a serious obstacle for achieving and maintaining a better economic standard. Our findings also confirm that growth in Chile has been based more on traditional production factors and exogenous technologies, in line with the reforms and policies implemented since the seventies, while more efforts should be made to definitely take advantage of the opportunities provided by a Knowledge-based economy that could avoid a possible falling down into a middle-income trap, as some authors suggest.

The first part of this chapter presents a brief review of the related literature and the main findings of scholars, which provide supporting arguments to the research. The second section provides a brief description of economic structure, performance and trajectory of Chile. The third section describes the methodology and data description, and the fourth section includes the most relevant results from the Metafrontier and GAP analysis with a discussion thereof.

5.2. Literature background

A wide body of literature shows how countries can face development challenges by exploiting their endowments and increasing productivity. The traditional growth theory emphasizes the transition towards the steady state, being capital, labor, and crucially productivity the basic components of the cumulative process that guarantees economic progress. Under this lens, countries may converge taking advantage of the leaders' technology, since the international diffusion of technology is seen as the main driving process. However, it is well known that growth path is country-specific, and while some economies actually converge other fall behind. This can be explained by asymmetric access to knowledge and innovation determinants, being possible to characterize them as endogenous, cumulative, and complementary sources of growth (Verspagen, 1993; Fagerberg, 1994; Dosi and Nelson, 2010).

In the neo-Schumpeterian and evolutionary tradition, the explanation of growth differences across countries are built over a complex and dynamic vision of development that pays more attention to the role of technology and knowledge (Verspagen, 1993; Nelson, 2007). This perspective is at the core of the knowledge-based economy framework and goes beyond the traditional productivity approach, claiming the crucial role of intangible assets as drivers of wealth creation (Edvinsson, 2003; Corrado et al., 2009; Dunning, 2009). In this line, the results of convergence analysis coincide to show that although countries can follow different development trajectories, they also share similar patterns resulting in clubs or groups of convergence (Verspagen, 1993). According to Castellacci (2008b), these clubs are mainly defined on the basis of their innovative ability and absorptive capacity, being the relevance of technology in economic progress and the confirmation of the capacity to absorb and adapt international technologies and local innovations, some remarkable factors that explain long-term differences in growth patterns (Castellacci and Álvarez, 2006; Fagerberg et al., 2007).

A key idea in this sense is that the international diffusion of technologies is not an automatic and effortlessly process. On the contrary, countries require domestic capabilities to select, imitate, adopt, and adapt foreign technologies and to create new ones, where the human capital and the institutional framework play a determinant role in this process (Verspagen, 1991; Nelson, 2007). Even more, the adjustments needed to absorb new technologies impose heavy costs on individual and society (Abramovitz, 1986). The opportunities to advance using knowledge from abroad also depend on the technology gap, because a closer proximity to leaders reduces the

potential options for catching up. Authors such as Porter (1990), Verspagen (1993) and Castellacci (2008b), point out that in early stages of convergence, where countries face a wider technology gap, imitation is the main channel for economic development, while innovation become the most important driver for those in more advanced stages.

Moreover, the technology gap is not static but it is in constant change due to the combined actions of followers and their decision to catch up on the one hand, and the decision of leaders to innovate permanently on the other, which explains the differences in growth rates between the two groups of countries. The literature underlines that developed economies can grow to a higher speed because they are able to create and to accumulate knowledge faster than others thanks to their better institutions and well-instructed human capital (Verspagen, 1991; Nelson, 2007). In addition, international protection of intellectual property, along with other regulatory mechanisms, act as barriers for international technology flows and knowledge spillovers, highlighting the relevance of internal capabilities. In this regard, Verspagen (1993) argues that total convergence is not reached by means of catching up alone, but the backward country has to increase the domestic research efforts up to a level comparable with advanced economies.

All this defines a dynamic and complex context where local factors and strategies become crucial to support growth in the long run. Available evidence shows that some developing countries have excelled by their high growth rates, such as BRIC or economies from Southeast Asia, which have been characterized for having moved towards more knowledge intensive activities, added value to their products and services, and increased their incomes. The experience of countries such as Korea and Taiwan are illustrative of the catching up process along which they have become developed economies taking foreign technologies, investing in human capital, improving their institutions and economic structures, and using their comparative advantages (Verspagen, 1993; Nelson, 2007). Others such as Japan and Singapore, have continue managing their intangibles and specializing in knowledge-intensive sectors, taking innovation as pillar of development and finally achieving higher economic standard (OECD, 2010; Felipe et al., 2012). From evidence of NR industries, examples of similar path are found in Finland, Sweden and USA, who have progressed through investment in intangibles in the knowledge-based sectors.

On the other hand, the exploitation of comparative advantages without appropriate investments in knowledge capabilities can make development problems persistent if

countries do not move toward more innovative bases of competitive advantages (Porter, 1990; Verspagen, 1993). Additionally, countries with low efforts in education, institutions, R&D, and innovation can be trapped in a slow growth path and also can fail in the transition from middle income to high income economy due to rising production costs and competitiveness decline (Griffith, 2011). The literature widely describes cases of middle-income trap, such as Morocco, Philippines, Romania, Tunisia, Uruguay, and Venezuela (Kharas and Kohli, 2011; Felipe et al., 2012), whose economies have fallen as a consequence of the definition and implementation of wrong policies and the inadequate growth strategies, mainly related to innovation and institutional factors that support the required changes of the development process (Pérez, 2012).

This adverse situation can be faced by countries through the acquisition of capabilities that permit the development of an appropriate national industrial strategy and the implementation of the most effective measures. According to Ohno (2009), it is required to implement more aggressive actions than those suggested by the Washington Consensus to introduce and to create innovations in the production system, paying attention to education for the improvement of human capital. The reason is that income convergence cannot be sustained over time unless it is accompanied by capability convergence (Pérez, 2012). In fact, countries that have jumped the barrier of middle-income becoming high-income economies enjoy a more diversified, sophisticated, and non-standard export basket (Felipe et al., 2012). Thus, the key aspects to avoid this trap and to converge with leading economies is related to both institutional reforms and innovations capabilities that lead to continuous updating of technologies, exports diversification, and adds value to products, maintaining high growth rates in the long term.

Likewise, evidence of middle-income trap is found in economies based on natural resources (NR) due to the fact that these endowments tend to adversely affect growth because several reasons such as the easy generation of high incomes, the low growth potential of a fixed production factor, the negative effect of currency appreciation over manufacturing exports (also called Dutch disease), the generation of a wrong feeling of economic security that discourages investments in other assets (Gylfason and Zoega, 2006), high levels of corruption and the reduction of the institutional quality (Sachs and Warner, 1999), an inadequate distribution of human capital among industries (Bravo-Ortega and De Gregorio, 2007), the negative effects in innovation systems (Fagerberg and Srholec, 2008), and the environmental damage (Smulders, 2005; Stavins, 2011). However, the literature on NR also suggests that countries could face

sustainable growth if they foster human capital, strengthen their institutions and invest in knowledge and technology (Iizuka and Soete, 2011).

Therefore, countries that expect to reach a better economic performance should walk through of path that combines their endowments with investments in physical assets and fostering the knowledge capabilities and innovation activities. In sum, closing the technology gap and the creation of innovations should be at the core of growth strategies that would support a sustainable progress.

5.3. The Chilean trajectory

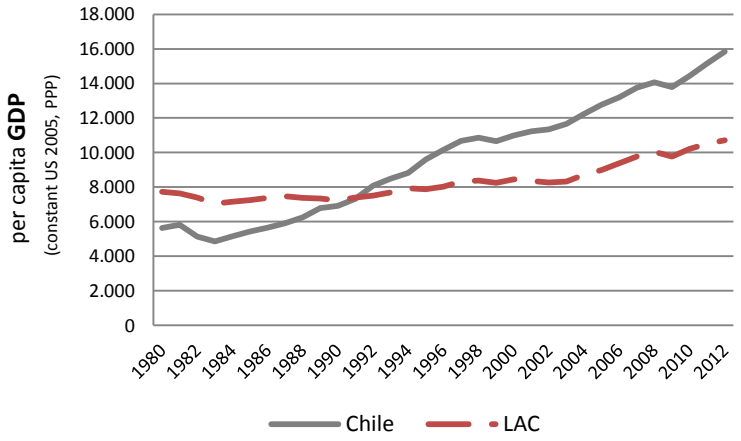
Located on the southwestern edge of South America and with less than 17 million people (INE, 2012), Chile has shown positive signs of economic progress in the global context. A large part of the policies and structural reforms applied along the last four decades have been oriented to increase the economic activity, transforming exports and invest into the main engines of growth (García, 2006). The economic trajectory of Chile shows that per capita GDP increased by more than one and a half times since 1980 (Graph V.1), reaching the highest growth within LA and indeed, in the last WB classification, Chile is found among the high-income countries (World Bank, 2013). However, the results have not always been so positive; at the beginning of the seventies, when the first economic reforms took place, the Chilean economy exhibited poor indicators in terms of inflation, fiscal deficit, and even growth rates. In addition, custom tariffs were in average about 105%, the State controlled about 600 enterprises that accounted for about 40% of the GDP, being the exports very scarce (Corbo et al., 2005), all these aspects offering a negative scenery for investment and progress. Thus, early studies classified Chile as a poor economy, among those "*missed opportunities or falling-behind countries*" (Verspagen, 1993).

In the 1970s, Chile began its successful international trade orientation and opening strategy through a reduction of protection at the multilateral level followed by bilateral free-trade agreements, which also attracted FDI flows (Álvarez and Fuentes, 2006; Pérez, 2012). The positive results of NR export orientation was the result of reforms and policies carried out, appropriate strategies of production based on comparative advantages, and a strong international demand for raw materials (Eyzaguirre et al., 2005; CNIC, 2010).

Macroeconomic reforms followed with different governments, driven by stabilization and opening, and also some microeconomic reforms were implemented to increase efficiency and productivity, while constitutional changes tried to strengthen the democratic governance of the country. However, natural monopolies, manage by the private sector, were not properly regulated and public goods and social infrastructure were not adequately provided by State (Eyzaguirre et al., 2005).

Since the early 1990s, four main policy areas have been prioritized: Infrastructures, human capital, productive development (support to SMEs and raise of R&D level), and economic institutions (mostly regulatory and anti-trust) (García, 2006). In addition, a number of other policy measures were implemented, such as privatizations, monetary and fiscal reforms, among others (Corbo et al., 2005).

Graph V.1. Per capita GDP of Chile and Latin America & Caribbean, between 1980 and 2010



Source: data from WB

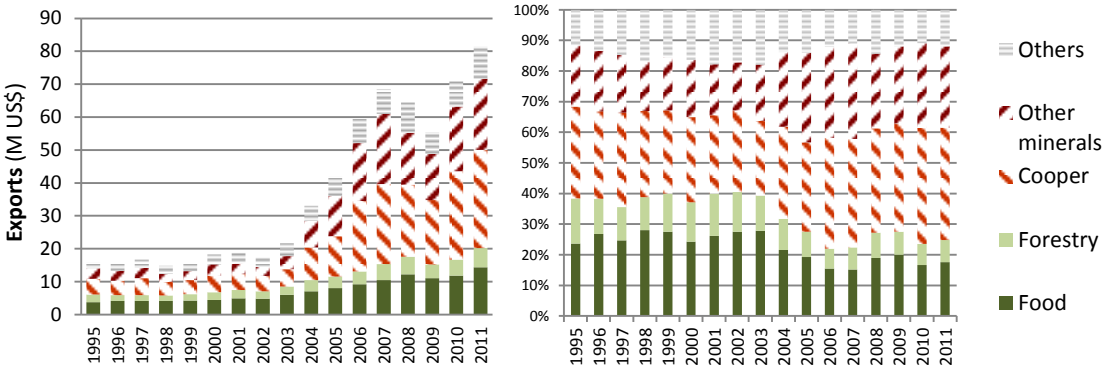
The changes defined decades ago continued during the 2000s and later, both in the economic, social and institutional fields. The new phase tried to reduce social inequality, improve higher value added exports and to develop new products and services, targets that have required changes in the national innovation system. In particular, innovation policy has focused on strengthening the links between science and the private sector to agree on a common research agenda, to foster R&D, and to increase human capital levels. Consequently, in 2005 the National Innovation Council (NIC) was created to define an innovation strategy to improve competitiveness, because Chile showed and still shows low value-added exports as a result of the traditional low R&D investment and other innovation deficits. To finance this strategy,

a royalty to the extraction of copper, the main industry in Chile, was applied along with a tax credit law launched to promote private R&D investments (Maloney and Rodriguez-Clare, 2007; Pérez, 2012).

Despite the remarkable progress achieved by all these economic and institutional reforms, the national economy has been losing dynamism in the last decade. Some specialists insist in the relevance of those policies that based on a traditional approach emphasize investments in tangibles assets, considering technology and knowledge exogenous factors that can be obtained elsewhere in the world, keeping the role of the State reduced to solve market failures and to promote entrepreneur activities. However, these policies seem not to be sufficient to support sustainable growth in future, an aspect reflected in the poor long-run trends of the Chilean economy, as well as in the fall of total factor productivity (CNIC, 2010; Pérez, 2012). This fact is also confirmed by the latest competitiveness report prepared by the World Economic Forum (WEF, 2013), where innovation factors along with other socio economic elements and infrastructures are underlined as main limits for the progress of this country. In this regard, some scholars agree that innovation capabilities become more important for catching up, whereas local capabilities must be developed and applied for countries' convergence toward the leaders (Verspagen, 1993; Castellacci, 2002). The reason is that in more advanced stages of the development' path, competitive advantages are based on innovation more than physical assets (Porter, 1990) and for the future in Chile, opening and FDI attraction as pillars of growth will not have the same effect on productivity growth (Álvarez and Fuentes, 2006).

To understand this trajectory and the potential future advance of the country, it is important to be aware that historically Chile has been characterized by a strong presence of NR-based industries, reason why it is considered as a NR-specialized economy (Maloney, 2007; CNIC, 2010). Both renewable and nonrenewable resources are present, having the sectors of mining, foods (agriculture and fishery) and forestry, a special relevance and orientation toward foreign markets (Graph V.2). The NR exports represent more than 80% of total exports, corresponding to mining more than 60% of them during last years, while renewable resources reached around 25%. These data comes to describe an economic structure that dominated by NR implies to consider this productive specialization in the definition of growth policies.

Graph V.2. Export of Chile by product. 1995 – 2011



Source: data from UNCTAD

Source: data from UNCTAD

After the boom and fall of the nitrate industry at the end of the XIX century and early the XX, accounting for more than 70% of total exports and over 50% of public revenues (Meller et al., 1996; Claude, 1997), the copper exploitation took the leadership as result of large endowments and foreign capital and technology, being nowadays the most important economic activity and determinant of Chilean GDP. In the seventies, the State decided to nationalize the companies of the sector for achieving the complete control over this strategic production, reason why the National Copper Corporation of Chile (CODELCO) was created, and it is today the main copper producer in the world, keeping around 10% of the total world reserves of this metal (CODELCO, 2013). Later, opportunities were given to private investors through mining concessions with the objective of increasing the copper production (Lagos and Blanco, 2010). Thus, since the beginning of the nineties and thanks to favorable FDI policies, large foreign investments have also been attracted and today about two-thirds of national production are handled by private capitals, representing around 35% of total exports (Arias et al., 2012). Besides, other minerals have gained importance in the mining industry such as potassium nitrate, sodium nitrate, lithium, iodine, and molybdenum, but have not reached the same economic relevance than copper (Wright and Czelusta, 2007). Nonetheless, the discovery of new deposits and new available exploitation technologies come to offer a prosperous long-term scenario.

This sector has been being vertically integrated since the eighties and a large number of companies are collaborating via subcontracts with a pattern of spatial labor division characterized by a functional specialization (Lagos and Blanco, 2010). This industry is a net importer of knowledge and technology due to the limited capacity of suppliers and mineral companies to generate innovations and knowledge transfer, and the poor

relationships within the industry where the collaborations are based on other types of services (Maloney, 2007). Moreover, research centers and universities have been mainly adaptors of technologies and organizational strategies created in more developed countries and scarcely devoted to the development of new ones (Arias et al., 2012). Today, the main challenges in this industry are related to environmental issues, potential substitutes, production cost and energy.

Additionally to non-renewable NR, Chile is well known in international markets for its food and forestry production (Maloney, 2007). The forestry sector includes both native forests and plantations with introduced species (mainly Pine and Eucalyptus), it represents around 3.1% of GDP and it accounts for 7% of total exports (CORMA, 2013). Apart from the raw materials production, products with added value, such as doors, windows, wood toys, newsprint and furniture, are also elaborated. These activities are highly concentrated in local companies that have invested also abroad in the last years in order to expand their production (Pérez, 2012). The technology used by this industry originally came from abroad, but decades ago local R&D has also been carried out by public and private research centers and universities in collaboration with firms. Although local knowledge has improved in several areas, flows of complementary foreign technologies still remains.

The food sector is other example of productive specialization. Several governments' interventions began in the sixties to capture technology from abroad through the creation of State agencies to drive development strategies and improving investments in human capital and infrastructure (Pérez, 2012). Then, Chile became leader in food production since the eighties, with special importance of fruits, wine, and fish products that is consequence of a planned process (CNIC, 2010; Figueroa and Calfucura, 2010), while the implemented strategy a few years ago expects to place Chile among the top-ten food producer countries in the world (ProChile, 2013).

Unlike forestry, food industry has been driven by small and medium producers distributed along the country, with the exception of salmon production where large Multinational Companies (MNC) took the control (Katz et al., 2011). The technologies are mainly from abroad and this has been the dominant situation of the production system until now. The suppliers have played an important role as promoters of innovation, providing new technologies and knowledge created in developed countries that have been adapted to local conditions by universities, research centers and private companies. Complementarily, local capacities have been improved, and there are important advances in human capital, infrastructures and R&D, as consequence of

both private and public efforts (Katz et al., 2011). Currently, several strategies are being implemented to create own technologies in a wide range of disciplines, such as genetic, industrial processes, primary production, transports, etc., that can contribute to support the long run development that may transform Chile into World Food Powerhouse.

There is a broad consensus about the achievements in food, forestry and mining sectors and, particularly, about the fostering action of governments, through macroeconomic and microeconomic policies, the strengthening of institutions, opening, local and foreign investments and foreign technologies, being also FDI a determinant factor that has provided resources from developed countries (Maloney, 2007; Bas and Kunc, 2009). Nonetheless, scholars also agree on the need to improve national innovation capabilities because the knowledge and technologies diffusion from abroad can be seen as a complementary source of growth but not as a sufficient condition (Verspagen 1993; Castellacci, 2006b). Indeed, available evidence shows that developed NR-based economies have invested in human capital and applied policies to develop innovation capacity in order to improve added value and to maintain sustainable growth (Sæther et al., 2011; Ville and Wicken, 2012).

5.4. Empirical analysis: Methodology and sources of information

The first step of this analysis was to identify the determinants of the GDP gap in economies based on NR, and this is based on aspects linked to technical efficiency and the catching up processes. This is especially relevant for the possibilities of middle-income countries (MIC), a reason that justifies the election of Chile as target economy. To answer the research question about what are the key dimensions and the pillars of the Chilean growth, an approach based on the Knowledge economy is followed. The results allow us to detect the relevant fields in which policies and strategies must focus to improve growth and development in the long run, and to avoid the NR curse and MIC trap. The orientation of innovation policies, taking into account the NR specialization and built over national system of innovation and Knowledge economy perspectives, make especially relevant to know the characteristics the gap between Chile and leader countries with similar economic structure and its dynamics. We can expect that our findings provide new clues for policy makers' decisions and for the definition and implementation of more efficient policies. The general assumption is that more efforts should be done to improve local capacities to innovate in NR sectors,

creating own technologies and knowledge to reduce the foreign dependence that would improve competitiveness, diversification and the added value of exports.

According to the Knowledge economy framework, knowledge and technology are crucial factors to support growth, reason why research in the area devotes great efforts to evaluate and to understand countries' technology gap and then to assist more precisely development strategies. Studies in this tradition have used different methodologies to identify the distance between the leader and countries applying catching-up and benchmarking strategies. It is frequent to measure the gap as the relative distance to leading economies, discussing the reasons explaining the value of this ratio and the need of the adequate policies to converge. Thereby, to detect the determinant factors of the gap, we estimated an applied growth model rooted on the Knowledge economy framework and the Evolutionary theory using a sample of countries identified by cluster technique. This sample is made up by economies characterized for a NR-specialized economic structure, being high or medium-high income according to the WB classification (more details in Annex 10). The solution of the Cluster analysis[31] is one group of countries (called SELECTED) made up by Argentina, Australia, Canada, Chile, Colombia, Kazakhstan, Mexico, Peru, Russia, and South Africa, which is consistent with other studies[32] that analyze NR specialization and successful cases of development.

In addition, it was used the metafrontier methodology to determine and to compare Technical Efficiency (TE) and Technological Gap Ratio (TGR) of SELECTED countries. In order to identify the opportunities derived from improved production efficiency or technological catching up, stochastic metafrontier methodology has become popular in the literature because it identifies the optimal production function of the firms within an industry and the distance of each individual to frontier. According to O'Donell et al. (2008), this econometric tool can also be applied to evaluate countries as units of analysis. The stochastic frontier production function postulates the existence of technical inefficiencies of production (Battese and Coelli, 1995), based on the concept of a production meta-function and assuming that all individuals have access to the same technology (Battese and Rao, 2002; Kudaligama and Yanagida, 2000). However, it is well known that technology is not a public good because there

[31] The variables used for the cluster analysis were: per capita GDP, growth rate, agriculture (added value) and mineral (rents).

[32] See Ferranti et al. (2002), León-Ledesma (2002), Castellacci (2006b), Catálan (2007), Gylfason and Zoega (2006), Giménez and Sanau (2007), Maloney and Rodriguez-Clare (2007), Smith (2007), Behbudi et al. (2010), CNIC (2010), Silva and Teixeira (2011), and Ville and Wicken (2012).

are several factors that limit cost-free technology transfer and diffusion processes. The meta-frontier production function proposed by Battese et al. (2004) is a frontier function that envelops all frontiers of individual regions or groups (Chen and Song, 2008), and permits to deal with the sample technology heterogeneity and to distinguish from technical inefficiency (Battese and Rao, 2002). Therefore, it is possible to estimate technology gap assuming different technologies relative to the frontier (Huang et al., 2010). This model includes an error term that comprises a symmetric random error and a technical inefficiency term (Battese and Coelli, 1995; Battese and Rao, 2002). Thus, two main components relative to efficiency can be determined: a component that measures the distance to the group frontier (commonly defined as Technical Efficiency), and a second element that measures the distance between the group frontier and the metafrontier, from which the Technological Gap Ratio can be identified (O'Donell et al., 2008).

The general function is represented as:

$$\mathbf{Y}_{\mathrm{it}} = \boldsymbol{f}\,(\mathbf{X}_{\mathrm{it}};\,\beta)\;\mathbf{e}^{\mathbf{V}_{\mathrm{ti}}\,-\mathbf{U}_{\mathrm{it}}} \qquad \text{(Equation V.1)}$$

Where Y is the output, X is the vector of independent variables or inputs, β is the vector of coefficients of inputs, V is the inefficiency term and U is error term. Finally, i and t represent the individuals and time, respectively.

The Technological Efficiency is the ratio between the actual production and the potential for using the technology available within the group analyzed. Our analysis was carried out considering as a group with homogeneous characteristics to SELECTED countries, while the complete sample also includes other NR-specialized economies as well as some developed countries. The function that defines TE is then:

$$\mathbf{TE}_{it} = \frac{\mathrm{TE}_{\mathrm{it}}}{\mathrm{e}^{\mathrm{x}_{\mathrm{it}}\,\beta+\,\mathrm{V}_{\mathrm{it}}}} = e^{-U_{it}} \qquad \text{(Equation V.2)}$$

The ratio between TE within the group and TE within all sample (metafrontier), represents the Technological Gap Ratio that shows the relationship between the production obtained using technology from homogeneous group (SELECTED) and that achieved by incorporating all technology available:

$$\mathbf{TGR} = \frac{e^{\mathrm{xi}\beta}}{e^{\mathrm{xi}\beta_{*}}} = \frac{\mathrm{TE}^{*}}{\mathrm{TE}^{k}} \qquad \text{(Equation V.3)}$$

where TE is the TE obtained using technology from group and TE^k is the TE achieved by incorporating all technology available

A second and complementary econometric analysis was conducted to identify the determinant factors of the technology gap in NR-based economies. Although a broad number of works referred to NR and growth adopts OLS as estimation method, one of the most outstanding inconvenient of this estimation method in cross-country analysis is the existence of countries specific-effects, reason why OLS is inconsistent and biased (Castellacci, 2008b). Therefore, to take into account individual effects Panel Data methodology is recommended. We estimate the model considering both fixed and random individual effects, using variables selected according to the literature review and taking into account the restrictions of the analytical method. We follow the conventional approach used in other applied growth models, taking labor and capital (investments) as the main traditional production factors (Romer, 1990; Aghion and Howitt, 1992). Physical investment was used as indicator of capital in a similar way as Stijins (2005) and Castellacci (2008b). For the analysis of the effect of natural resources, an index of Specialization was calculated as the ratio between natural resources exports and total exports. According to evolutionary framework, we also include indicators that reflex innovation capabilities –patents- and absorptive capacity – schooling - (Castellacci, 2007a, 2007b). Moreover, an indicator of institutions has also been introduced: the Institutions index elaborated according to WB methodology (Kaufmann et al., 2003). Finally, the openness and foreign direct investment (inward FDI stock) were selected to proxy international influences. Table V.1 shows the definition and sources of all the variables used in our empirical analysis, whose specification would adopt the following form:

$$\textbf{GDP GAP}_{it} = \beta 0 + \beta 1 K_{it} + \beta 2 L_{it} + \beta 3 NR_{it} + \beta 4 Pat_{it} + \beta 5 FDIIS_{it} + \beta 6 Op_{it} + \beta 7 Sch_{it} + \beta 8 Ins_{it} + \eta_i + \gamma_t + \varepsilon_{it}$$

(Equation V.4)

Where:
GDP GAP: ln GDP GAP
GDP: Gross Domestic Product (GDP) per capita
K: ln Capital, investment
L: ln Labor
NR: ln natural resources, specialization
Pat: ln Patents
FDIIS: ln FDI, inwards
Op: ln Openness
Sch: ln Schooling
Ins: Institution index
The subscript *it* refers to the country *i* in period *t*, η_i and γ_t represent individual and time effects, respectively; ε_{it} is a random error term.

Table V.1. Definition of variables, indicators and data sources

Variable	Definition	Source
GDP	Per capita GDP, PPP, at 2005 constant prices	CANA from Penn World Table
Labor	Labor force, total	WDI
Capital	(%) Investment. Share of per capita GDP at constant prices 2005 PPP converted	Penn World Table
Patents	US Patents granted per Country of Origin. Number of utility patents granted by the USPTO by year and Inventor's Country of Residence per inhabitant	CANA from USPTO
Schooling	Mean years of schooling. Average number of years if school completed in population over 14.	CANA from Barro & Lee; WB
Inward FDI	FDI Inward Stock (%GDP)	UNCTAD
Openness	Openness Indicator: (Import+ Export)/GDP. PPP	CANA from UNCTAD
Institutions	Index made up Rule of law, Corruption control, Voice and Accountability, Political stability and Absence of violence/terrorism, Government effectiveness, and Regulatory quality.	World Bank
NR specialization	NR exports as share of total exports	UNCTAD (exports), CANA and WDI

Source: Author's elaboration

To take into account possible endogenous structures of the model, dynamic specifications are performed[33] using Difference and System GMM method and the xtabond2 estimator (Roodman, 2006).

$$\textbf{GDP GAP}_{it} = \beta 0 + \beta 1 \textbf{GDP GAP}_{it-1} + \beta 2 K_{it} + \beta 3 L_{it} + \beta 4 NR_{it} + \beta 5 Pat_{it} + \beta 6 FDIIS_{it} + \beta 7 Sch_{it} + \beta 8 Ins_{it} + \eta_i + \gamma_t + \varepsilon_{it}$$

(Equation V.5a)

$$\textbf{GDP GAP}_{it} = \beta 0 + \beta 1 \textbf{GDP GAP}_{it-1} + \beta 2 K_{it} + \beta 3 L_{it} + \beta 4 NR_{it} + \beta 5 Pat_{it} + \beta 6 Op_{it} + \beta 7 Sch_{it} + \beta 8 Ins_{it} + \eta_i + \gamma_t + \varepsilon_{it}$$

(Equation V.5b)

Where:
GDP GAP: ln GDP GAP
GDP: Gross Domestic Product (GDP) per capita
K: ln Capital, investment
L: ln Labor
NR: ln natural resources, specialization
Pat: ln Patents
FDIIS: ln FDI, inwards
Op: ln Openness
Sch: ln Schooling
Ins: Institution index
The subscript *it* refers to the country *i* in period *t*, η_i and γ_t represent individual and time effects, respectively; ε_{it} is a random error term.

In order to asses in depth the convergence of each gap component of Chilean economy and the evolution of them, a distance or convergence analysis (β) was driven following

[33] Dynamic model's estimations were performed incorporating openness and FDI separately, because the model is overidentified when both variables are included together.

Li and Liu (2005), and Sala-i-Marti (2000) to evaluate the gap dynamic or convergence. The distance was calculated according to the next specification:

$$GAP_{it} = (A_{max} - A_{it}) / A_{it} \quad \text{(Equation V.6)}$$

Where:
GAP: is the GAP between the leader and the economy analyzed i in the time t
A_{max}: data from leader economy
A_{it}: data from economy analyzed (i) in the time t

Meanwhile, the convergence is estimated as follow:

$$A_{it} = \alpha + \beta t \quad \text{(Equation V.7)}$$

Where:
A: is the GAP between country i and the leader, in the time t.
β: Convergence coefficient
t: time
α: Intersect of the model

Among SELECTED countries, Australia and Canada showed the highest per capita GDP and Technical Efficiency, and the smallest technology gap; but Australia has a more specialized economic structure, thus this country has been considered as leader. In addition, the Chilean data were also compared with USA because this economy is one of the most developed, was a NR specialized country and it is usually used as reference in the gap analysis. However, a complete set of result is also offered in Table V.4, and in Annex 6 can be found more results of robustness check using different economies as frontiers.

Finally, an analysis of the dynamic evolution of Chile's GDP is offered following Faberberg et al. (2007) classification of countries, which identify and classify the economies into four categories: Catching up, Losing momentum, Moving ahead, and Falling behind. Unlike the work conducted by Faberberg et al., we take several periods of a same individual – Chile - to try to understand the evolution of growth.

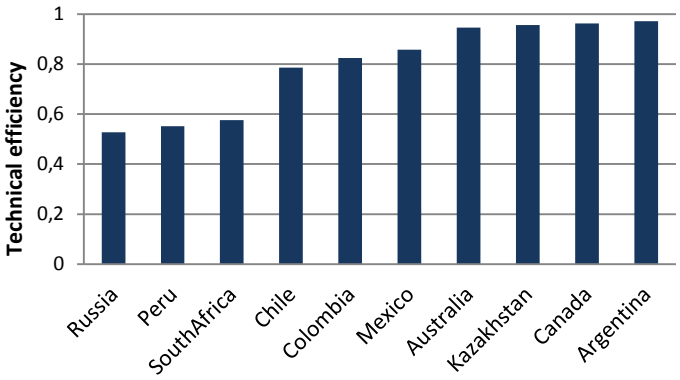
5.5. Discussion of results

5.5.1. Technical Efficiency and Technical Gap Ratio

The analysis of Technical efficiency allows us to know efficiency level of a country to employ its resources -tangible and intangibles- and then management abilities are

crucial to understand potential improvements (Battese and Coelli, 1995; Battese and Rao, 2002; O'Donnell et al., 2008). The results show that Russia, Peru, and South Africa have the lowest TE, with values under 60% (Graph V.3). This indicates that these economies can achieve higher performance with the stock of available resources (technologies, NR, capital and intangibles assets) and then their growth opportunities are defined through resources' management. Moreover, although Chile, Colombia, and México have also the opportunity to growth faster by improving their internal processes and use of resources, their gap is narrower and hence they have lesser options via management. On the other hand, Argentina, Canada, Kazakhstan, and Australia are the countries with highest TE, thus growth can be improved from development of new technologies, innovations, or the incorporation of new advances from areas different than the reorganizations of available resources. For the specific case of Chile, the opportunities to improve TE by benchmarking or the incorporation of best practices from the leaders are limited because these have similar TE and the threshold is small; thus it is more suitable to orient efforts to develop its own knowledge, technology and innovations.

Graph V.3. Technical efficiency (TE) taking into account country effects

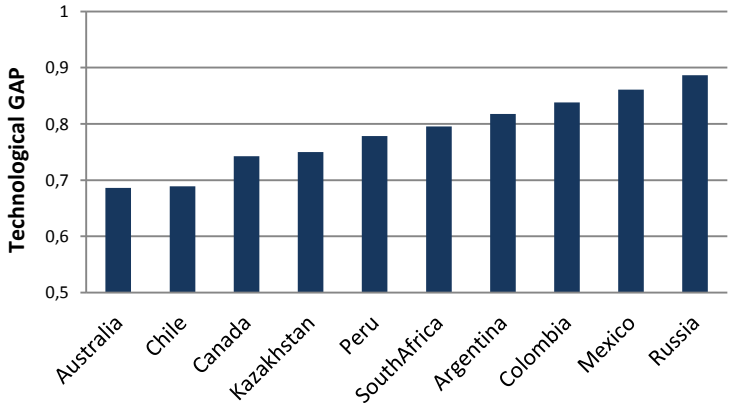


Source: Author's elaboration

Taking into account that the Technological Gap Ratio reflects the available technologies in one country, technological gap is equivalent to 1-TGR and this indicates catching up opportunities (Graph V.4). Accordingly, Chile, Canada, and Australia show the lower gap (higher TGR values); however, an important distance still persists, reason why these countries can achieve income improvement using technology available abroad. From the Chilean perspective, both Australia and Canada may serve as leaders for the gap analysis and benchmarking strategies; however, the former has a more similar economic structure to Chile and hence a more similar development path

to follow. Thus, it can be said that Chile could increase its economic performance both from foreign technologies, using catching up processes beyond NR industries, and improving strategies of resource management. However, these options are not unlimited and local innovations (technological and no-technological) can be encouraged to advance because total convergence does not reached by catching up alone and even more, leaders are pressed to innovate in order to expand production and technological frontier to follow their growth path (Porter 1990; Verspagen, 1993).

Graph V.4. Technological gap considering country effects



Source: Author's elaboration

5.5.2. GAP analysis: GAP model and Catch up convergence

Considering Australia as leader of those economies specialized on NR that show a high performance, the next convergence analysis tries to identify the key determinants to build a sustainable development strategy. This analysis was focused on Chile, although policy implications derived from our findings can be generalized to other specialized nations. Additionally, USA and Canada were also alternatively used for convergence analysis. The USA was taken as leader, because this economy was based on RN before the Second World War and moved to a knowledge economy by introducing knowledge assets into economy (Wright, 1990) and today has a high economic standing, while Canada is a NR specialized country with sophisticates activities. In any case, the variables that define the gap between Chile and USA, Canada or Australia, follow a similar pattern, as is observed in the correlation matrix (see Annex 7). This indicates that there is a similar growth trajectory between these countries, confirming both the adequate selection of leaders in the analysis and the possibility for considering our findings to discuss policy implications for NR-based economies.

The GAP model

As the results show, the income gap of economies dominated by NR is explained not only by the traditional production factors but also by international dimension and other elements postulated by the national system of innovation and knowledge economy approaches (Table V.2). The results come to indicate that the reduction of the gap in these countries can be done by an increase in capital investment (tangible), in accordance with the nature of this economic activity, as well as by the development of innovation capabilities, being also significant trade openness and FDI attraction. This combination of factors is coincident with the assumption that natural resources can lead development when intangible assets are also incorporated into the strategy. In fact, natural resources specialization positively affect the gap narrowing, a finding that find support in the related literature and evidence that point out that NR may successfully contribute to growth when natural and other traditional factors (capital and labor) endowments are combined with strategic intangible assets, such as human capital, good institutions, and openness policies (Bravo-Ortega and De Gregorio, 2007; Iizuka and Soete, 2011).

Table V.2. Effects of physical, technological and intangibles factors on per capita GDP gap. Estimation of static panel data.

Variable	Model A		Model B		Model C	
	coef	se	coef	se	coef	se
Labor	0.014***	0.003	0.018***	0.003	0.020***	0.003
NR	-0.003	0.002	-0.004**	0.002	-0.003**	0.002
Investment	-0.007***	0.002	-0.006***	0.001	-0.007***	0.001
Patent	-0.001*	0.000	-0.001*	0.000	-0.001*	0.000
Schooling	-0.005	0.005	-0.004	0.005	-0.004	0.005
Openness			-0.003**	0.001	-0.002**	0.001
FDIIS					-0.001**	0.000
Institution	0.000	0.001	-0.001	0.001	-0.001	0.001
_cons	-0.205***	0.052	-0.268***	0.041	-0.299***	0.036
Hausman test (Chi-sq)	45.31		63.04		122.36	
Num. of obs.	128		128		128	
R-sq: within	0.5196		0.5547		0.588	
R-sq: between	0.0490		0.0648		0.0496	
R-sq: overall	0.0590		0.0740		0.0580	

Note: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors. Fixed effects.
Source: Author's elaboration.

The internationalization of these economies is also revealed as a significant factor that affects convergence in accordance with the importance that in the literature has the international dimension as main source of technology, capital and demand. When the

model is estimated without considering the global dimension, the NR exploitation has not a significant impact on the income gap; when openness and FDI are incorporated into the model, NR positively affect growth, reducing the gap. This result remarks this aspect for specialized economies, being takeoff inconceivable for a closed NR-producer country. In addition, a more open economy implies that the workforce can move to other productive activities generating the opportunity to develop complementary knowledge intensive goods and services, and even promoting new sectors.

Despite institution index did not showed a significant relationship with income gap, possibly due to the small variation of this index compared with the dependent variable, previous studies have indicated an important impacts of good institutions on growth, in this specialized countries (Iizuka and Soete, 2011; Sæther et al., 2011). Thus, from these results along with those obtained in Chapter IV, it could indicate that good institutions are a fundamental condition to the growth of industries based on NR, but when countries reach a sufficient level, other factors become more important to grow faster than the leaders.

The positive relationship between labor and the GDP gap (see Table V.2) can be explained attending to the fact that natural resources activities are nowadays capital and scale economies intensive, requiring less amount of labor to increase or maintain the production level (Álvarez and Fuentes, 2006; Arias et al., 2012). Thus, low-skilled workforce or with limited education can be qualified increasing the level of human capital and then be employed in activities related to natural resources but being more knowledge-intensive, such as the creation of new technologies or knowledge services, in a process of diversification within NR sector. In this regard, Manzano (2012) argues that for upgrading their productive structure, these economies need to adequate human capital, along with R&D infrastructure and appropriate institutions, highlighting the importance of skilled workers to face more complex activities in order to add value to exports by creating and incorporating innovations.

Successful evidence related to NR industries and growth can be also found in the literature. In fact, similar findings have been described from case studies of some positive experiences. Examples of them are Finland, Norway and Sweden who have moved from primary industries to knowledge-based economic drivers, in a process of sectorial transformation and diversification (between sectors). However, the estimation of Gap model offer an additional perspective, because to reduce the distance with leaders economies, countries can continue investing in NR activities, but also incorporating more knowledge assets. This effort should be oriented to improve

competitiveness in primary sector and create new knowledge-based business, in order to diversify economy (within NR sector) and reduce the risks of commodity volatility and the emergence of new substitutes.

Finally, to test the potential endogenous process, dynamic panel specifications were estimated (Table V.3). The results do not differ from the static estimation, i.e., it is confirmed that intangible assets (openness, foreign direct investment, technology capability - patents) and tangible investments (capital) contribute significantly to close the GDP gap in economies specialized in NR. In addition, education also shows a positive effect on the reduction of the gap. (Model Z in Table V.3). Moreover, although the institutions have not significant impact on the GDP gap, when they are included in the estimation, natural resources contribute to closing the GDP gap (Models Y and Z in the table below).

Table V.3. Effects of physical, technological and intangibles factors on per capita GDP gap. Estimation of dynamic panel data.

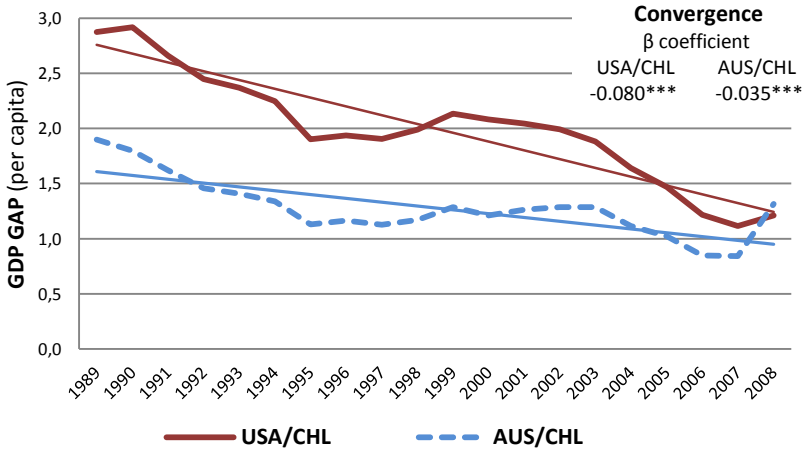
	Model W		**Model X**		**Model Y**		**Model Z**	
	coef	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
GDP GAP (L1) (per capita, US$ 2005)	0.266	0.71	0.761	0.80	-0.573	0.42	0.187	0.20
Investment	-0.463*	0.25	-0.542**	0.27	-0.829***	0.24	-0.271***	0.07
Labor	0.807	0.55	1.795***	0.59	1.768**	0.86	0.971***	0.15
NR	0.244	0.21	-0.075	0.17	0.318	0.34	-0.163**	0.08
Schooling	-0.633	0.59	-1.124	0.84	-2.525**	1.18	-0.585***	0.22
Patent	-0.251**	0.12	-0.187***	0.06	-0.283*	0.15	-0.142***	0.04
Openness					0.189	0.49	-0.094**	0.04
FDI	-0.069	0.11	-0.149*	0.09				
Institutions			1.137	1.54			-0.372	0.28
_cons	-12.90*	7.70	-28.74***	9.31	-23.26	14.70	-14.95***	1.46
Number of observations	60		60		60		60	
Number of instruments	10		10		10		10	
Arellano-Bond test for Ar(1)	-1.71*		-1.88*		-1.75*		-1.76*	
Arellano- Bond test for Ar(2)	0.28		0.10		1.37		0.64	
Sargan test (chi-sq)	10.75		1.14		0.33		1.23	
Hansen test (chi-sq)	3.26		0.31		0.03		0.04	

Note: *** p<0.01, ** p<0.05, * p<0.1. Negative coefficients mean closing the gap. Two steps. Robust standard errors. Source: Author's elaboration.

An illustration of convergence and gap factors

The illustration of the convergence analysis presented in next graphics allows us to identify different factors affecting the gap evolution and the reasons of the remaining distance from the leaders. The results show the successful path of Chile closing the income gap with leaders (Australia, Canada and USA), but its per capita GDP is still about half of the most advanced countries (Graph V.5). Several authors, such as Álvarez and Fuentes (2006), García (2006) and Pérez (2012) have noted that Chile has achieved a high economic standard in recent decades, with a faster growth in the 90s, but this progress has not yet been sufficient to complete income convergence.

Graph V.5. GAP of GDP, between Chile and the leader Australia and USA



Source: Author's elaboration

Some of the causes for this convergence are found among the government's reforms and the policies implemented decades ago, oriented to opening the country and attracting FDI as a source of capital and technology (García, 2006; Bas and Kunc, 2009). However, if we analyze different determinant factors of the gap reduction, important differences arise, because Chilean policies have been more oriented to opening and catching up than to building local capabilities (Table V.4).

In general, differences in convergence with Australia, USA and Canada are slight and can be explained by the diversity of industrial structures, growth strategies and development stage. The empirical results show a robust convergence in schooling, scientific articles and infrastructure (roads), confirming the effort carried out for the government to improve productive infrastructures and facilitating the population access to education, at least to primary and secondary levels. Nevertheless, several

authors based on international evaluations[34] of the education system indicate that quality is still deficient, and this represents one of most relevant bottlenecks to cross the development threshold, as Eyzaguirre et al. (2005) warned a decade ago.

Table V.4. Convergence coefficients between Chile and Australia, USA, and intragroup leader

Variable	β (AUS)	β (USA)	Intragroup Leader	
			Country	β (leader)
Per capita GDP (US$ 2005)	-0.035***	-0.080***	CAN	-0.053***
Investment	0.010**	0.0000	AUS	0.010**
Patent	0.919	-9.645	CAN	-2.372
Schooling	-0.014***	-0.013***	AUS	-0.014***
Openness	-0.006**	-0.002	CAN	-0.008
FDIIS	0.0002	0.008**	CHL	---
Institutions	-0.002	-0.011***	CAN	-0.006***
Scientific articles	-0.209***	-0.346***	CAN	-0.360***
Royalties	-0.105***	-0.008	CAN	-0.161***
GINI	-0.019***	0.003	CAN	0.002**
R&D	-0.008	-0.017	CAN	0.037***
Infrastructure	-0.075***	-0.083***	KAZ	-0.044***

Coefficient negative of β means convergence of Chile with leading economies. Robust standard errors. Source: Author's elaboration.

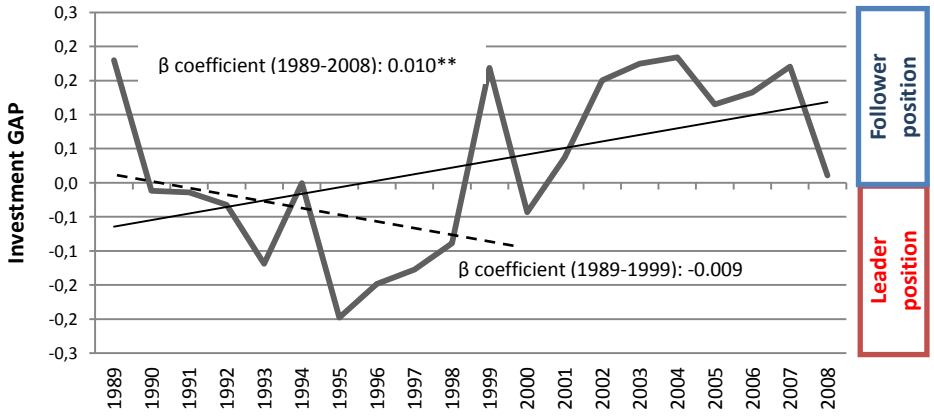
The convergence values of the institutions' indicator differ depending on the leader chosen. According to WB data, the negative shift of this index in Chile is linked to lower government effectiveness and the loss of government ability to define and implement policies to promote private business, while Australia exhibits a strengthening in these parameters. This context clearly shows the need to enhance the institutional environmental in Chile in order to avoid potential social conflicts, provide more stability to investments, and contribute to strengthen the international relationships, because they are the pillar to achieve higher economic progress (Nelson, 2007). As Alonso and Garcimartín (2008) point out, for advanced development level, the first-order conditions, such as macro-stability and respect for the rule of law, are not enough for advanced stages of development, and thus it is required more institutional quality (governance, regulatory capacity, transparency, etc.).

As the NR industries are capital-intensive and require important investments in physical assets, a gap reduction in this production factor is determinant to exploit these endowments. Despite the fact that investment gap has increased during the

[34] More details of evaluation of education quality see Pisa report on http://www.oecd.org/pisa/

entire period (Graph V.6), Chile has narrowed it in the nineties (see Annex 9) which confirms the success of policies applied to promote investments in NR sectors and related services during the last decade of XXI century. This is the result of external inflows of capital through FDI (mainly in mining and salmon subsectors) and other foreign investments, mainly as a consequence of public service privatizations, and also due to the reinvestment of NR revenue (Álvarez and Fuentes, 2006; García, 2006; Pérez, 2012). However, in an extended analysis from 1996 to 2008, signs of broadening the gap are found at the end of the period although the gap values are around zero (Annex 9). Taking into account the strategic relevance of physical investment as a way to improve the innovation capacility, because some innovation activities require high-cost physical facilities such as scientific infrastructures (Verspagen, 1993; Castellacci and Natera, 2013), it is interesting to pay more attention to this variable in the analysis of the causes of the reduction in Chile's attractiveness as a destination for investors. In this sense, related explanations point out the raise of labor costs, environmental policies and the perception of higher risks, which could be offset if Chile makes more efforts on other factors of production, as proposed by the Knowledge economy.

Graph V.6. Gap of investment, between Australia and Chile



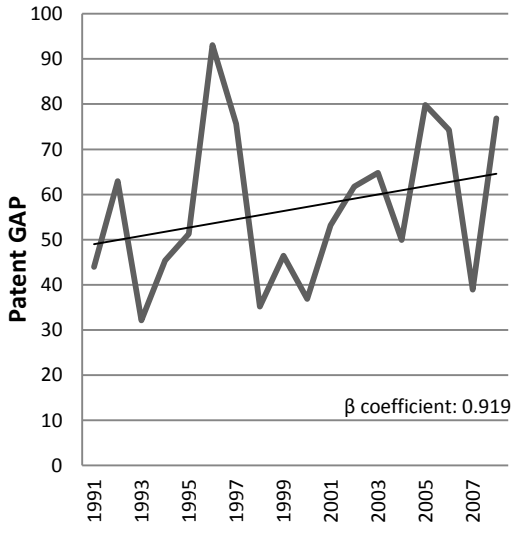
Source: Author's elaboration

As already said, other assets along with physical investment are needed to exploit successfully NR such as knowledge and technology (Ferranti et al., 2002; Silva and Teixeira, 2011). The reason is that countries can improve the production of goods and services with higher value added, to create new ones, or to reduce the costs through innovation, and the NR industries are not an exception, as leader countries have shown, e.g. Finland, Sweden, New Zealand, Australia, and Canada. Thus, innovation

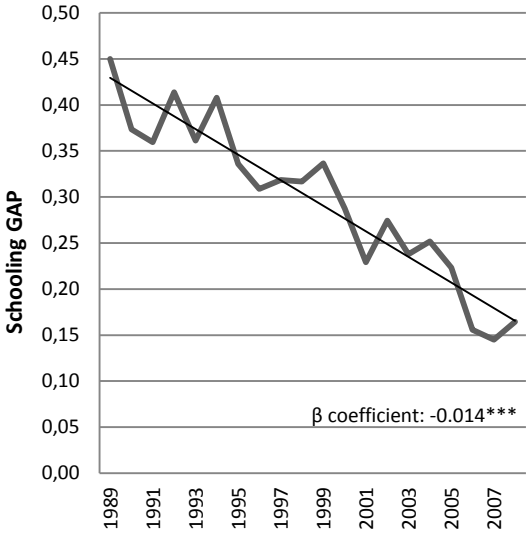
becomes a key factor for getting higher competitive advantages that guarantee sustainable growth and development, and the ability of countries is directly conditioned by the characteristics of the national system of innovation (Nelson and Winter, 1982; Lundvall, 2007).

In this sense, both technological and absorption capabilities are fundamental to developing countries, such as Chile, for catching up and for the development of new knowledge in order to improve the performance of traditional sectors (Verspagen, 1993; Castellacci and Natera, 2013). Therefore, now we move to focus the analysis to patents, as a proxy of innovation capability, while schooling is taken as an indicator of absorption capacity and human capital (Graph V.7). Chile does not show a reduction in the gap of patents, and this can be seen as a serious barrier for development. In fact, there is evidence in the literature on the weakness that Chile presents in terms of innovation capability or innovation shortfall, regarding R&D investment level, human capital, and scientific facilities (Benavente, 2006; Maloney and Rodriguez-Clare 2007; Pérez, 2012). On the other hand, the indicator of schooling reveals a reduction of this gap by two-thirds regarding the existing in the late eighties, reflecting the advance of absorption capabilities; this is likely the consequence of national policies and the largest education expenditures in the country during recent decades. Nonetheless, there is still the need to increase it at a tertiary level and improve quality (García, 2006) to impact positively on the innovation performance, since innovation and human capital is strongly related. The improvement of absorptive capabilities is also crucial in the development strategy to support the generation of innovations and to provide the required skills to select, adapt, and apply knowledge developed in other latitudes.

Graph V.7. Gap of Patent and Schooling, between Australia and Chile



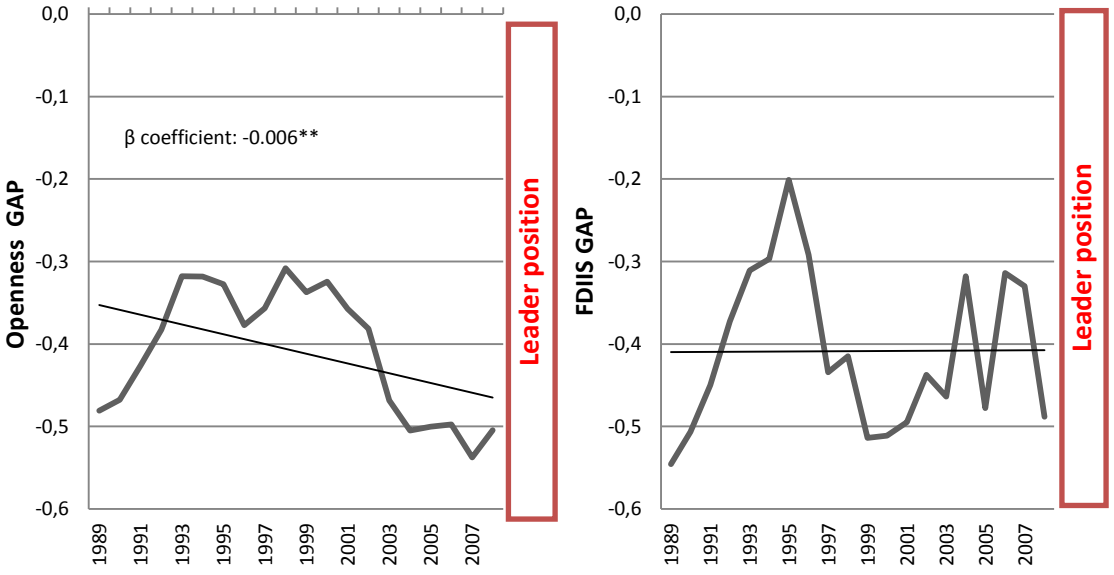
Source: Author's elaboration



Source: Author's elaboration

The important structural reforms established by Chilean governments in the seventies and eighties were orient to improve the macroeconomic behavior, the control of inflation, and to promote international trade and foreign capital inflows and technology (Paunovic, 2000). The opening process turned Chile into one of the leaders of international trade (Graph V.8), showing a higher openness level than Canada and Australia. Chile is one of the most attractive countries to invest in the World, and not only in NR industries but also in service and infrastructures (Bas and Kunc, 2009; Pérez, 2012). Scholars agree on the crucial role that the international dimension acquired in the development path of the country, being considered one of the growth engines that has been possible thanks to the economic and sociopolitical stability, which offer suitable incentives to foreign investments and the production of tradable goods (Álvarez and Fuentes, 2006; García, 2006). Thus, this is a key aspect to explain the Chilean economic success that has also been supported by policies that have taken advantage of catching up possibilities in the global market.

Graph V.8. Gap of Trade Openness and FDIIS, between Australia and Chile



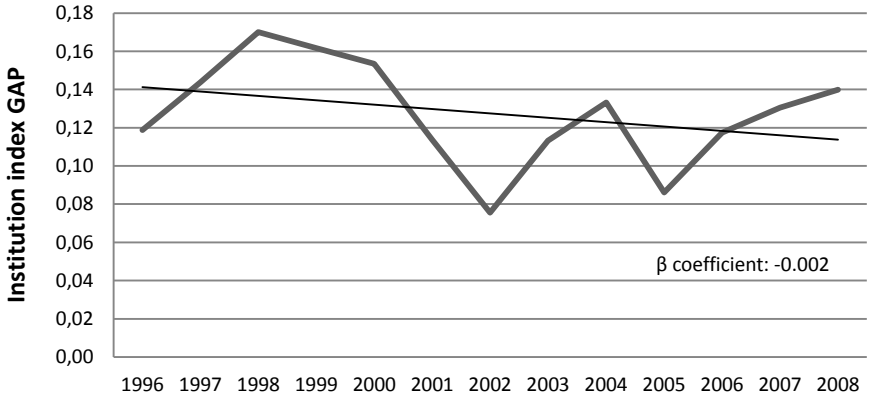
Source: Author's elaboration

Source: Author's elaboration

However, since capital and technology are not enough to achieve a permanent successful result of NR exploitation, because the problems of deindustrialization, depletion, corruption, and social conflicts, it is grounded in the related literature on NR that institutions are an essential factor to avoid NR curse and turn it into a blessing (Frankel, 2010; Sæther et al., 2011; Manzano, 2012). The institution's index of Chile presents a lower value (weaker institutions) than leader, but the difference between

Australia and Chile is only around 10% with a decreasing trend (Graph V.9), while with Canada or USA is significant lower. Then, adequate institutions (comparatively to other NR-based countries) have also been a determinant factor of Chilean growth (García, 2006; Álvarez and Calfucura, 2010). This nation has been successful implementing deep reforms on governance, transparency, and corruption control, without falling into pressures resulting from natural resources windfall, but the indictors still have space to improve. In particular, challenges are related to the improvement of institutions quality to maintain the development path, mainly those areas related to control of corruption, government effectiveness, and regulatory capacity. According to García (2006), the main weakness of Chile are related to democratic governance and income distribution, while Figueroa and Calfucura (2010) and Lagos and Blanco (2010) also suggest that environmental policies should be urgently improved in order to avoid depletion and pollution.

Graph V.9. Gap of institutions, between Australia and Chile



Source: Author's elaboration

Other key component of the social dimension is the income distribution in which Chile also shows a deficit (see Annexes 6 and 8). The gap with the USA and Canada has not been closed and the Gini index is still high, an aspect that can affect negatively growth due to the relation of this variable with the stability and persistence of productivity dynamics in the long run (Castellacci and Álvarez, 2006). As Morawetz (1977, p.41) point out "*it is not possible to grow first and redistribute later*", because progress is defining the pattern of distribution; indeed, multiples social protests and strikes in productive sectors have occurred in recent years, affecting social harmony and production levels as well.

Following the literature on national innovation systems, there is a wide amount of variables that can be used to its analysis, including those related to inputs, outputs and

processes. In Annex 6 is presented the gap evolution of some input variables of innovation system, in accordance with Castellacci and Natera (2013). The production of scientific articles shows a clear convergence, but the distance to leaders is still large (between eight and nine times less than Australia), which is also consistent with the low technological capabilities (patents indicator). The combined gap of patents and scientific articles denotes a lack of local capacities for the generation of new knowledge and technologies that affect negatively growth. Even more and according to Bas and Kunc (2009) and Arias et al. (2012), the patent production of Chile in the mining sector is principally done by non-resident inventors remarking this domestic default and confirming that international technology inflows remain being the cornerstone of Chilean growth. The statistics on royalties (payments) also show convergence (Annex 6), which is an example of catching up phase, but this is not sufficient condition for convergence since local innovation and R&D are development pillars of advanced economies when they are near the frontier (Porter, 1990; Verspagen, 1993; Castellacci, 2002). Therefore, to reach a higher income level, opening and catching up strategies should be strongly complemented with internal capacities in Chile, fostering education, technological capacity and innovation.

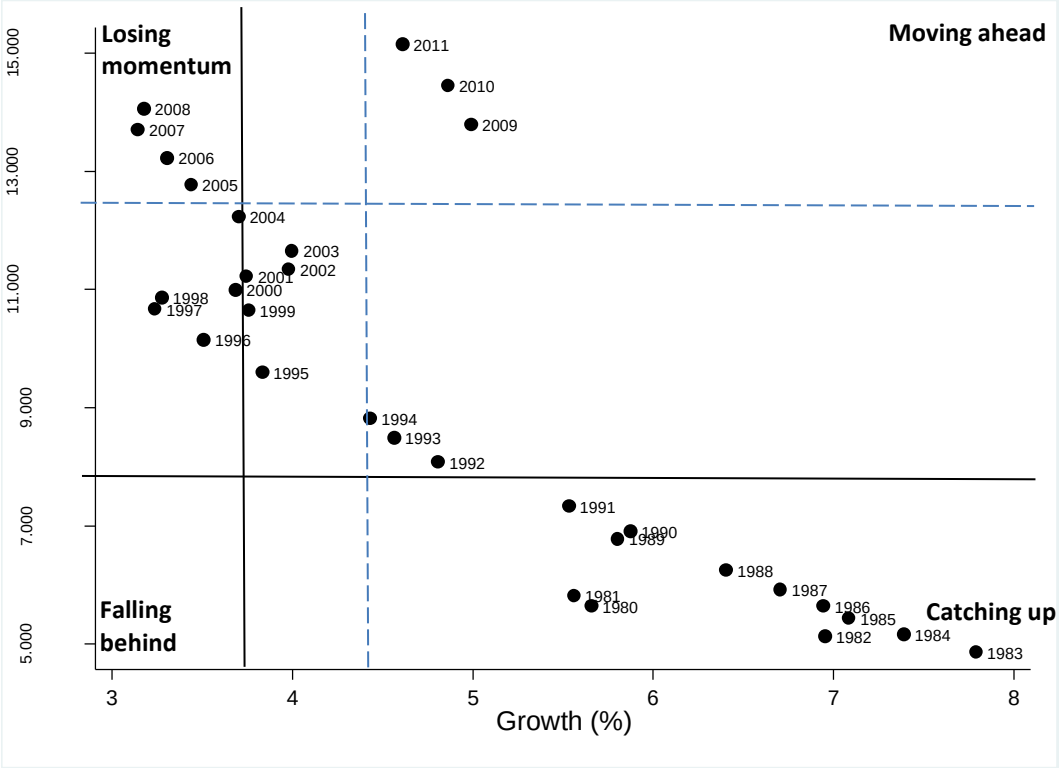
There is also convergence in physical assets, such as infrastructures (see in Annexes 6 and 8), a result that is consequence of the successful reforms applied in the past that lead the increase of foreign and local investments in road, telecommunications, ports, airports and other strategic facilities and public services, all of this with effects in international trade of NR and the country's competitiveness (Porter, 1990).

Although the majority of these factors can be understood as general conditions for different sub sectors (food, mining, forestry), there are some differences that should be taken into account. In the mining sector, the geographical concentration, the enclave nature, high dependence on foreign technology, and environmental externalities offer some specific challenges for innovation policies. This industry has an significant availability of specialized HC, and the main weakness are the lack of strong links with other sectors and even with universities and research centers, environmental issues, substitutes and productivity.

Moreover, food industry is an active industry in innovation activities but it requires more HC, increase investment in R&D, and strengthen knowledge transfer, while forestry should solve environmental concerns and social restrictions, develop new products, and increase technology as way to achieve greater competitiveness.

Finally, a categorization of the Chilean growth dynamics has been conducted following the taxonomy presented by Fagerberg et al. (2007) on country development and catching up process. The next graph (Graph V.10) clearly shows a declining trend in the growth path and this confirms the problems to sustain a high development standard. The vertical axis represents the initial per capita GDP and the horizontal axis is the average annual growth over the period. Solid lines define the classification of country growth stage according to the criteria offered by Fagerberg et al. (2007) while the dashed limits are the average of SELECTED countries. During the eighties the economy was in a catching up stage, while in the nineties it moved toward losing momentum where was in place during the 2000s. At the end of the period analyzed, new signs of dynamism are observed, probably because of high commodity prices (mainly cooper), rather than a real improvement of competitiveness, internal capacities or structural changes. This is also apparent in the competitiveness data reported by WEF, indicating a constant and worrying drop in competitiveness indicator (Graph V.11). The same trend shows the innovation index (Graph V.12), elaborated by Cornell University, INSEAD and WIPO (2013) confirming the low innovation capability of Chile.

Graph V.10. GDP growth dynamics of Chile (1989 –2011).

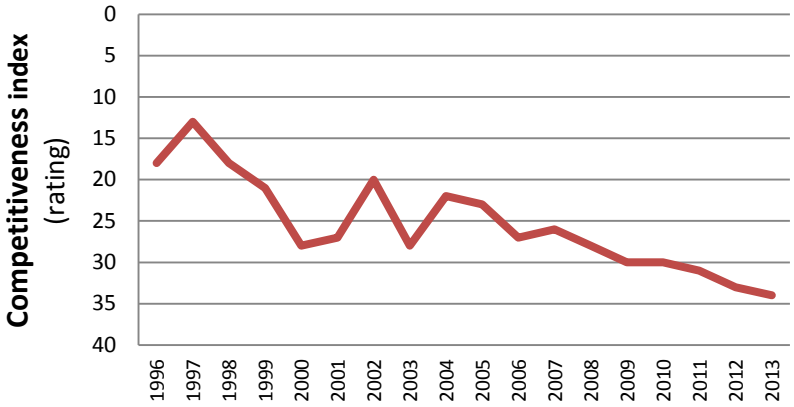


Dashed line (blue): Selected countries' average; Solid line (black): Classification according to Fagerberg et al. (2007). Source: Own elaboration based on World Bank data.

Thus, current intellectual capital in Chile does not seem to be enough to advance and support sustainable growth and incorporate to this country within the developed economies group. As the ex-Ministry of Economy of Chile, Félix de Vicente said (Terra, 2013): "the innovation is the tool to jump to development", that clearly indicates its importance for growth over capital or labor. However, the stock of Chile's innovation capability remains below advanced economies and far from the level of developed countries with similar industrial structures.

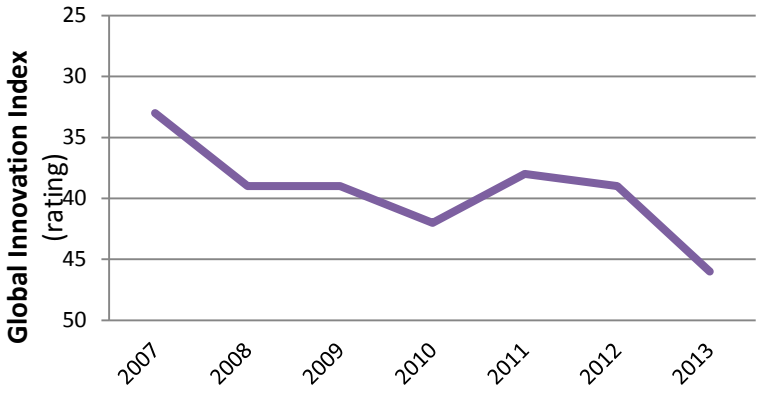
Therefore, to achieve the goal of become a developed nation, Chile should invest more in intangibles assets in NR sectors, as well as in transversal activities, such as ICTs, materials, nanotechnologies, robotic, sensors, etc. In addition, it is required more innovation capacities, and hence more opportunities for university formation, mainly in sciences, and improve education quality, are also urgent tasks.

Graph V.11. Competitiveness index of Chile by WEF



Source: Data from WEF´s reports

Graph V.12. The global innovation index of Chile



Source: Data from reports of Cornell University, INSEAD and WIPO

CHAPTER VI. CONCLUSIONS AND POLICY IMPLICATIONS

6.1. Conclusions

This PhD thesis has tried to contribute to the analysis of the relationship between intangibles and development, and in particular, how these assets can assist sustainable growth paths even in countries with an economic structure specialized in NR industries. The conclusions presented below have been structured according to the different analyzes performed.

The first problem addressed in this study was the limited, scattered and inconclusive information available on Intellectual capital (IC) at a country level, and the discrepancies on how to measure it, and the conclusions are as followed:

Intellectual capital is crucial for countries' growth

The systematic literature review and the model analyses to evaluate IC confirmed the strategic value of intangibles in creating wealth and conferring competitive advantages to countries for sustainable growth.

The comparison of models showed that there is a close relationship between economic performance of countries and their IC, allowing understanding the causes of growth or failure in the knowledge era.

Although this issue is a key to development, there are still few academic studies related to IC at the macro level. Around 60% of the identified studies on IC were published in scientific journals, and 80% of all the documents were published since 2005, mainly in the Journal of Intellectual Capital and the Journal of Knowledge Management, which account for nearly 80% of all papers found in the main journals related to IC.

Models for evaluation of intellectual capital of countries differ from those used at the firm level

There are several models to evaluate intangibles at country level, which differ from those developed to assess the intellectual capital of firms, although all models maintain their basic components: human capital, structural capital and relational capital.

Macro-level assessment systems not only include intangible assets related to the economic activities of enterprises, but also a number of institutional, social and other contextual elements that reflect the national and supranational development environment that affects business and sectorial performance, and even personal progress.

At the macro level, there are two main work lines for the development of IC assessment

At the macro level, two main lines of work on intangibles were identified, one closer to the study of IC at micro level (*Academic models*), and the other developed by international organizations and business schools (*International organizations' models*), which takes into account the value of

models, which differ in methodology, objectives and types of results.

intangibles as a way to measure competitiveness, development, or innovation capacity.
These two groups of models also differ both in the methodology and indicators used to measure intangibles. Academic models, closer to the KE approach, use indicators of intangibles separately from those of tangible assets, which allow reporting the IC as a whole. Moreover, International organizations' models permanently integrate tangible assets and intangible indicators to meet the objectives of each system, but it is not possible to independently identify the IC. This latter group of models provides indexes that are easier to understand for users, but do not directly report the IC.

The results reported by intellectual capital models are coincident

Despite the differences among models in terms of objectives, components and methods for assessing intangibles, the reported country rankings tend to converge (except Human Development indicator–HDI). This would indicate the high conceptual proximity.

The selection of model for IC management at the national level can be based on pragmatic issues

Policy makers have many ways to measure the strategic intangibles of countries that provide similar rankings, but require different inputs. Indeed, analytic results show that there are several alternatives for the user, and the selection can be based on pragmatic issues, such as the availability of data, whether or not the model is easily applicable, and the level of complexity of the reported information.

From the analysis of the models, it is possible to build a taxonomy that improves the understanding and management of intellectual capital.

The analysis of the models carried out in this study offers a preliminary taxonomy of this topic at macro level, which provides a more understandable way for the evaluation and management of IC.
Models more closely related to the accounting of the stock of intangible assets, with or without IC indices, are highly very similar and belong to the same category. At the other end of the classification are the models that try to capture the dynamic dimension and efficiency, which result in a different group.

The management of intangibles is a crucial tool for sustainable growth of countries.

The country classification based on intangibles clearly confirms that economic performance is strongly connected to IC. The cluster analysis showed that peripheral European nations are clustered into the same group characterized by a low IC level. In contrast, economically robust countries, such as Nordic states, made up an independent group far from the most vulnerable nations, and with the highest IC scores. Therefore, managing IC is crucial to progress, reducing the negative effects of economic crisis and achieving sustainable development.

With this information on IC, as well as information related to growth theories and the related analytical frameworks, the second question posed in this Thesis refers to the key aspects for development in countries where the specialization of the industrial structure is clearly dominated by natural resources.

Natural resources may positively impact on growth if traditional production factors are appropriately combined with others of intangible nature.

Combining the available knowledge on the impact of intangibles on the economy and new opportunities offered by the evolutionary approach, even for countries based on NR industries, the empirical analysis carried out indicates that NR may generate a positive impact on GDP if traditional production factors (capital investment, labor and NR) are appropriately combined with strategic intangibles (openness, FDI, strong institutions and innovation capability), as proposed in the Knowledge economy, opening new and effective options for specialized economies.

There is a group of countries specialized in NR (SELECTED) that describes a successful development path based on the exploitation of natural resources

The findings confirm that natural resources show a positive effect on growth in some countries while in others, such as OECD members, their impact is not significant or even tends to adversely affect development. In particular, a group of nations with economic structures dominated by natural resources was identified (this is called SELECTED). This group is characterized by a sustainable growth path supported by NR, although we observed different impacts of renewable and non-renewable resources. In fact, agriculture did not have a significant effect on growth in SELECTED economies, while in OECD the impact was even negative. Oil had a positive influence in all analyzed samples, and the impact of mining was only significant and positive in SELECTED countries while in other NR-specialized economies it was not.

Under the Knowledge economy perspective, it is possible to identify a growth path based on RN and Intellectual capital

These results justify the design of a comprehensive framework for understanding the economic evolution of nations and the possibilities for defining a different development strategy based on the strengths of the national system of innovation and intangibles without leaving their natural resource-intensive industries completely aside, but this strategy would require high investment in knowledge assets as well as in complementary and transversal sectors.

International openness positively affects growth of NR based countries, as a channel to access foreign technologies

The empirical analysis also revealed the importance of openness as a channel to increase trade flows and to access embodied technologies and foreign knowledge via FDI in NR-based countries. This can be understood as a mechanism that may facilitate the international diffusion of technologies, with a potentially positive impact on development in resource-

and knowledge.	specialized economies. In addition, international networks, along with advanced human capital, are key elements to build absorptive capacities, which are critical for these economies.
Innovation capabilities are essentials for economies specialized in natural resources	Favorable effects of local innovative capabilities and the generation of technologies have also been detected as pillars supporting the development path of countries specialized in natural resources. This would indicate that not only the presence of higher levels of absorptive capacity, but also the capability for creating technologies, are required to progress, which becomes a key element to sustaining development and increasing long-term productivity in NR industries.
Good institutional quality positively affects GDP of natural resources based economies.	Institutions also have a positive impact on GDP in economies based on NR (SELECTED), because better institutions allow countries to overcome negative pressures. (Political, social and economic) of NR incomes, achieve a political, social and economic stability that promote investments, along with a transparent system that providing guarantees to investors. Good institutions provide a favorable long-term framework to carry out innovation activities in these sectors.
Investment in intangible assets in NR-based industries, allow growth and avoid the adverse effects that these resources could have on the economy of specialized countries.	The findings also reveal that the group of SELECTED countries describes a development path that integrates the exploitation of natural resources and investment in physical assets, with relational, structural and human capital in an international perspective. This integration of tangible and intangible resources is crucial for maintaining economic performance and even for avoiding negative effects of commodity booms or Dutch disease problems, and this has been done without a radical shift in their industrial structure. The key would be the transformation of activities related to NR exploitation in an endogenous process, by integrating and strengthening the knowledge-based assets of endogenous nature, into the NR industry.
Specialized NR economies need to diversify their products in order to achieve economic standard of a developed country.	Another important fact that emerges from our results is that to achieve a high economic level, diversification is also important for countries based NR, as advanced economies have shown. However, this process can be based on NR sectors, without giving up traditional sectors, which opens a new perspective for sustainable growth

Having identified the strategic role of intangibles in development, even in traditional economies based on NR, the third challenge addressed was to determine the supports to long-term growth in Chile, a developing country dominated by NR industries, in

order to identify the reasons for the structural economic slowdown observed in the last decade and to provide some useful implications for policy makers to encourage new waves of growth. In this regard, the case of Chile was taken to illustrate the development path and to detect the factors that contribute to reducing the gap with the leading economies.

In order to become a developed country, Chile may base its growth strategy on natural resources along with intellectual capital investment.

Unlike conventional recommendations, primary industries can be the pillars of progress, if they are complemented with intangible assets, especially human and structural capital, in order to diversify economic activities and add value their products. The economy should incorporate new technology business related to natural resources sectors.

The main opportunities to improve Chile's income come mainly from the incorporation of new technologies into production processes and management.

As Chile's technical efficiency is close to frontier, opportunities for the implementation of best practices from other countries are scarce, unlike what happened in the past. The policy targets should be technological and social innovations rather than management improvement or technological imitation. The rest of analyzed economies (SELECTED group) show similar results, hence, the main opportunities come from the incorporation of new technologies into production processes and management.

International openness, FDI and capital investment have been the main factors involved in the gap reduction of Chile with leading economies.

The convergence analysis of GDP and its determinants shows that per capita GDP of Chile has converged with NR-specialized leaders and the USA. The same results show the dimensions of education and openness. In addition, Chile is leader in inward FDI among the countries analyzed, which is a positive consequence of macro and micro economic reforms implemented since the seventies, and intensified since the nineties. Additional elements related to the national innovation system, such as scientific articles, royalty payments and infrastructures also show convergence with developed economies, confirming that Chile has based its growth mainly on tangible assets and foreign technology, along with creating absorptive capacities.

The main challenges for Chile to become a developed economy are: increasing innovation capabilities, reducing the gap in income and improving the quality of institutions.

The results of the convergence analyses, and empirical gap model, indicate that the main weaknesses of Chile are lack of technological capability, social inequality and inadequate institutional quality, particularly regulatory capacity, to close the GDP gap.

Even though foreign knowledge and technologies flow easily into the country, new barriers could emerge and affect economic progress, if complementary measures do not enter the scene in order to improve local capabilities and to

strengthen technological ties at an international level. In addition, the closer the country is to the technological frontier, the greater the need to create own technologies because there are fewer opportunities and more restrictions.

This Thesis has sought to provide new evidence to understand the role of intangibles in economies based on natural resources, and to answer the question of how these specialized economies may face the challenges of development, taking the opportunities offered by the new economic frameworks, with the ultimate purpose of finding the deep causes and probable solutions to the long-term growth of Chile and other NR countries, taking into account their natural endowments as a pillar of growth.

Despite the caution taken in the analytical analysis and the review of literature, the study has some limitations common to this type of work and field. The literature review and model comparisons show restrictions due to the wide dispersion of information related to intellectual capital, much of which is not found in published journals, congress proceedings or books. Therefore, there is probably more information on intellectual capital at the macro level, and it is possible that other models or complementary information are not included. However, reviewed literature is the most often cited and recognized by leading authors, and the analyzed models correspond to those most frequently referenced and used by scholars and international organizations. Another limitation is the subjectivity associated with some of the variables created to compare models. The results may differ partially if other criteria were applied. In addition, reports on the evaluation systems are not available for the same period or for the same number of countries, and therefore it is not possible to carry out perfect comparisons, even though the reported data and results tend to converge.

The weakness of the study in the analysis of the relationship between NR and development, common in economic research, arises from the use of several proxies in the study of technological and intangible factors, as it is always difficult to choose the most adequate indicators for broad samples that include developed and developing countries. This also happens with NR indicators, because both specialization and intensity could lead to different impacts when the sample of countries is very diverse. Despite the foregoing, all the indicators are fully justified and the results of analyses are statistically robust and show the same tendencies using different approaches. In addition, the macro perspective adopted in this Thesis provides some advantages to perform econometric and comparative analyses, although it is difficult to address a

more detailed discussion on the factors involved. Finally, this study has been focused on the economic dimension of development, while social and environmental aspects have only been partially discussed. However, according to the literature, it cannot deny the determining effect of economic growth on development of countries.

Although there are some weaknesses, the results are robust and widely supported by the scientific literature. The findings open new research lines on growth and development of specialized regions, countries, and territories, as well as at a sectorial level, mainly in agriculture and mining. In particular, future works will seek to analyze the creation and absorption processes of knowledge and technology, and the mechanisms to improve their impact on income in agriculture and mining sectors. These studies will attempt to figure out the type and size of the efforts required for building the absorption capacity and the innovation capability, current weakness, and the opportunities that still exist to converge via imitation. For this purpose, new researches could use information at micro level provided by local institutions applying econometric analyses. The findings may lead to important policy implications for promoting science and technology creation, as an engine of growth in specialized economies. A further research proposal is to analyze spillovers from clusters made up of agents involved in activities related to raw materials (producers, suppliers, exporters, related and supporting industries, public and science and technology sectors), identifying the characteristics of evolution of knowledge creation and technology diffusion in these sectors, how can it be improved, and what its effects are on local and national development.

Finally, below are presented the publications resulting from Theses.

Álvarez, I. & Labra, R. (2014). Technology gap and catching up in economies based on natural resources. The case of Chile, *Journal of Economics, Business and Management,* 3(6), 619-627.

Álvarez, I. & Labra, R. (2013). Identifying the role of natural resources in knowledge-based strategies of development. *ICEI WP, 05*(13)

Labra, R. & Sánchez, M. P. (2013). National intellectual capital assessment models: A literature review. *Journal of Intellectual Capital, 14*(4), 582-607.

Labra, R. & Sánchez, M.P. (2012). Analysis and comparison of national intellectual capital assessment models. *Knowledge, Innovation, and Sustainability: Integrating Macro & Micro Perspectives*. June 13-15, 2013. Matera, Italy.

Conclusiones

Esta Tesis ha tratado de contribuir al análisis de los activos intangibles, su relación con el desarrollo, y cómo éstos podrían asistir al crecimiento de las economías especializadas en tradicionales industrias basadas en los recursos naturales, bajo un marco que integra las perspectivas económicas más tradicionales con aquellas derivadas de la Economía del conocimiento. Las conclusiones son presentadas estructuradamente en relación a cada uno de los análisis llevados a cabo.

La primera cuestión abordada fue la escasa, dispersa y poco concluyente información existente sobre el Capital Intelectual a nivel agregado, así como las discrepancias en cómo medirlo y contabilizarlo, y las conclusiones son las siguientes:

El Capital Intelectual es un factor determinante para el crecimiento de los países

La revisión de la literatura y el análisis de los modelos de evaluación del CI, permitió confirmar el valor estratégico de los intangibles en la creación de riqueza y ventajas competitivas de los países. Los resultados obtenidos a partir de la comparación de modelos, mostraron que existe una estrecha relación entre el desempeño económico de los países y su CI, permitiendo entender así las causas del crecimiento o fracaso en la actual era del conocimiento.

A pesar de la reconocida relevancia de estos activos para el progreso, existen aún pocos estudios sobre este tópico, a diferencia de lo que ocurre en el entorno de las empresas. Cerca del 60% de los estudios han sido publicados en revistas científicas y alrededor del 80% se ha realizado a partir del año 2005, utilizando como principales vías el Journal of Intellectual Capital y el Journal of Knowledge Management, los cuales concentran casi el 80% de todos los trabajos académicos publicados.

Los modelos para evaluación del Capital intelectual de los países difieren de aquellos utilizados en el ámbito de las empresas

Existen diversos modelos para medir aquellos activos intangibles que generan riqueza en las naciones, los que difieren de aquellos empleados para las evaluaciones del CI de las empresas, aunque comparten los componentes fundamentales: capital humano, estructural y relacional.

Las evaluaciones en el ámbito macro no sólo incluyen los intangibles relacionados directamente con las actividades económicas, sino también una serie de elementos del contexto institucional y social, los cuales reflejan el entorno nacional y supranacional que afecta el desarrollo económico de las personas, empresas y sectores.

Existen dos principales líneas de desarrollo de modelos para la evaluación y estudio

En el ámbito macro, fue posible identificar dos líneas de trabajo relacionadas la CI, una más cercana al estudio de los intangibles de las empresas, la cual ha sido desarrollada principalmente por académicos (*Modelos académicos*), y otra impulsada fundamentalmente por organismos internacionales y escuelas de

del capital intelectual de las naciones, las que difieren en la metodología, objetivos y tipos de resultados que reportan.

negocio (*Modelos de organizaciones internacionales*). Estos últimos se caracterizan por evaluar solo indirectamente el CI, tomando en cuenta el valor de los intangibles en conjunto a los activos físicos y financieros, para determinar la competitividad, el desarrollo o la capacidad de innovación de los países.

Estos dos tipos de herramientas difieren también en la forma de contabilizar los intangibles, ya que los modelos académicos evalúan estos activos independientemente de aquellos de naturaleza tangible, mientras que el otro grupo usan indicadores de activos tangibles e intangibles en forma conjunta e integrada en todas las etapas de la medición, dando lugar a índices compuestos de fácil interpretación por parte de los usuarios. Sin embargo, estos modelos no proveen directamente información sobre el capital intelectual, o sus componentes.

Los resultados que reportan los diferentes modelos de evaluación del CI son altamente coincidentes

Aunque existen importantes diferencias entre los dos grupos de modelos en cuanto a metodología, estructura e indicadores, los resultados que reportan tienden a converger (con excepción del Human Development indicator -HDI), lo cual refleja la alta coincidencia conceptual. El análisis de correlación confirma que los valores resultantes de las evaluaciones de los intangibles de los países son significativamente coincidentes.

La elección del modelo a utilizar para la gestión del CI es flexible y puede basarse en aspectos operativos.

Los gobernantes, responsables de las políticas, académicos y estudiantes, disponen de varias alternativas para evaluar los activos inmateriales estratégicos de una nación, las cuales arrojan resultados similares y comparables. Por tanto, la selección podría estar basada en aspectos pragmáticos, tales como son los datos disponibles, la facilidad de aplicación, la proximidad con la estrategia de desarrollo del país, o la complejidad de interpretación de los reportes.

A partir de las características de los modelos se puede construir una taxonomía que permite mejorar la comprensión y la gestión del Capital intelectual.

El análisis de los modelos ha permitido avanzar hacia una taxonomía que permite clasificar y entender mejor el contenido de los informes que se generan a partir de la evaluación del Capital intelectual de los países. En particular, aquellos modelos más fuertemente relacionados a la contabilización del stock de activos intangibles, reporten o no directamente el CI, son altamente próximos y conforman una misma categoría. En el otro extremo están aquellos modelos que tratan de capturar elementos dinámicos o de eficiencia, dando lugar así a otro grupo claramente diferenciado.

La gestión de los intangibles es una herramienta crucial para el progreso sostenible de los países.

La clasificación de países realizada a partir del nivel de CI que poseen, muestra cómo el desempeño económico está vinculado con los intangibles que posee un país ya que, por ejemplo, las denominadas naciones periféricas de Europa conforman un grupo caracterizado por el bajo nivel de intangibles, comparado con el resto de los países de su entorno. En contraposición, países con mayores fortalezas económicas, como son los

nórdicos, dan lugar a otro grupo muy distante de aquéllos más vulnerables económicamente, lo cual confirma la relevancia de los intangibles en el desempeño económico de los países.

Con estos hallazgos sobre el Capital intelectual, más la información contenida en la literatura sobre el crecimiento económico y los recursos naturales, se aborda la segunda cuestión de esta Tesis, la cual está relacionada con las claves del desarrollo en países especializados en la explotación de sus recursos naturales.

Los recursos naturales pueden impactar positivamente el crecimiento si los factores tradicionales de producción se combinan apropiadamente con otros de carácter intangible.

A partir de las oportunidades abiertas por el enfoque económico evolutivo, y sobre la base de las conocidas dificultades que pueden ocasionar los RN al desarrollo, los resultados obtenidos del análisis empírico indican que estos recursos pueden impactar positivamente el ingreso de una nación si los tradicionales factores de producción (capital, trabajo y recursos naturales) se conjugan adecuadamente con otros de carácter intangible (capacidad tecnológica, instituciones y apertura internacional), como propone la Economía del conocimiento, lo cual abre nuevas y efectivas oportunidades para las economías especializadas en la explotación de sus recursos naturales.

Existe un grupo de países (SELECTED) altamente dotados con RN que describen una trayectoria de exitoso crecimiento basada en los recursos naturales.

Los hallazgos confirman que los recursos naturales tienen un efecto positivo sobre el crecimiento en algunas economías, mientras que en otras, como las de la OCDE, su impacto no es significativo o incluso tiende a impactar adversamente. En particular, ha sido posible identificar una trayectoria positiva de crecimiento en un grupo de países con estructuras económicas dominadas fuertemente por la explotación y comercialización de sus recursos naturales (grupo SELECTED), aunque sí se detectó que dichos impactos no eran iguales si la actividad estaba basada en recursos renovables o no renovables. En efecto, la explotación agrícola no tiene un efecto significativo en el crecimiento del grupo SELECTED, mientras que en la OCDE el impacto fue negativo. La extracción y comercio de las reservas de petróleo tiene un impacto positivo en todos los casos, y el efecto de la minería fue solo significativo y positivo en las economías del grupo SELECTED.

Bajo la perspectiva de la Economía del conocimiento, fue posible identificar una senda de crecimiento basadas en RN y el Capital intelectual.

Los resultados de los análisis empíricos justifican la concepción de un marco que integre los elementos de la Economía del conocimiento con aquellos de carácter más tradicional, como son los recursos físicos, para entender la evolución de los países especializados, y las posibilidades que tienen para definir una estrategia de desarrollo basada en las fortalezas del sistema de innovación, sin abandonar las industrias intensivas en recursos naturales, sino más bien invirtiendo en ellas en activos basados en el conocimiento, así como en sectores transversales que contribuyan a su competitividad.

La apertura internacional influye positivamente en el crecimiento de países

El análisis econométrico muestra la relevancia que tiene la apertura de los países como un canal para incrementar el flujo comercial y acceder a tecnologías y conocimientos foráneos, vía Inversión extranjera directa, en países especializados en RN. Lo anterior puede

basados en RN, la que actúa como vía para capturar tecnologías y conocimientos extranjeros.	ser entendido como un mecanismo que facilite la efectiva difusión internacional de tecnologías y el positivo impacto sobre el desarrollo. Además, la internacionalización favorece las redes de trabajo en un ámbito global, lo que contribuye a la construcción de las capacidades de absorción, las cuales son fundamentales para este tipo de economías especializadas.
La capacidades de innovación y la generación local de tecnologías son esenciales para las economías especializadas en RN	Los resultados empíricos muestras un positivo efecto de la capacidad de creación de tecnologías sobre la trayectoria de desarrollo de países con economías basadas en materias primas. Esto indicaría que no sólo son necesarias las capacidades para absorber tecnologías y beneficiarse de los avances logrados por naciones más avanzadas, sino también, y aún más importante en etapas avanzadas de desarrollo, son imprescindibles las capacidades para la creación local con el fin de sostener e incrementar la productividad de las industrias primarias y diversificarlas, bajo una visión de largo plazo.
Sólidas instituciones también afectan positivamente el PIB de los países especializados en RN.	Buenas instituciones influyen positivamente sobre el producto de países especializados en RN (SELECTED), pues ellas permiten contener las adversas presiones (políticas, económicas y sociales) resultantes de las ganancias inesperadas resultantes de la producción de materias primas, logrando una mayor estabilidad política, social y económica, además de incrementar la transparencia, todo lo cual proporciona garantías a los inversionistas. Sólidas instituciones ofrecen además, un marco favorable para llevar actividades relacionadas a la innovación en una perspectiva de largo plazo.
La inversión en activos intangibles en las industrias basadas en los RN permiten el crecimiento de los países y evita los efectos adversos que estos recursos pueden ocasionar.	Los resultados obtenidos también revelan que el grupo de países denominado SELECTED, describe una trayectoria que integra exitosamente el capital humano, estructural y relacional con la explotación de recursos naturales y la inversión en activos físicos, todo lo cual es crucial para mantener resultados económicos positivos y evitar los potenciales problemas derivados de la denominada enfermedad holandesa o del boom de precios de las materias primas. La clave sería la trasformación de las actividades productivas relacionadas a la explotación de estos recursos construyendo un proceso endógeno, es decir, integrando y fortaleciendo los activos basados en el conocimiento, de naturaleza endógena, al interior de estas industrias.
Los países especializados en RN debieran diversificar sus economías para alcanzar el estándar de país desarrollado.	Otro hecho importante que se desprende de los análisis y evidencias es que para lograr el estándar de un país desarrollado, la diversificación productiva también es fundamental para los países basados en RN, al igual que en las economías más avanzadas. Sin embargo, este proceso puede basarse en los mismos sectores primarios, sin tener que renunciar a ellos, lo que abre una nueva perspectiva para su crecimiento.

De esta forma, habiendo identificado el rol estratégico de los intangibles en el desarrollo, el efectivo papel que tienen incluso en economías basadas en tradicionales industrias, y la necesaria complementariedad de ambos tipos de activos - tangibles e intangibles - para el crecimiento de países especializados en los recursos naturales, el tercer problema abordado guarda relación con las dificultadas exhibidas por Chile. Este país es tomado como caso para ilustrar una senda de desarrollo que podría caracterizar a diversas naciones con estructuras productivas similares, detectando los factores que puedan contribuir a la reducción de la brecha existente con las economías líderes.

Para alcanzar el desarrollo, Chile puede basar su estrategia de crecimiento sobre la base de los recursos naturales e invirtiendo en intangibles.

A diferencia de lo sugerido por visiones más tradicionales, las industrias primarias pueden seguir siendo pilares del progreso de Chile, siempre y cuando sean complementadas con activos de naturaleza intangibles, en especial capital humano y estructural, con el fin de mejorar la competitividad y diversificar la actividad económica, ya que para lograr un estándar de país desarrollado, la economía debe integrar nuevos negocios tecnológicos, los cuales pueden estar relacionados a los recursos naturales.

Las principales oportunidades para mejorar el ingreso de Chile provienen fundamentalmente de la incorporación de nuevas tecnologías.

Los resultados muestran que la eficiencia técnica de Chile es cercana a la frontera, por lo cual las oportunidades de implementación de buenas prácticas observadas en otros países son escasas, mientras que el gap tecnológico es elevado, por lo cual el foco debiera estar dirigido hacia la innovación más que a la imitación. Estos resultados son similares para todas las economías especializadas en recursos naturales que fueron analizadas, y por tanto las mayores posibilidades provienen de la incorporación de tecnologías.

La apertura internacional, la inversión extranjera directa y la inversión en capital físico, han permitido reducir la brecha entre Chile y los líderes.

Los resultados del análisis de convergencia del PIB, y sus determinantes, muestran que el producto interno bruto (per cápita) de Chile ha logrado una gran convergencia con el de los países líderes. La misma tendencia muestra las variables educación y apertura, siendo Chile líder en la atracción de inversión extranjera directa, resultados que son fruto de las reformas políticas, económicas y sociales implementadas a partir de los años setenta, e intensificadas durante los noventa. Otros factores relacionados con el sistema de innovación, tales como la producción de artículos científicos, royalties e infraestructuras, también presentan convergencia con las economías desarrolladas, confirmando que Chile ha basado su desarrollo fundamentalmente en los activos tangibles, tecnologías foráneas y en la creación de las capacidades de absorción.

Los principales desafíos de Chile para llegar a ser

El análisis de los factores determinantes del gap en economías especializadas en recursos naturales muestra que la capacidad tecnológica, la desigualdad en el ingreso y la calidad institucional

una economía desarrollada son: incrementar las capacidades de innovación, reducir la brecha en el ingreso y mejorar las instituciones.

son los principales obstáculos para el cierre de la brecha del PIB entre Chile y los líderes.

En cuanto a la falta de capacidades tecnológicas, principal debilidad identificada, Chile la ha compensado a través de la importación de conocimientos y las tecnologías, los que han fluido fácilmente hacia este país. Sin embargo, nuevas barreras podrían aparecer y afectar el avance económico, sino entran en escena medidas complementarias tendientes a fortalecer los lazos tecnológicos internacionales y el desarrollo de capacidades locales. Asimismo, mientras más cercano esté el país de la frontera tecnológica, mayor será la necesidad de desarrollar sus propios conocimientos y tecnologías.

La contribución de esta Tesis, por tanto, se asienta en la comprensión del rol que tienen los intangibles en economías basadas en recursos naturales, y cómo éstas pueden hacer frente a los desafíos aprovechando las ventajas que ofrece un enfoque de desarrollo basado en la Economía del conocimiento, con el fin último de buscar las causas y posibles soluciones a los signos del letargo del crecimiento de Chile. A pesar de los relevantes hallazgos, el estudio presenta algunas limitaciones comunes a este tipo de trabajos. En primer lugar, la revisión de la literatura y la comparación de modelos de evaluación de intangibles tienen restricciones debido a la gran dispersión de la información existente sobre el Capital intelectual, mucha de la cual no se encuentra publicada en revistas, resúmenes de congresos, libros, u otro tipo de materiales habitualmente empelados en el ámbito académico. Por lo tanto, es probable que haya más información sobre esta materia, así como también, es posible que algunos modelos no estén incluidos. Sin embargo, la literatura revisada es la más citada y reconocida por los principales autores, y los modelos analizados corresponden a los más frecuentemente referenciados y utilizados por académicos y organizaciones internacionales. Otra limitación es la subjetividad asociada con algunas de las variables diseñadas para evaluar los modelos, pues los resultados podrían diferir parcialmente si se aplican otros criterios. Además, los reportes de los sistemas de evaluación no están disponibles para el mismo período o para el mismo número de países, por lo que no es posible llevar a cabo una comparación perfecta, a pesar de ello los resultados son similares y tienden a converger.

En cuanto al estudio de la relación entre los recursos naturales y el desarrollo, la principal debilidad surge como resultado del uso de varios indicadores para estudiar los factores tecnológicos e intangibles, siendo siempre difícil seleccionar los más adecuados para amplias muestras, que incluyan tanto países desarrollados como en aquellos en vías de desarrollo, lo cual es común investigaciones de este tipo. Lo anterior, también sucede con los indicadores de recursos naturales, debido a que tanto especialización como intensidad, podrían llevar a diferentes resultados, fundamentalmente cuando la muestra de países es muy diversa. A pesar de lo anterior,

todos los indicadores utilizados están plenamente justificados, y los resultados de los análisis son robustos y muestran la misma tendencia utilizando diferentes aproximaciones. Adicionalmente, la perspectiva macro adoptada en esta Tesis, junto con proveer algunas ventajas para la realización de los análisis econométricos, también hace más difícil abordar en detalle la discusión de los factores que afectan el crecimiento. Finalmente, el estudio se ha centrado fundamentalmente en la dimensión económica del desarrollo, mientras que los aspectos sociales o ambientales solo han sido discutidos parcialmente. Sin embargo, y de acuerdo con la literatura, no se pude negar el determinante efecto del crecimiento económico en el desarrollo de los países.

Los resultados obtenidos abren también nuevas líneas de investigación relacionadas con el crecimiento y desarrollo de los países, regiones y territorios, como así también en el ámbito sectorial, fundamentalmente minería y agricultura. En particular, futuros trabajos podrían analizar la importancia del conocimiento y la tecnología, tanto aquella de creación local como la que puede ser absorbida desde el extranjero, y los mecanismos necesarios para mejorar su impacto en el ingreso. Estos estudios ayudarían a dilucidar qué tipo de esfuerzos se requieren y de qué dimensión debieran ser, tanto para la construcción de capacidades de absorción como de creación tecnológica, además de las oportunidades aún existentes para converger vía imitación. Para ello, podrán ser empleados datos micro elaborados por organizaciones locales, modelo de trabajo aplicable también en el ámbito regional, intentando promover la ciencia, la tecnología y el conocimiento como motor de las industrias basadas en recursos naturales. Igualmente, otra propuesta sería analizar los spillovers que se generan en los clúster conformados por empresas con actividades relacionadas a los recursos primarios, y cómo éstos evolucionan afectando la economía local y nacional, con el fin de identificar las claves que permitan fortalecer las interconexiones y el desarrollo de ventajas competitivas.

Finalmente, a continuación se presentan las publicaciones resultantes del trabajo llevado a cabo:

Álvarez, I. & Labra, R. (2014). Technology gap and catching up in economies based on natural resources. The case of Chile, *Journal of Economics, Business and Management,* 3(6), 619-627.

Álvarez, I. & Labra, R. (2013). Identifying the role of natural resources in knowledge-based strategies of development. *ICEI WP, 05*(13).

Labra, R. & Sánchez, M. P. (2013). National intellectual capital assessment models: A literature review. *Journal of Intellectual Capital, 14*(4), 582-607.

Labra, R. & Sánchez, M.P. (2012). Analysis and comparison of national intellectual capital assessment models. *Knowledge, Innovation, and Sustainability: Integrating Macro & Micro Perspectives*. June 13-15, 2013. Matera, Italy.

6.2. Policy implications

The challenge of leading a country toward development and improving the quality of life for its citizens seems to have many alternatives; however, the possibilities of failure are also high, especially when the wrong strategies are chosen, there are not enough productive inputs, or antagonistic factors are present. Among the latter, throughout history natural resources have shown contrasting effects on the economy and society when certain key elements are not taken into account. Therefore, it is essential that policy makers design and implement appropriate policies taking into account the diverse evidence stemming from rigorous analysis in order to achieve positive impacts from NR, and to advance on a sustainable growth path. The Knowledge economy framework provides some valuable foundations for this purpose.

Based on the empirical results and international experiences, a series of policy recommendations to improve the economic performance of countries are proposed below. At the end of this section, a table (Table VI.1) with the most important recommendations is offered.

Managing of Intellectual Capital

Numerous studies have demonstrated that IC is essential for growth, both for countries with conventional economic policies and those more involved in the Knowledge economy. Consequently, and in general terms, it is crucial to incorporate strategies that promote the creation and accumulation of intangible assets, through the following actions:

- Developing advanced human capital (in frontier technologies) to support the competitiveness of NR sectors, diversify them, and close the technological gap..
- Transforming NR sectors from a condition of adapters and adopters of technology to creators, by stimulating invention and innovation processes, as a way to increase the structural capital..
- Promoting relationships and links within innovation system in order to transform production enclaves, which is characteristic of many NR-based industries, into dynamic clusters.
- **For the management of intellectual capital, appropriate assessment and monitoring tools are required**. In this regard, the proximity of the results reported by the analyzed models leads to the conclusion that the methodology

to be used should be selected on the basis of available information (indicators) and key elements of development strategy, because the intermediate outputs are not equal in all models. Likewise, it is recommended to use at least two models, one more related to the traditional view of IC (academic models) and another that provide a comparative assessment of competitiveness or innovation capability, for benchmarking purposes and to monitor policy performance related to these topics.

- **The results of IC evaluations should be widely informed and shared** at all levels to achieve the commitment and awareness of all citizens, creating a culture of innovation.

This list of recommendations is not one-dimensional, but on the contrary multiple interactions can be detected and may coexist between policies. Therefore, it is desirable that countries try to build long-term agendas focused on the improvement of IC.

Evidence indicates that successful economies are also those with the highest levels of intangible resources, such as Finland, Sweden and Denmark. These nations have implemented policies oriented to improving HC through education. In this sense, educational strategy includes ample opportunities for accessing university studies, and also for a lifelong upgrading and training process of continuing education. Complementarily, the State and private sectors invest around 3% or more of their GDP[35] in R&D, offering opportunities to this qualified HC to engage in innovation activities. Furthermore, cluster policies are also implemented to close the gap between science and private sectors in order to improve the efficiency and efficacy of investments in R&D, and to create an appropriate environment for innovation. Other interesting examples are South Korea and Japan, who have paid more attention to education quality[36] to increase HC, along with strong investments in R&D (over 3% of GDP and mainly private), incorporating PhD graduates not only into universities and research centers, but also into firms. In addition, companies participate in drafting innovation agendas, which also stimulates private R&D&I investment.

[35] OECD. StatExtracts. http://stats.oecd.org/

[36] According to the PISA report, this country has one of the highest educational levels. More information at http://www.oecd.org/pisa/

Growth in natural resources based economies

A key target for developing economies specialized in NR is to follow strategies and implement policies that foster high growth rates and avoid the middle-income trap and the NR curse, as the literature suggests. The recommended actions include the following:

- **To increase scientific activities in research centers, universities and companies, located close to resources endowments**, increasing absorptive and innovation capacities.
- ***To intensify*** **the creation of scientific facilities placed in NR exploitation areas** in order to develop new technologies and specialized human capital.
- **To refocus catching-up policies** by incorporating incentives to local innovation and technology creation. These measures could include providing advanced scientific and precompetitive facilities; **boosting the public procurement of innovative products and services related to NR sectors**; and promoting higher added value exports (e.g. through tax incentives).
- **To attract foreign human capital** with high technology competences oriented toward NR sectors.
- To foster knowledge and technology transference programs within NR industries and between sectors, to reduce enclave structures.
- **To promote international scientific collaborations in topics related to NR industries**, as well as in transversal areas such as ICT, remote sensing, environment and biotechnology. In addition, state should stimulate trade liberalization and technological openness in order to increase the knowledge sources.
- **To implement programs to attract FDI**, with knowledge and technology components, in **NR sectors.**
- To stimulate **foreign direct investment, with particular focus on those knowledge-based**. In this sense, policies could aim to promote the access of MNC in NR sectors that also perform innovation activities in host locations, by applying specific incentives for the generation of knowledge and spillover effects.
- Owing to the geographic concentration of natural resources, these **polices should be constructed at a regional level**, between actors directly involved, avoiding centralized planning. Growth and innovation strategies must have a

long-term perspective to avoid circumstantial decisions or requirements made by interest groups.

A remarkable example in this direction is the multi-annual program of the EU, which is defined for a period longer than political cycles, offering stability to work plans, investors, science sectors and other IS actors, in order to reduce uncertainty and increase stability.

- To strengthen quality of institutions, in particular corruption control, democracy and transparency, because currently these industries require social acceptance, stability and environmental concern. Specific attention should be paid to windfall management, which could be saved and used, in addition to traditional recommendations, to improve innovation capability by education (scholarships, university programs, etc.) or be invested in transversal and promissory technologies for NR industries.
- **To boost links between NR industries and those knowledge-based** in order to promote new business and add value to exports. Interesting examples in developed countries, such as Sweden and Australia, show that cluster policies reduce enclave formation and favor links.

This smart development process should build the knowledge drivers that will support new NR industries based on technology. In contrast to past policy recommendations, countries could progress without abandoning these traditional activities as long as they incorporate knowledge assets, create local capacities, and promote the international flows of capital and technology.

Economic revitalization of Chile

Evidence and results from the analysis carried out in this Thesis show what actions Chile should strengthen in order to return to the successful path of growth exhibited in recent decades, and overcome the decline in economic and competitiveness indicators.

Factors that have shown a positive behavior until now, such as policies of openness, macroeconomic stability, FDI, and capital investments, should follow the marked trajectory, whereas institutions ought to continue the strengthening process, mainly in regulatory capacity. In particular, openness driven by free trade and supplementary agreements must remain a central role into State policy.

Regarding attracting domestic and foreign investment, institutions must continue making efforts to maintain macroeconomic and social stability, an attractive business environment and the rule of law, all of which places Chile as one of the most attractive destinations for FDI in the region. In the social sphere, the country needs actions that lead to greater equity and the reduction of the economic gap between its citizens, which will enhance institutional, policy and economic stability.

According to the empirical results and international studies on Chile's innovation system, its institutional framework for innovation must have more powers to drive strategy and coordinate actors, and more attributions for the evaluation and control of public organizations (for innovation) and R&D&I programs.

The lack of skilled human resources in Chile is a major weakness in its development and one of its most urgent challenges. Additional efforts should be focused on strategic areas oriented to NR industries, concentrating resources in regions largely endowed with NR. Furthermore, education must be improved in terms of quality[37] and quantity, mainly university and technical levels, as a tool to strengthen the innovation system.

Another important weakness of the Chilean economy is the low technological capability. There is an agreement among scholars that the lack of innovation capability is a major obstacle to development, which is directly linked to insufficient human capital, poor scientific facilities in several areas, and reduced and/or inappropriate incentives. Moreover, the private sector seems to find a better way to overcome local weaknesses by acquiring technology abroad, affecting local capability creation and resulting in a vicious circle.

In order to reduce the gap in technological capability, in addition to the policies to improve HC, a robust policy to enhance R&D&I investment, both public and private, is fundamental. Current R&D investment, equivalent to 0.4% of GDP, is still far behind leading countries[38] specialized in NR.

Some proposals, based on successful innovation policies worldwide and the characteristics of the IS of Chile, are given below:

[37] According to the PISA evaluation Chile's performance is poor. For more details see: http://www.oecd.org/pisa/

[38] According to WDI, countries such as Australia and Canada invest in R&D around 2% of their GDP.

- **The creation of specialized research centers** oriented to technology process of production system in industries based on NR, and with an intensive international collaboration. Research agendas should be built jointly with the industry. These centers should be placed in NR production areas as a mechanism to bring together supply and demand for technology. Current research centers should be strengthened and integrated into this policy, in a coordinated manner.
- **To invest in pilot plants** to test local and foreign prototypes and adapt them to local requirements, in order to develop incremental innovations.
- **The creation of more Consortiums and Partnerships, and strengthening existing ones**, in specific thematic areas oriented to the main challenges of each NR subsector (Food, Mining and Forestry).

  From successful experiences, such as the 7th Framework Programme in the European context, Cluster programs in Australia or Board strategies in New Zealand, and some Chilean experiences, this associative structures must include producers, suppliers, universities, research centers, and technology brokers, and incorporate activities such as R&D, training and knowledge (and technology) management, in a long-term agenda.
- **To increase investment in supporting infrastructures** to facilitate innovation processes. Among they are: high-speed broadband, digitalization in rural zones, environmental monitoring, analytical laboratories, etc.
- Regarding scientific infrastructures, Chile needs more facilities to carry out sophisticated scientific projects and establish horizontal collaboration with leaders.
- **To draft a road-map for new scientific infrastructures** in accordance with the development strategy, endeavoring to concentrate facilities and HC in regions with NR endowments, thus defining a smart specialization. In addition, a system of regional incentives is needed to attract investment to the production zones, because the country has a high concentration of capabilities in the capital, very far from NR endowments.
- To promote a domestic market development for knowledge and technology, connected to an international level and including brokers and other intermediaries. This market will also improve knowledge transfer and feedback.

Taking into account that each subsector (food, mining and forestry) within the NR industry has its own peculiarities, some specific suggestions for improving innovation capabilities can be provided:

Subsector: Food

According to international evaluations, this subsector lacks HC in strategic fields such as genetics, automation and nanotechnologies. In addition, updated scientific and pre-competitive infrastructures are scarce. The following actions may be taken to remedy this situation:

- To establish a specific education program and scholarships in strategic thematic areas such as genetic, biotechnology and nanotechnology.
- **To strengthen existing research centers by updating their facilities**, increasing HC and redefining their research priorities.
- To establish a program for 'brain gain' in critical fields.
- **To explore and promote new related business**, such as organic compounds, genetics, food conservation and automation.

Subsector: Mining

Large companies manage the majority of this industry, mainly using foreign technology. Furthermore, Chilean mining is concentrated in copper extraction and primary processing. This metal is commercialized, basically, as a raw material. In this context some recommendations would be:

- To **promote a more active participation of large companies in existing research centers** in mining regions, **stimulating mining companies' investment in R&D** in collaboration with domestic firms.
- To encourage research in environmental issues, because mineral exploitation is a potential antagonist to the environment.
- To develop innovation activities in potential new products, in order to reduce the risk of substitutes and diversify.
- **To foster cluster relationships** in order to enhance the possibilities for spillovers and the development of new business.

Subsector: Forestry

This subsector is developing own technologies in fields such as genetics, forest and environmental management, pest control and processing, while others are imported (e.g. harvesting, transport, telecommunications and measuring technologies). Forestry activity has more advanced HC than other NR subsectors, and a strong international connection. The most important weaknesses are the low added value of its exports and the weak diversification of production. Taking into account these characteristics, the following recommendations could be applicable:

- To **re-orientate specialized human capital** to new challenges through education and training programs.
- To encourage R&D for the development of new products and business, taking advantage of new opportunities in fields such as environment services, biofuel and new materials.

To sum up, Chile faces the urgent task of stimulating the existing talent, implementing policies to increase an interconnected innovation process, and promoting the necessary incentives to undertake high-risk activities. In addition, it needs to undertake more investment projects in scientific facilities and in infrastructures, to support production activities, along with improving institutional quality. The Table below (Table VI.1) shows a summary of the main policy implications.

Table VI.1. Main policy recommendations

Focus	Recommendations
Intellectual Capital management	• Policy makers should use appropriate assessing and monitoring tools for IC management. • The results of IC evaluations must be widely informed and shared at all levels to achieve the commitment and awareness of all citizens, creating a culture of innovation.
Growth in natural resources based economies	• In contrast to past policy recommendations, countries can progress without abandoning these traditional economic activities as long as they incorporate knowledge assets, create local capacities, and promote the international flows of capital and technology. • Development policies should be constructed at a regional level, avoiding centralized planning. • To refocus catching-up policies by incorporating incentives to local innovation and technology creation. • To promote trade liberalization and technological openness in order to expand the knowledge sources and the scientific collaborations in topics related to NR industries. • To increase scientific activities in research centers, universities and companies located close to resources endowments. • To boost links between NR and knowledge-based industries in order to promote new business. • To stimulate foreign direct investment in NR sectors, with particular focus on those based on knowledge.
Economic revitalization of Chile	• To develop new specialized research centers oriented to technological processes for production systems in industries based on NR, and with an intensive international collaboration. • To create more Consortiums and Partnerships, and strengthen existing ones, in specific thematic areas oriented to the main challenges of each NR subsector: Food, Mining and Forestry. • To improve the educational system in terms of quality and access; to reduce social inequality and to strengthen institutions, mainly in their regulatory and control capacity.

Implicaciones para la elaboración de políticas

El desafío de conducir un país con el fin de crecer y mejorar la calidad de vida de sus ciudadanos parece tener muchas alternativas, sin embargo las posibilidades de fracasar son también elevadas, sobre todo cuando son aplicadas estrategias equivocadas, se carece de un adecuado stock de factores productivos, o existen recursos de compleja gestión o de antagónico efecto. Dentro de estos últimos, la literatura ha argumentado que los recursos naturales pueden llegar a causar impactos negativos sobre la economía y la sociedad, si elementos clave no son tomados en cuenta. Por ello, es fundamental el diseño y aplicación de políticas apropiadas, de forma tal de lograr efectos positivos y avanzar en la senda del desarrollo, y es la Economía del conocimiento la que nos ofrece un propicio marco para este propósito.

Sobre la base de los resultados obtenidos y las experiencias internacionales, se entrega a continuación una serie de recomendaciones para la elaboración de políticas, con el fin de mejorar el desempeño económico de los países. Al final de esta sección (Tabla VI.1) se ofrece un resumen de las recomendaciones más relevantes.

La gestión del Capital Intelectual

Diversos estudios han demostrado que este tipo de recursos son vitales para el crecimiento, tanto en aquellas naciones que siguen políticas económicas cercanas a los principios neoclásicos, como para aquellas más insertas en la Economía del conocimiento. Por lo anterior y con carácter general, se vuelve indispensable incorporar estrategias que promuevan el desarrollo de los activos intangibles de un país, a través de políticas conducentes a:

- Desarrollar capital humano altamente especializado en tecnologías avanzadas que ayuden al desarrollo de sectores basados en los recursos naturales, diversificarlos, y permitan cerrar la brecha tecnológica.
- Trasformar los sectores de recursos naturales desde una condición de adaptadores y adoptadores de tecnologías a otra de creadores, a través de estímulos a los procesos de invención y desarrollo tecnológico como vía para incrementar el capital estructural.
- Promover las articulaciones en el sistema de innovación para pasar de estructuras productiva del tipo enclave, típica de gran parte de las industrias basadas en los recursos naturales, a otras con mayor dinamismo.

- ***Para la gestión del capital intelectual se requieren herramientas que permitan cuantificarlo y hacer seguimiento***. En este sentido, la similitud de los resultados ofrecidos por los diversos modelos de evaluación analizados permite indicar que los responsables de políticas podrán seleccionar el modelo que les ofrezca una mayor facilidad en su utilización, se adapte de mejor forma a los datos disponibles, y se ajuste a la estrategia de desarrollo implementada. Asimismo, sería interesante conjugar el uso de al menos dos de estas herramientas de medición, una del tipo denominado "Modelos académicos", para tener una aproximación más cercana del CI y sus diferentes componentes para la definición de políticas más específicas, y otro de aquellos desarrollados por los organismos internacionales, con el fin de aplicar procesos de benchmarking y hacer seguimiento a la competitividad y a la capacidad de innovación de un país o región.
- ***Los resultados de las evaluaciones del CI debieran ser ampliamente difundidos*** y compartidos a todos los niveles, de manera de lograr el compromiso de la mayor parte de los ciudadanos, contribuyendo así a crear una cultura pro-innovación.

Esta lista de recomendaciones no es unidimensional, sino que por el contrario tiene múltiples niveles e interacciones. Por lo tanto, es deseable que los países construyan agendas de largo plazo centradas en incrementar su Capital intelectual.

Algunas evidencias indican que las economías exitosas son aquellas que tienen los mayores niveles de capital intelectual, y en particular de capital humano, como son los casos de Finlandia, Suecia y Dinamarca. Dichos países han puesto en práctica políticas destinadas a incrementar su capital humano a través de intensos programas de educación orientados a la innovación y la tecnología. En este sentido, la estrategia educacional comprende una amplia oferta y oportunidades para emprender estudios superiores, como así también procesos de formación continua a lo largo de la vida de las personas. Complementariamente, el Estado y el sector privado invierten en la I+D en torno al 3%, o más, de su PIB, lo que ofrece una gran abanico de posibilidades para que el capital humano calificado participe y lleve a cabo actividades de innovación. Aún más, las políticas que promueven los clúster industriales son otra herramienta para cerrar la brecha entre el sector de la ciencia y el productivo, con el fin de mejorar la eficiencia y la eficacia de las inversiones en I+D, además de crear un ambiente propicio para la innovación. Otros ejemplos interesantes son Corea del Sur y Japón,

quienes han prestado atención a la calidad de la educación como vía para mejorar su capital humano, junto con grandes inversiones en I+D (más del 3 % del PIB, fundamentalmente privada), y programas para la incorporación de los graduados de doctorados en las universidades, centros de investigación y en las empresas. Además, las firmas participan activamente en la elaboración de agendas de innovación, lo que a su vez estimula la inversión privada en I+D+i.

Crecimiento en economías basadas en los recursos naturales

Las economías especializadas en la explotación y comercialización de este tipo de recursos debieran velar por implementar estrategias que eviten la entrada en ciclos de ralentización económica conducentes a la denominada *Trampa del ingreso medio,* o que sorteen favorablemente los potenciales efectos negativos derivados de la denominada *Maldición de los recursos*. Entre las acciones recomendadas estarían:

- I**ncrementar las actividades científicas que se llevan a cabo en los centros de investigación y empresas localizadas en los entornos geográficos de explotación de los recursos naturales**, aumentando así las capacidades de absorción e innovación.
- **Intensificar la creación de instalaciones científicas localizadas cerca de las áreas altamente dotadas de recursos naturales** productivos, y destinadas a desarrollar tecnologías y capital humano avanzado para dichos sectores.
- **Reorientar las políticas de captura tecnológica, incorporando otras que incorporen estímulos a la innovación local**, a través de medidas específicas para este tipo de países como son **el impulso de la compra pública de productos y servicios innovadores relacionados con los sectores primarios**; incentivos fiscales orientados incrementar el valor agregado en las industrias primarias; y subsidios para el desarrollo de infraestructura científica y precompetitiva ad hoc a las condiciones y desafíos locales.
- **Atraer talento extranjero** con conocimientos fundamentalmente en tecnologías facilitadoras del desarrollo de negocios relacionados a los RN.
- Para reducir la condición de enclave productivo, el Estado debe promover programas de vinculación, transferencia y difusión tecnológica entre área áreas geográficas, empresas, y proveedores, como así también entre industrias las trasversales y aquellas basas en recursos naturales.

- P**romover la colaboración científica internacional en temas relacionados a los RN**, así como en áreas transversales (TIC, medioambiente, nanotecnología, biotecnología, etc.), estimulando además la apertura comercial y tecnológica, con el fin de ampliar las fuentes de conocimiento.
- Implementar programas de **atracción de empresas multinacionales del sector de RN que realicen actividades de I+D en el país huésped**. Para ello se puede fomentar la inversión en I+D de las EMN otorgando incentivos específicos para la entrada de conocimientos, creación local, y generación de efectos spillover, contribuyendo así a generar capacidades en el país.
- Debido a la concentración geográfica de los RN, **las políticas de desarrollo debieran ser construidas e implementadas a un nivel regional**, entre los agentes directamente involucrados, evitando una planificación centralizada y desconectada de la realidad local. Además, las políticas de crecimiento e innovación deben contemplar estrategias de largo plazo para evitar las decisiones de carácter coyuntural o que son el resultado de la presión generada por determinados grupos de interés.

  Un ejemplo notable en este sentido, es el programa plurianual de la UE, el cual se define para un período de tiempo más largo que el de los ciclos políticos, ofreciendo así una mayor estabilidad a los planes de trabajo, los inversores, al sector de la ciencia y tecnología, y al resto de los actores del sistema de innovación. La elaboración de estas estrategias de desarrollo debe ser participativa, de forma tal de lograr el compromiso de todas las partes interesadas.
- Fortalecer la calidad institucional, en particular la capacidad de regulación, el control de la corrupción, la democracia y la transparencia, debido a que estas industrias requieren en el actual contexto, alta aceptación social, estabilidad, y compromiso ambiental y social. Especial atención se debe prestar a la gestión de los beneficios extraordinarios provenientes del boom de los precios de los commodities, los cuales se podrían emplear, además de lo que indica la literatura, para mejorar la educación (becas, programas universitarios, etc.) e incorporar tecnologías transversales y promisorias para las industrias primarias.
- **Conectar las industrias basadas en RN con aquellas de base tecnológica**, estimulando la creación de nuevos negocios. Ejemplos interesantes en este sentido son las políticas de impulso a los clúster en Suecia y Australia.

Este proceso de desarrollo inteligente debe construir las bases del conocimiento que soportarán el crecimiento de estas industrias primarias en el largo plazo. A diferencia

de las recomendaciones de políticas en épocas pasadas, los países no necesitarán dejar a un lado los sectores tradicionales, siempre y cuando inviertan en activos intangibles, creen capacidades locales, y promuevan flujos internacionales de capital y conocimiento, bajo un apropiado marco institucional.

La revitalización económica de Chile

Los resultados obtenidos indican claramente en qué áreas Chile debiera poner especial atención con el fin de retomar la trayectoria de crecimiento, y superar así la caída en sus indicadores macroeconómicos y de competitividad. En este sentido, las variables relativas a tecnología e innovación son las claves en las cuales Chile no ha logrado dar avances sustantivos.

Los factores que han mostrado un comportamiento positivo hasta ahora, como son las políticas de apertura, la estabilidad macroeconómica, la inversión extranjera directa, y las inversiones de capital, deben seguir la trayectoria marcada, mientras que las instituciones deben reactivar su proceso de fortalecimiento, principalmente en lo que respecta a la capacidad regulatoria. En particular, la apertura resultante de los tratados de libre comercio y los acuerdos complementarios, debe continuar ejerciendo un rol central en la política del Estado.

En cuanto a la atracción de inversiones nacionales y extranjeras, el sistema institucional debe seguir haciendo esfuerzos para mantener la estabilidad macroeconómica y social, un entorno estimulante para las empresas, y el resguardo del estado de derecho, todo lo cual ha permitido convertir a este país en uno de los más atractivos de la región para la inversión extranjera. En el ámbito social, el país necesita medidas que conduzcan a una mayor equidad y a la reducción de la brecha económica entre sus ciudadanos, lo que contribuirá a una mayor estabilidad institucional, política y económica.

De acuerdo a los resultados empíricos obtenidos y a los análisis internacionales sobre la institucionalidad del sistema de innovación chileno, dicho marco institucional debiera tener más poder para conducir la estrategia de innovación, articular los actores, y evaluar los organismos públicos dedicados a la I+D+i y a los programas relacionados con la innovación y el desarrollo, pues es imperativo acelerar la actividad innovadora para reducir la gran brecha tecnológica que se observa en el país.

La falta de suficientes recursos humanos calificados en Chile, es una importante debilidad revelada en este estudio, y uno de los desafíos más urgentes. Parte importante de los esfuerzos en educación, debieran centrarse en las áreas estratégicas relacionadas a las industrias de RN, concentrándolos en aquellas regiones con más dotaciones de estos recursos. Además, la educación debe ser mejorada, tantos en términos de calidad[39], así como incrementando las oportunidades para acceder a ella, fundamentalmente a nivel universitario y técnico, como herramienta para dinamizar el sistema de innovación.

Otra de las debilidades de la economía chilena es la baja capacidad tecnológica. Existe un consenso en que la falta de capacidad de innovación, es uno de los principales obstáculos para su desarrollo, el que a su vez está interconectado con las inadecuadas instalaciones científicas en muchas áreas, los insuficientes incentivos a la innovación, y por cierto a la falta de capital humano. Por otra parte, el sector privado parece encontrar un camino para superar estas deficiencias en la adquisición de tecnología extranjera, lo cual afecta la creación de capacidades locales, resultando en un círculo vicioso.

Con el fin de reducir la brecha de la capacidad tecnológica, además de las políticas destinadas a mejorar el capital humano, es fundamental una fuerte y estable política para incrementar la inversión en I+D+i pública y privada. Actualmente, dicha inversión en Chile, equivalente al 0,4% de su PIB, está muy lejos de la que ostentan los países líderes especializados en RN[40].

Algunas sugerencias para el desarrollo de políticas, pueden ser:

- **Creación de centros de investigación especializados, orientados a los procesos tecnológicos de las industrias basadas en RN, y con una alta articulación internacional**. Los planes de investigación de estos centros debieran ser construidos en conjunto con la industria. La localización, por su parte, debiera ser en áreas altamente dotadas de RN estratégicos, como mecanismo para reunir la oferta y la demanda tecnológica. A su vez, los centros de investigación actuales se deben fortalecer e integrar en esta política, de una manera coordinada.

[39] De acurdo con la evaluación de la calidad PISA, Chile obtiene un mal resultado. Para más detalles, revisar: http://www.oecd.org/pisa/

[40] Según el WDI del BM, Australia y Canadá invierten en I+D alrededor del 2% de su PIB.

- **Invertir en la creación de plantas piloto** para testear prototipos, locales e internacionales, y adaptarlos a los requerimientos locales, de forma tal de generar innovaciones incrementales.
- **Creación de más consorcios de I+D+i y otros tipos de asociaciones, además de fortalecer los existentes**, orientándolos a la búsqueda de soluciones en área específicas relacionadas con los principales desafíos tecnológicos y productivos de cada subsector (alimentaria, minera, forestal).

  Tomando como base la experiencia del Séptimo Programa Marco de la Unión Europea, los programas de consorcios tecnológicos de Australia, las estrategias de los Consejos (Board) en Nueva Zelanda, y algunas experiencias ya implementadas en Chile, la conformación debiera ser, al menos, entre los productores, proveedores, universidades, centros de investigación, y brokers tecnológicos, e incluir actividades de I+D, formación y gestión del conocimiento, en una perspectiva de largo plazo.
- Para facilitar los procesos productivos innovadores, se requiere **incrementar la inversión en infraestructura de soporte** a las actividades productivas primarias que en la actualidad no son suficientes para satisfacer la demanda, tanto en términos de cantidad como de calidad del servicio requerido para procesos productivos más intensivos en conocimiento. Entre ellas están: banda ancha de alta velocidad, digitalización de zonas rurales, laboratorios analíticos, red de monitoreo ambiental, etc.
- En cuanto a la infraestructura científica, Chile necesita más instalaciones para llevar a cabo proyectos científicos más complejos, y a la vez incrementar la colaboración horizontal con los líderes internacionales a fin de acceder a instalaciones científicas de vanguardia.
- **Elaborar una hoja de ruta para la creación de nuevas infraestructuras científicas y tecnológicas**, de acuerdo a la estrategia de desarrollo definida, intentando concentrar las instalaciones y el capital humano en regiones altamente dotadas con RN, definiendo así una especialización inteligente. Además, es necesaria la implementación de un sistema de incentivos regionales para atraer inversiones a las zonas de producción primaria, ya que el país tiene una alta concentración de sus capacidades en el área metropolitana, lejos de los sitios de explotación de los RN.
- Promover el desarrollo de un mercado del conocimiento y la tecnología, conectado a nivel internacional e incluyendo la figura del “bróker” y otros

intermediarios. Este mercado mejoraría la transferencia de tecnologías y know how, así como la retroalimentación, dinamizando el sistema de innovación.

Tomando en cuenta que cada subsector (alimentario, minero y forestal) tiene sus particularidades, algunas sugerencias específicas destinadas a mejorar las capacidades de innovación son:

Subsector: Alimentos.

De acuerdo a los análisis internacionales, este subsector carece de suficiente capital humano en campos estratégicos, como son la genética y la nanotecnología. Además, la infraestructura científica es reducida y no del todo actualizada. Por ello, algunas acciones podrían ser:

- Establecer un **programa específico de formación** y becas en áreas temáticas estratégicas para este subsector, como son genética, biotecnología, sensores, nanotecnología.
- **Fortalecer los centros de I+D existentes por medio de la actualización de sus instalaciones**, incrementando su capital humano y redefiniendo sus prioridades de investigación.
- **Explorar y promover nuevos negocios relacionados a los alimentos**, como pueden ser los compuestos orgánicos, la genética, la conservación, y la automatización.
- Implementar un programa de atracción de capital humano extranjero en los campos críticos donde Chile carece de competencias.

Subsector: Minería

Las grandes empresas son las que manejan la mayor parte de la industria minera, haciendo uso principalmente de tecnologías extranjeras. Además, este subsector está concentrado geográficamente y en la extracción y procesamiento primario del cobre, metal que se comercializa básicamente como materia prima. Bajo este contexto, algunas recomendaciones serían:

- Promover una participación más activa de las grandes empresas en los centros de investigación existentes en las regiones mineras, **estimulando las inversiones en I+D de las empresas extranjeras en colaboración con las nacionales**.

- Fomentar la investigación en temas relacionados al medioambiente, pues la explotación mineral es un potencial antagonista de su entorno natural.
- Fortalecer el desarrollo de nuevos productos, con el fin de reducir los riesgos ante el surgimiento de sustitutos, agregar valor y diversificar.
- **Fomentar las relaciones y la configuración de conglomerados** (clúster) con el objetivo de incrementar los spillovers y el desarrollo de nuevos negocios.

Subsector: Forestal

Esta industria está desarrollando tecnologías propias en campos como la genética, la gestión forestal y ambiental, control de plagas, y el procesamiento, mientras que en otros, continúa con la estrategia de importación (por ejemplo para cosecha, comunicación, transporte, y tecnologías de medición). La actividad forestal en Chile tiene más capital humano avanzado que los otros subsectores, además de una fuerte conexión internacional. Por su parte, las debilidades más importantes son el bajo valor agregado de sus exportaciones y la escasa diversificación de sus productos. Teniendo en cuenta estas características, algunas de las políticas de innovación podrían estar orientadas a:

- La **reorientación del capital humano especializado** hacia los nuevos retos, mediante programas de formación y capacitación.
- El fomento de la I+D para el desarrollo de nuevos productos y **negocios forestales emergentes**. La idea sería aprovechar las nuevas oportunidades emergentes para desarrollar: servicios medioambientales, biocombustibles, nuevos materiales, y nuevos productos forestales.

En resumen, Chile tiene la urgente tarea de estimular el talento existente, la implementación de políticas para incrementar un proceso de innovación interconectado nacional e internacionalmente, y promover los incentivos necesarios para llevar a cabo actividades empresariales de alto riesgo. Además, es necesario llevar a cabo más proyectos de inversión en instalaciones científicas y en infraestructura de apoyo a las actividades de producción, junto con mejorar la calidad institucional y reducir la desigualdad social.

A continuación se entrega un resumen con las principales recomendaciones (Tabla VI.1).

Tabla VI.1. Principales recomendaciones para la elaboración de políticas.

Área de acción	Recomendaciones
Gestión del Capital Intelectual	• Emplear herramientas de evaluación del capital intelectual que permitan cuantificarlo, hacer seguimiento, y llevar a cabo análisis comparados con otras naciones. • Los resultados de las evaluaciones del capital intelectual deben ser ampliamente difundidos y compartidos a todos los niveles, de manera de lograr el compromiso de la mayor parte de los ciudadanos, contribuyendo así a crear una cultura pro-innovación.
Crecimiento en economías basadas en los recursos naturales	• A diferencia de tradicionales recomendaciones, estos países pueden basar su desarrollo en los recursos primarios siempre y cuando inviertan en ellos en activos intangibles, creen capacidades locales, y promuevan flujos internacionales de capital y conocimiento. • Las políticas de desarrollo deben ser construidas a nivel regional, evitando una planificación centralizada y desconectada de la realidad local. • Reorientar las políticas de captura tecnológica por otras que incorporen un estímulo a la innovación local. • Promover la apertura comercial y tecnológica del país, con el fin de ampliar las fuentes de conocimiento y las opciones de colaboración científica internacional en temas relacionados a los RN y en áreas transversales. • Incrementar las actividades científicas en centros de investigación y empresas localizadas en los entornos geográficos de explotación de los RN. • Conectar las industrias basadas en recursos naturales con aquellas de base tecnológica, estimulando la creación de nuevos negocios interconectados. • Implementar un programa de atracción de empresas multinacionales del sector de RN, que realicen actividades de I+D en el país huésped.
Revitalización económica de Chile	• Creación de centros de investigación especializados, orientados a los procesos tecnológicos de las industrias basadas en RN, y con una alta articulación internacional. • Creación de más consorcios de I+D+i y otros tipos de asociaciones, además de fortalecer y actualizar los existentes en cada subsector: alimentario, minero y forestal. • Corregir las deficiencias en el sistema educativo en cuanto a calidad y acceso; reducir la desigualdad en el ingreso y superar debilidades institucionales relacionadas fundamentalmente a la capacidad regulatoria y de control.

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ANNEXES

Annex 1. List of acronyms

AT	Austria
BE	Belgium
BM	Banco Mundial
BRICS	Brazil, Russia, India, China, and South Africa
CH	Capital humano
CI	Capital Intelectual
CNIC	Consejo Nacional para la Innovación y Competitividad de Chile
CODELCO	Corporación Chilena del Cobre (National Cooper Corporation of Chile)
CORMA	Corporación de la Madera
DE	Germany
DG	Danish Government
DK	Denmark
EMN	Empresas multinacionales
ES	Spain
EU	European Union
FDI	Foreign Direct Investment
FI	Finland
FP7	7th Framework Programme
FR	France
GCI	Global Competitiveness Index
GDP	Gross domestic product
GII	Global Innovation Index
GR	Greece
HC	Human capital
HDI	Human Development Index
H2020	HORIZON 2020
IC	Intellectual capital
IC-dVAL	Intellectual capital dynamic value
ICI	Intellectual Capital Index
ICM	Intellectual Capital Monitor
ICN	Intellectual Capital Navigator
ICN(W)	Intellectual Capital Navigator, Wealth Index
ICT	Information Communication Technology
IE	Ireland
IJKM	International Journal of Knowledge Management
IMD	International Institute for Management Development
INNCI	Innovation Competitive Index
INSEAD	Institut Européen d'Administration des Affaires
INTAN	Integral Analysis
ISI	Institute for Scientific Information
IT	Italy
IUS	Innovation Union Scoreboard
I+D	Investigación y Desarrollo
JCR	Journal Citation Reports
JIC	Journal Intellectual Capital
JKM	Journal of Knowledge Management
JMR&P	Knowledge Management Research and Practice
KAM	Knowledge Assessment Methodology
KAM(KEI)	Knowledge Assessment Methodology, Knowledge Economy Index
KE	Knowledge Economy
LO	Learning Organization
MIT	Middle Income Trap
MNC	Multi-National Company
NIC	National Innovation Council
NICI	National Intellectual Capital Index
NIS	National Innovation System
NL	Netherland
NR	Natural Resources
OCDE	Acronym in Spanish of Organization for Economic Co-operation and Development
OECD	Organization for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
OPEP	Acronym in Spanish of Organization of the Petroleum Exporting Countries
ProChile	Programa de fomento a las exportaciones chilenas
PT	Portugal
PyME	Pequeñas y Medianas Empresas
RIS	Regional Innovation System
R&D	Research & Development
RN	Recursos naturales
RwC	Renewal capital
SC	Structural capital
SE	Sweden
SI	Sistema de innovación
SIS	Sectoral Innovation System
SME	Small and Medium Size Enterprise
SMS	Structural Monitoring System
SNEI	State New Economy Index
S&T I	Science, Technology and Industry Outlook
TE	Technical Efficiency
TGE	Technological Gap Ratio
TIC	Tecnologías de la Información y Comunicación
TFP	Total Factor Productivity
UE	European Union
UK	United Kingdom
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
VAIC	Value-Added Intellectual Coefficient
WB	World Bank
WCI	World Competitiveness Index
WCI (EP)	World Competitiveness Index, Economic Performance Index
WDI	World Development Indicators
WEF	World Economic Forum
WOK	Web of Knowledge
WTO	World Trade Organization

Annex 2. List of countries of each group analyzed

ALL				OPEC	OECD	NR SPECIALIZED		SELECTED
Albania	El Salvador	Lebanon	Russia	Algeria	Australia	Algeria	Madagascar	Argentina
Algeria	Estonia	Lesotho	Rwanda	Angola	Austria	Angola	Malawi	Australia
Angola	Ethiopia	Liberia	Saudi Arabia	Ecuador	Belgium	Argentina	Mali	Canada
Argentina	Fiji	Lithuania	Senegal	Iran	Canada	Armenia	Mauritania	Chile
Armenia	Finland	Madagascar	Sierra Leone	Kuwait	Chile	Australia	Moldova	Colombia
Australia	France	Malawi	Singapore	Nigeria	Czech Republic	Azerbaijan	Mongolia	Kazakhstan
Austria	Gabon	Malaysia	Slovakia	Qatar	Denmark	Bahrain	Namibia	Mexico
Azerbaijan	Gambia	Mali	Slovenia	Saudi Arabia	Estonia	Benin	New Zealand	Peru
Bahrain	Georgia	Mauritania	South Africa	Venezuela	Finland	Bolivia	Nicaragua	Russia
Bangladesh	Germany	Mauritius	South Korea		France	Botswana	Niger	South Africa
Belgium	Ghana	Mexico	Spain		Germany	Burundi	Norway	
Benin	Greece	Moldova	Sri Lanka		Greece	Cameroon	Oman	
Bolivia	Guatemala	Mongolia	Sudan		Hungary	Chad	Paraguay	
Botswana	Guyana	Morocco	Swaziland		Iceland	Chile	Peru	
Brazil	Haiti	Mozambique	Sweden		Ireland	Colombia	Qatar	
Bulgaria	Honduras	Namibia	Switzerland		Israel	Coted'Ivoire	Russia	
Burkina Faso	Hungary	Nepal	Tajikistan		Italy	Ecuador	Rwanda	
Burundi	Iceland	Netherlands	Tanzania		Japan	Egypt	Saudi Arabia	
Cambodia	India	New Zealand	Thailand		Mexico	Ethiopia	Senegal	
Cameroon	Indonesia	Nicaragua	Trinidad and Togo		Netherlands	Fiji	Sierra Leone	
Canada	Iran	Niger	Tobago		New Zealand	Gabon	South Africa	
Chad	Ireland	Nigeria	Tunisia		Norway	Gambia	Sudan	
Chile	Israel	Norway	Turkey		Poland	Georgia	Tanzania	
China	Italy	Oman	Uganda		Portugal	Ghana	Togo	
Colombia	Jamaica	Pakistan	Ukraine		Slovakia	Guatemala	Trinidad and Tobago	
Costa Rica	Japan	Panama	United Kingdom		Slovenia	Guyana	Uganda	
Cote d'Ivoire	Jordan	Paraguay	United States		South Korea	Iceland	Uruguay	
Croatia	Kazakhstan	Peru	Uruguay		Spain	Iran	Uzbekistan	
Czech Republic	Kenya	Philippines	Uzbekistan		Sweden	Jamaica	Venezuela	
Denmark	Kuwait	Poland	Venezuela		Switzerland	Kazakhstan	Yemen	
Dominican Republic	Kyrgyzstan	Portugal	Vietnam		Turkey	Kenya	Zambia	
Ecuador	Lao PDR	Qatar	Yemen		United Kingdom	Kuwait	Zimbawe	
Egypt	Latvia	Romania	Zambia		United States	Kyrgyzstan		
			Zimbabwe			LaoPDR		

Annex 3. Models, indexes, and countries used for the correlation analysis

Models	Indexes	Countries
ICN	Wealth (W)	SE DK FI DE UK BE AT NL IE FR PT ES IT GR
	IC	
ICI	ICI	
VAIC	VAIC	
	IC Efficiency (E)	
ICM	Assets (A)	
	Investment (I)	
	Effects (E)	
IC-dVAL	IC-dVAL	
INTAN	INTAN	
KAM	Knowledge Economy (KEI)	
	Knowledge (KI)	
GII	GII	
GCI	GCI	
WCI	Economic Performance (EP)	
	Business Efficiency (BE)	
HDI	HDI	
IUS	IUS	
INNCI	Innovation Competitive Index	

Annex 4**.** Variables of the evaluation system

VARIABLE	CONTENT	EVALUATION SCALE
INTANGIBLE INDICATORS	Included: Ratio: Indicators of intangibles versus indicators of tangibles Aggregation methodology	1: Only intangible assets are evaluated 0.8: Mainly indicators of intangibles. Tangible assets are measured separately from intangibles 0.6: Mainly indicators of intangibles are included. Tangible and intangible assets are measured somewhat separately 0.4 Mainly indicators of intangibles are included. Tangibles and intangibles are integrated 0.2: Mainly indicators of tangibles. Completely integrated with intangibles in the evaluation. 0: Only tangibles are evaluated
OBJECTIVE	Main and specific objectives	1: Determine IC composite index 0.66: Determine total wealth using IC composite index as an intermediate objective 0.33: Determine competitiveness, development, innovative capacity, or other related concepts. IC is a component of the main objective 0: Determine competitiveness, development, innovative capacity, or other related concepts Intangibles are only considered as indicators
COMPONENTS OF IC	IC components included	1: HC, SC or RC are included explicitly 0.66: HC, SC, or RC are included implicitly 0.33: Intangible's indicators of the three components are used without determining IC, HC, RC nor SC 0: Only indicators of intangibles of one of the three IC components (HC, SC, RC) are included
INTANGIBLE/TANGIBLE MEASUREMENT	Measurement methodology	1: Tangible and intangible assets are assessed separately 0.5: Tangible and intangible assets are assessed somewhat separately. 0: Tangible and intangible assets are assessed together
APPLICABILITY	Applicability of the models to country and firm levels	1: Model can be applied to country level and firm level with some adaptations 0: Model can only be applied to the country level

Annex 5. System of evaluation for model comparison. Qualitative variables

VARIABLE	CONTENT	RANGE	EVALUATION
WEALTH	Does the model seek to evaluate country wealth?	0-2	0: not evaluated. 1: indirectly evaluated. 2: is the main objective.
INTELLECTUAL CAPITAL	Does the model evaluate the IC of the country?	0-2	0: not evaluated. 1: indirectly evaluated. 2: directly evaluated and reported.
COMPETITIVENESS	Does the model evaluate the competitiveness of the country?	0-2	0: not evaluated. 1: indirectly evaluated. 2: directly evaluated and reported.
DEVELOPMENT	Does the model evaluate the development of the country?	0-2	0: not evaluated. 1: indirectly evaluated. 2: directly evaluated and reported.
KNOWLEDGE ECONOMY	Has the model been structured on the principles and conceptual framework of knowledge economy?	0-1	0: conceptual framework (KE) is not the main basis of the model. 1: conceptual framework (KE) is the main basis of the model.
ECONOMY	Has the model been structured on micro/macroeconomic principles?	0-1	0: micro/macroeconomic conceptual framework is not the main basis of the model. 1: micro/macroeconomic conceptual framework is the main basis of the model.
SOCIAL	Does the model contemplate additional social elements?	0-2	0: not included. 1: included but is not the main element[1] 2: model strongly oriented.to social issues
HUMAN CAPITAL	Does the model evaluate and determine human capital?	0-2	0: HC is not included. 1: HC is included through indicators but not as component. 2= HC is included as component.
STRUCTURAL CAPITAL	Does the model evaluate and determine structural capital?	**0-2**	0: SC is not included. 1: SC is included through indicators but not as component. 2= SC is included as component.
RELATIONAL CAPITAL	Does the model evaluate and determine Relational capital?	**0-2**	0: RC is not included. 1: RC is included through indicators but not as component. 2= RC is included as component.
QUALITATIVE VARIABLES	Does the model use qualitative variables and indicators?	0-1	0: not used. 1: used.
COMPOSITE INDEX	Does the model report a composite index or indexes?	0-2	0: no composite index. 1: more than the final composite index. 2: only one final composite index.
SURVEY	Does the model apply surveys to collect data?	**0-1**	0: surveys not applied. 1: surveys applied.
IC INDEX	Does the model report an IC composite index or indexes?	**0-2**	0: no composite index. 1: more than one final composite index. 2: only one final composite index.

Note. 1: Education and income are not considered as elements of a social nature in this classification because they are included in other categories. This refers to, for example, life expectancy, social cohesion, gender inequality, and equal opportunity.

Annex 6. Convergence coefficients (β) between Chile and leaders

Annex 6.1. Convergence coefficients (β) between Chile and Australia

	AUS/CHL			
	β	**initial**	**final**	**DS**
GDP (per capita)	-0.035***	1.90	1.32	0.27
Investment	0.010**	0.18	0.01	0.12
Patent	0.919	44.0	76.9	17.7
Schooling	-0.014***	0.45	0.16	0.09
Openness	-0.006**	-0.48	-0.50	0.08
FDIIS	0.000	-27.69	-28.68	0.10
Institution	-0.002	0.12	0.14	0.03
Scientific articles	-0.209***	11.63	8.87	1.40
Royalties	-0.105***	0.97	0.76	1.01
GINI	-0.019***	-0.22	-0.51	0.13
R&D	-0.008	2.02	1.83	0.55
Infrastructure	-0.075***	1.93	0.53	0.45

Source: Author's elaboration

Annex 6.2. Convergence coefficients (β) between Chile and Canada

	CAN/CHL			
	β	**inicial**	**final**	**DS**
GDP (per capita)	-0.053***	2.23	1.08	0.37
Investment	-0.000	0.06	-0.21	0.10
Patent	-2.372	120.4	130.7	49.5
Schooling	-0.008***	0.27	0.11	0.05
Openness	-0.008	-0.14	-0.23	0.25
FDIIS	0.004*	-0.62	-0.50	0.06
Institution	-0.006***	0.15	0.14	0.04
Scientific articles	-0.360***	13.30	8.12	2.31
Royalties	-0.161***	1.89	0.88	1.49
GINI	0.002**	-0.51	-0.44	0.03
R&D	0.037***	1.94	2.02	0.38
Infrastructure	-0.053***	1.63	0.67	0.34

Source: Author's elaboration

Annex 6.3. Convergence coefficients (β) between Chile and USA

	USA/CHL			
	β	**inicial**	**final**	**DS**
GDP (per capita)	-0.080***	2.87	1.21	0.51
Investment	-0.000	-0.07	-0.34	0.11
Patent	-9.645	338.6	328.5	151.6
Schooling	-0.013***	0.49	0.25	0.09
Openness	-0.002	-0.69	-0.69	0.04
FDIIS	0.008**	-0.81	-0.69	0.10
Institution	-0.011***	0.09	0.04	0.05
Scientific articles	-0.346***	12.19	7.06	2.16
Royalties	-0.008	-0.67	-0.39	0.25
GINI	0.003	-0.32	-0.28	0.06
R&D	-0.017	4.32	3.54	0.55
Infrastructure	-0.083***	3.40	1.72	0.52

Source: Author's elaboration

Annex 7. Correlation between the Chile's gap, using different countries as leaders

Annex 7.1. Spearman's rank correlation between the Chile's gap, using different countries as leaders

	chlau~dp	chlca~dp	usach~dp	chlaus~v	chlcan~v	usachl~v	chlau~at	chlca~at	usach~at	chlaus~h	chlcan~h	usachl~h	chlausop	chlcanop	usachlop	chlau~di	chlca~di	usach~di	chlau~st	chlca~st
chlausgdp	1																			
chlcangdp	0.88***	1																		
	0																			
usachlgdp	0.82***	0.96***	1																	
	0	0																		
chlausinv	-0.03	-0.14	-0.20	1																
	0.88	0.55	0.39																	
chlcaninv	0.23	0.27	0.26	0.72***	1															
	0.33	0.24	0.28	0.00																
usachlinv	0.16	0.34	0.33	0.53**	0.67***	1														
	0.51	0.15	0.16	0.02	0.00															
chlauspat	-0.23	-0.42	-0.45	0.04	-0.09	-0.23	1													
	0.36	0.09	0.06	0.87	0.72	0.36														
chlcanpat	0.03	0.02	0.01	-0.21	-0.20	-0.07	0.82***	1												
	0.91	0.93	0.98	0.41	0.42	0.79	0													
usachlpat	0.34	0.36	0.36	-0.09	0.09	0.00	0.73***	0.97***	1											
	0.15	0.12	0.12	0.70	0.71	1.00	0.00	0.00												
chlaussch	0.72	0.83	0.88	-0.32	0.04	0.06	-0.35	0.09	0.43	1										
	0.00	0.00	0.00	0.16	0.86	0.82	0.15	0.72	0.06											
chlcansch	0.62	0.79	0.82	-0.46	-0.06	0.01	-0.16	0.30	0.54	0.92***	1									
	0.00	0.00	0.00	0.04	0.82	0.97	0.53	0.22	0.02	0										
usachlsch	0.74	0.87	0.89	-0.28	0.10	0.18	-0.41	0.06	0.35	0.94***	0.88***	1								
	0.00	0.00	0.00	0.22	0.67	0.44	0.10	0.80	0.14	0	0									
chlausop	0.20	0.39	0.46	-0.66	-0.47	0.07	-0.47	-0.08	-0.05	0.49	0.50	0.56	1							
	0.41	0.09	0.04	0.00	0.03	0.76	0.05	0.76	0.85	0.03	0.02	0.01								
chlcanop	-0.13	0.11	0.19	-0.45	-0.35	0.30	-0.30	0.11	-0.03	0.25	0.28	0.33	0.85***	1						
	0.57	0.63	0.42	0.04	0.13	0.20	0.23	0.66	0.89	0.30	0.23	0.15	0							
usachlop	-0.17	0.09	0.18	-0.62	-0.43	0.07	-0.29	0.14	-0.08	0.29	0.36	0.36	0.83***	0.91***	1					
	0.46	0.71	0.46	0.00	0.06	0.77	0.24	0.58	0.74	0.21	0.11	0.11	0	0						
chlausfdi	-0.37	-0.32	-0.30	-0.40	-0.66	-0.57	-0.04	-0.05	-0.19	-0.03	0.00	-0.24	0.17	0.09	0.27	1				
	0.11	0.16	0.20	0.08	0.00	0.01	0.89	0.84	0.42	0.90	1.00	0.32	0.47	0.71	0.25					
chlcanfdi	-0.65	-0.65	-0.63	-0.34	-0.70	-0.62	0.13	-0.04	-0.31	-0.35	-0.27	-0.45	0.05	0.09	0.26	0.83***	1			
	0.00	0.00	0.00	0.14	0.00	0.00	0.60	0.86	0.19	0.13	0.26	0.04	0.85	0.72	0.27	0				
usachlfdi	-0.77	-0.63	-0.52	-0.18	-0.27	0.01	-0.04	-0.07	-0.37	-0.48	-0.42	-0.37	0.25	0.55	0.53	0.12	0.45**	1		
	0.00	0.00	0.02	0.44	0.25	0.97	0.88	0.77	0.11	0.03	0.07	0.11	0.29	0.01	0.02	0.62	0.05			
chlausinst	0.01	0.12	0.25	-0.32	-0.06	0.00	-0.51	-0.46	-0.43	0.52	0.29	0.56	0.48	0.50	0.47	-0.15	0.08	0.74	1	
	0.99	0.71	0.40	0.28	0.84	1.00	0.08	0.11	0.14	0.07	0.33	0.05	0.09	0.08	0.11	0.63	0.79	0.00		
chlcaninst	0.22	0.38	0.49	-0.60	-0.29	0.00	-0.29	-0.08	-0.05	0.66	0.60	0.76	0.77	0.70	0.66	-0.20	-0.05	0.74	0.83***	1
	0.47	0.20	0.09	0.03	0.34	1.00	0.34	0.79	0.87	0.01	0.03	0.00	0.00	0.01	0.01	0.52	0.86	0.00	0.00	
usachlinst	0.42	0.60	0.69	-0.59	-0.32	0.18	-0.29	0.08	0.09	0.80	0.75	0.90	0.89	0.84	0.75	-0.30	-0.24	0.63	0.70***	0.95***
	0.15	0.03	0.01	0.03	0.29	0.57	0.34	0.80	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.44	0.02	0.01	0

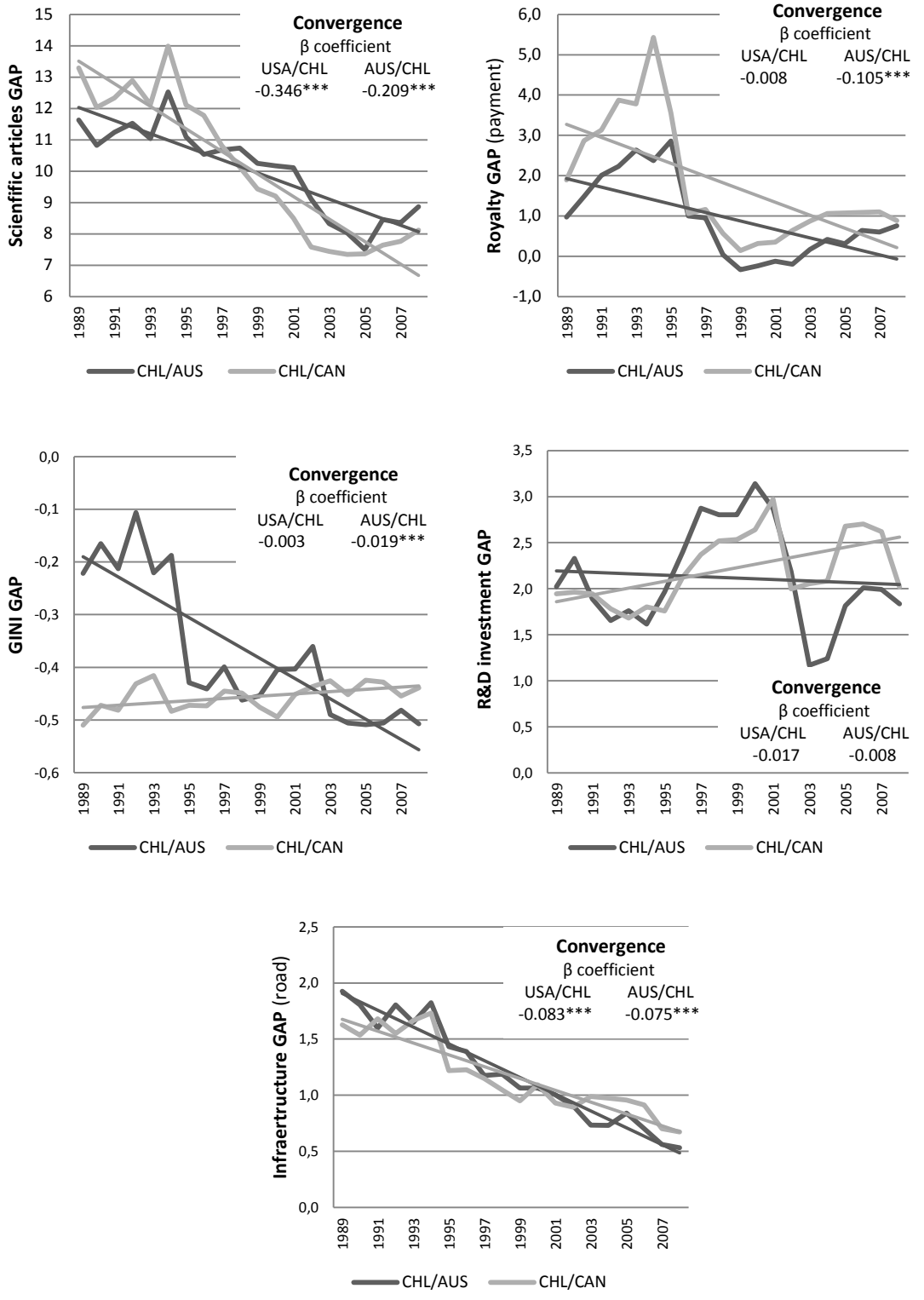
Source: Author's elaboration

Annex 7.2. Pairwise correlation between the Chile's gap, using different countries as leader

	chlau~dp	chlca~dp	usach~dp	chlaus~v	chlcan~v	usachl~v	chlau~at	chlca~at	usach~at	chlaus~h	chlcan~h	usachl~h	chlausop	chlcanop	usachlop	chlau~fi	chlca~fi	usach~di	chlau~st	chlca~st
chlausgdp	1																			
chlcangdp	0.97***	1																		
	0																			
usachlgdp	0.89***	0.95***	1																	
	0	0																		
chlausinv	-0.05	-0.07	-0.22	1																
	0.85	0.77	0.34																	
chlcaninv	0.37	0.41	0.25	0.80***	1															
	0.11	0.07	0.28	0																
usachlinv	0.11	0.19	0.28	0.49**	0.62***	1														
	0.63	0.42	0.23	0.03	0.00															
chlauspat	-0.23	-0.34	-0.37	0.00	-0.19	-0.31	1													
	0.36	0.17	0.13	0.99	0.46	0.22														
chlcanpat	0.08	0.07	0.15	-0.36	-0.39	-0.14	0.79***	1												
	0.77	0.79	0.56	0.14	0.11	0.58	0.0001													
usachlpat	0.60	0.63	0.57	-0.16	0.14	-0.06	0.74***	0.99***	1											
	0.01	0.00	0.01	0.51	0.57	0.80	0.00	0.00												
chlaussch	0.74	0.79	0.90	-0.35	0.03	0.14	-0.29	0.24	0.48	1										
	0.00	0.00	0.00	0.13	0.90	0.57	0.24	0.35	0.03											
chlcansch	0.65	0.73	0.86	-0.47	-0.04	0.13	-0.15	0.40	0.51	0.95***	1									
	0.00	0.00	0.00	0.04	0.86	0.60	0.54	0.10	0.02	0										
usachlsch	0.71	0.76	0.88	-0.42	-0.01	0.23	-0.38	0.19	0.39	0.91***	0.92***	1								
	0.00	0.00	0.00	0.06	0.98	0.33	0.12	0.45	0.09	0.00	0.00									
chlausop	0.07	0.11	0.38	-0.64	-0.51	0.20	-0.38	0.15	-0.11	0.51	0.56	0.66	1							
	0.75	0.64	0.10	0.00	0.02	0.40	0.12	0.56	0.66	0.02	0.01	0.00								
chlcanop	-0.16	-0.12	0.17	-0.45	-0.44	0.38	-0.28	0.21	-0.15	0.31	0.37	0.46	0.91***	1						
	0.51	0.63	0.48	0.05	0.05	0.10	0.27	0.41	0.52	0.18	0.11	0.04	0							
usachlop	-0.21	-0.15	0.13	-0.63	-0.56	0.16	-0.30	0.19	-0.18	0.35	0.43	0.46	0.90***	0.92***	1					
	0.37	0.53	0.58	0.00	0.01	0.51	0.22	0.45	0.46	0.13	0.06	0.04	0.00	0.00						
chlausfdi	-0.47	-0.42	-0.30	-0.38	-0.61	-0.48	-0.03	0.04	-0.25	-0.04	-0.01	-0.20	0.16	0.11	0.30	1				
	0.04	0.07	0.20	0.10	0.00	0.03	0.90	0.88	0.28	0.86	0.95	0.39	0.49	0.65	0.20					
chlcanfdi	-0.78	-0.75	-0.66	-0.35	-0.69	-0.50	0.13	0.07	-0.43	-0.44	-0.34	-0.44	0.09	0.16	0.32	0.81***	1			
	0.00	0.00	0.00	0.13	0.00	0.03	0.61	0.78	0.06	0.05	0.14	0.05	0.69	0.51	0.17	0				
usachlfdi	-0.76	-0.72	-0.55	-0.14	-0.34	0.18	-0.07	-0.01	-0.47	-0.42	-0.34	-0.26	0.32	0.57	0.58	**0.17**	0.50**	1		
	0.00	0.00	0.01	0.55	0.15	0.45	0.78	0.95	0.04	0.06	0.15	0.27	0.17	0.01	0.01	0.47	0.03			
chlausinst	0.10	0.08	0.18	-0.37	-0.17	0.05	-0.50	-0.27	-0.24	0.34	0.23	0.44	0.39	0.39	0.59	-0.11	-0.06	0.71	1	
	0.75	0.79	0.55	0.21	0.59	0.86	0.08	0.38	0.43	0.26	0.45	0.13	0.18	0.18	0.04	0.73	0.85	0.01		
chlcaninst	0.25	0.29	0.48	-0.54	-0.36	0.14	-0.39	-0.02	0.02	0.59	0.50	0.72	0.72	0.70	0.79	-0.18	-0.16	0.77	0.85***	1
	0.42	0.33	0.09	0.06	0.23	0.65	0.18	0.95	0.95	0.03	0.08	0.01	0.01	0.01	0.00	0.57	0.61	0.00	0.0002	
usachlinst	0.39	0.52	0.69	-0.61	-0.36	0.30	-0.37	0.12	0.15	0.75	0.70	0.88	0.89	0.87	0.91	-0.28	-0.26	0.74	0.75***	0.95***
	0.18	0.07	0.01	0.03	0.23	0.32	0.22	0.70	0.62	0.00	0.01	0.00	0.00	0.00	0.00	0.35	0.39	0.00	0.00	0

Source: Author's elaboration

Annex 8. Evolution of gap between Chile and Australia and Canada.
Variables: royalty (payment), R&D investment, GINI index, and infrastructure



Source: Author's elaboration

Annex 9. Convergence (β) between Chile and Australia and Canada.
Period: 1989-1999; 2000-2008; 1989-2008

	β (CHL/AUS)			β (CHL/CAN)		
	1989-1999	2000-2008	1989-2008	1989-1999	2000-2008	1989-2008
GDP	-0.072***	-0.033	-0.035***	-0.106***	-0.067***	-0.053***
Investment	-0.009	0.009	0.010**	-0.020*	-0.007	-0.000
Patent	0.019	2.628	0.919	2.974	-3.305	-2.372
Schooling	-0.010***	-0.017***	-0.014***	-0.006***	-0.012***	-0.008***
Openness	0.014***	-0.025***	-0.006**	0.070***	-0.083***	-0.008
FDIIS	0.008	0.014	0	0.011*	0.009**	0.004*
Institutions	0.016***	0.001	-0.002	0.017	-0.002	-0.006***
Scientific articles	-0.099*	-0.210***	-0.209***	-0.307***	-0.109	-0.360***
Royalties	-0.161*	-0.133***	-0.105***	-0.271*	0.094***	-0.161***
GINI	-0.034***	-0.016***	-0.019***	0.002	0.004	0.002**
R&D	0.095***	-0.0126*	-0.008	0.066***	-0.025	0.037***
Infrastructure	-0.083***	-0.063***	-0.075***	-0.073***	-0.039***	-0.053***

Source: Author's elaboration

Annex 10. Country profile of SELECTED

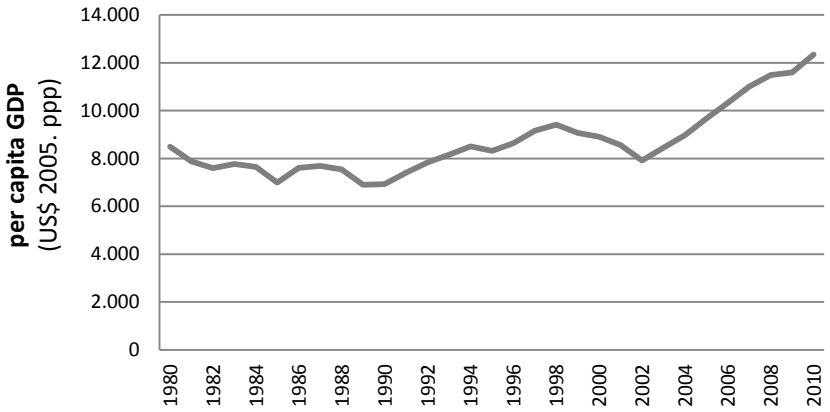
Table A. Overall information of country. Argentina

Country	Argentina
Capital	Buenos Aires
Population (2012)	41,086,927
Population 15-64 years (2012) (%)	64.8
Surface area (sq. km)	2,780,400
Agricultural land (% of land area)	53.9
Institution index (2008)	2.20

Source: World Bank

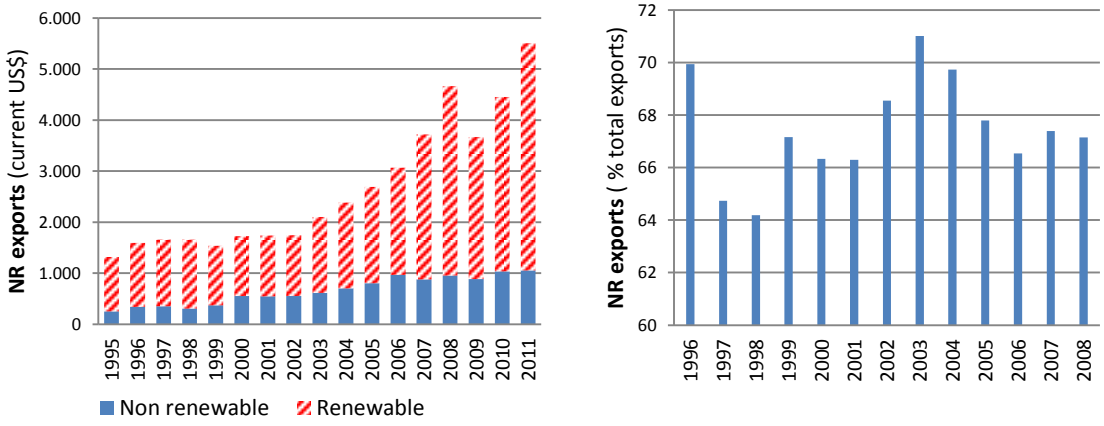
Economic facts

Graph A. Per capita GDP. Argentina



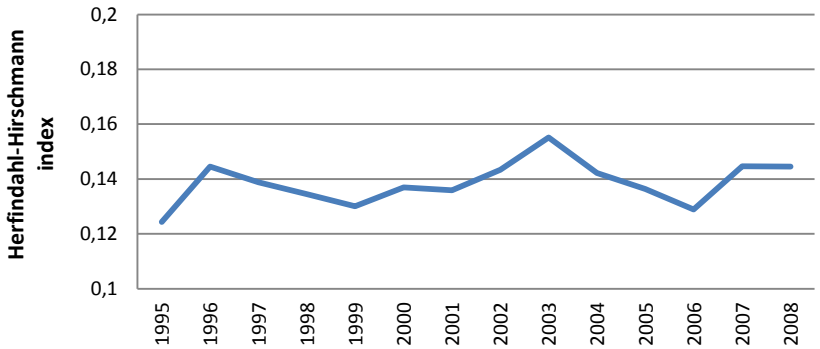
Source: Author's elaboration from WDI database

Graph B. NR exports. Argentina



Source: Author's elaboration from UNCTAD database

Graph C. Herfindahl-Hirschmann index. Argentina



Source: Author's elaboration from UNCTAD database

Technology and innovation facts

Table B. Selected indicators of technology and innovation. Argentina

Year	R&D expenditure (% of GDP)	Patents (per mill inhab., res.)	School enrollment, tertiary (% gross)	Researchers in R&D (per million people)
1996	0.42	31.1		
1997	0.42	23.1		695.0
1998	0.41	23.8	46.0	703.9
1999	0.45	24.6	47.9	712.2
2000	0.44	28.8	53.1	715.9
2001	0.42	18.5	58.3	688.3
2002	0.39	19.1	62.2	693.2
2003	0.41	20.9	64.9	720.7
2004	0.44	20.5	65.4	769.3
2005	0.46	27.3	64.0	824.6
2006	0.49	26.2	67.1	898.7
2007	0.51	23.8	66.7	983.5
2008	0.52	20.2	68.7	1046.5
2009	0.60		71.3	1092.3
2010	0.62		74.8	1178.5

Source: Author's elaboration from WDI database

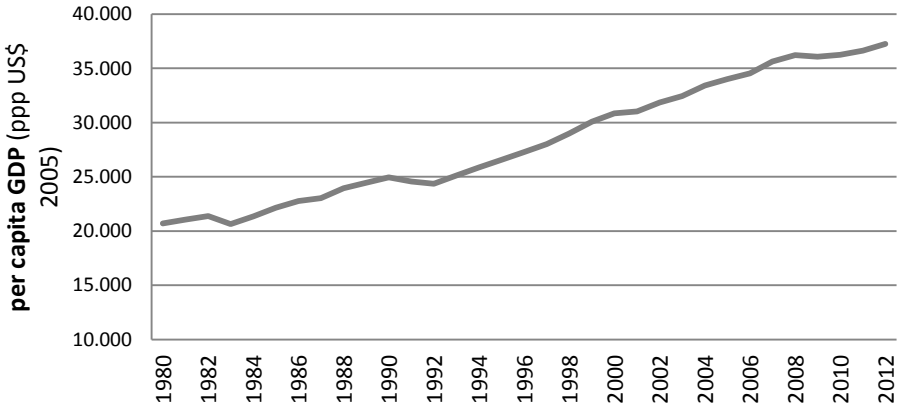
Table C. Overall information of country. Australia

Country	Australia
Capital	Canberra
Population (2012)	22,722,000
Population 15-64 years (2012) (%)	67.1
Surface area (sq. km)	7,741,220
Agricultural land (% of land area)	53.3
Institution index (2008)	4.13

Data source: WDI database

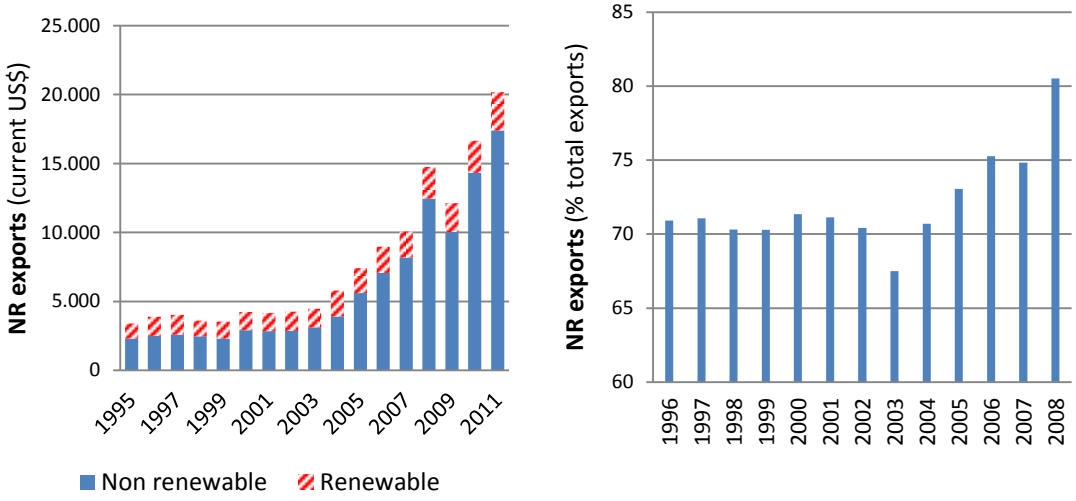
Economic facts

Graph D. Per capita GDP. Australia



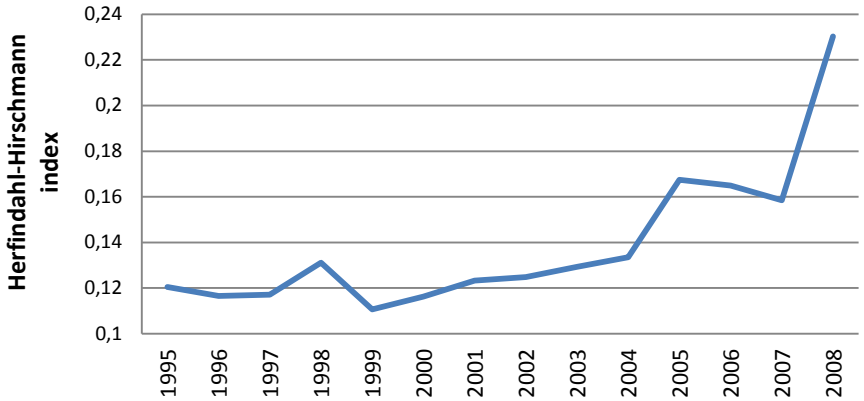
Source: Author's elaboration from WDI database

Graph E. NR exports. Australia



Source: Author's elaboration from UNCTAD database

Graph F. Herfindahl-Hirschmann index. Australia



Source: Author's elaboration from UNCTAD database

Technology and innovation facts

Table D. Selected indicators of technology and innovation. Australia

Year	R&D expenditure (% of GDP)	Patents (per mill inhab., res.)	School enrollment, tertiary (% gross)	Researchers in R&D (per million people)
1996	1.66	98.1	75.0	3328.5
1997		95.0	79.7	
1998	1.51	99.5	67.3	3344.8
1999		98.2	65.6	
2000	1.57	100.7	65.0	3427.0
2001		112.7	65.2	
2002	1.75	120.3	74.0	3711.6
2003		121.5	72.0	
2004	1.86	127.1	70.5	4015.7
2005		125.3	71.2	
2006	2.19	137.1	70.5	4179.2
2007		130.5	71.5	
2008	2.41	132.8	71.8	4280.4
2009		115.0	75.6	
2010	2.38	109.3	79.8	

Source: Author's elaboration from WDI database

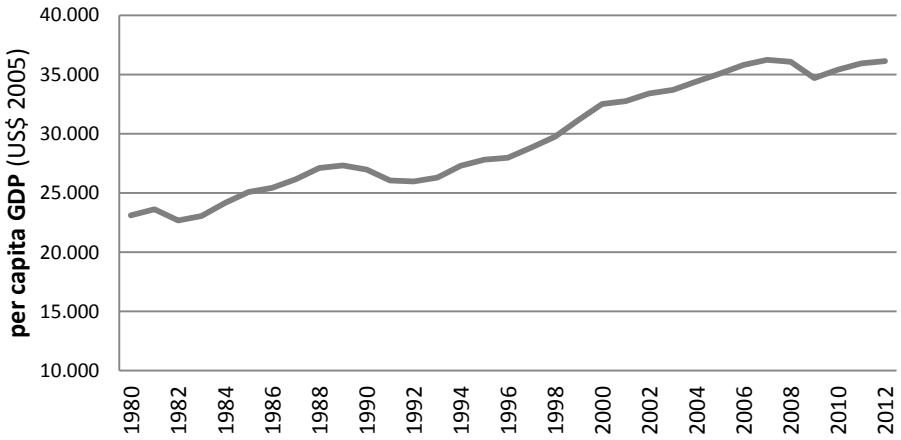
Table E. Overall information of country. Canada

Country	Canada
Capital	Ottawa
Population (2012)	34,754,312
Population 15-64 years (2012) (%)	68.8
Surface area (sq. km)	9,984,670
Agricultural land (% of land area)	6.9
Institution index (2008)	4.12

Data source: WDI database

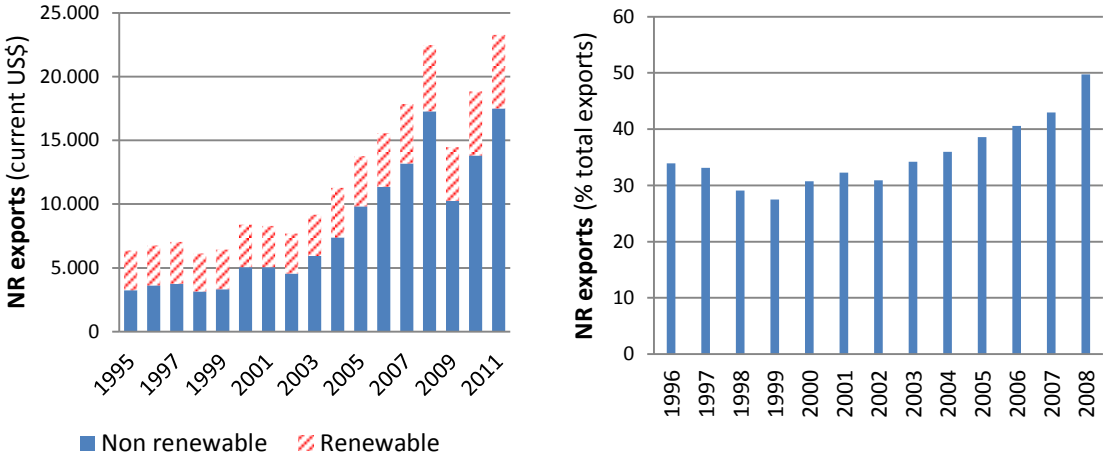
Economic facts

Graph G. Per capita GDP. Canada



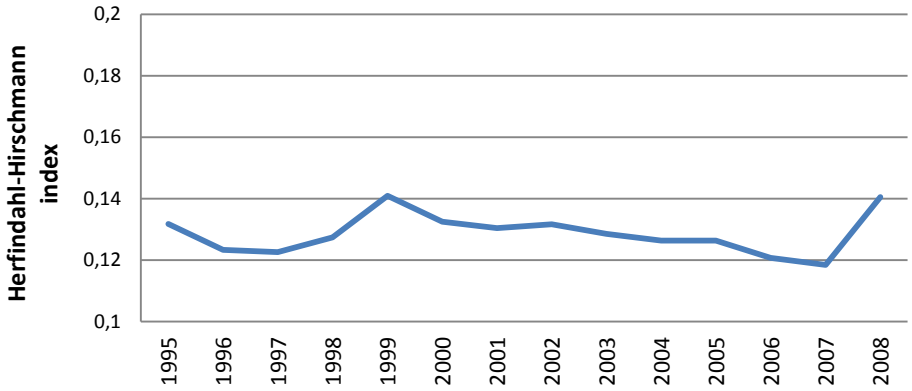
Source: Author's elaboration from WDI database

Graph H. NR exports. Canada



Source: Author's elaboration from UNCTAD database

Graph I. Herfindahl-Hirschmann index. Canada



Source: Author's elaboration from UNCTAD database

Technology and innovation facts

Table F. Selected indicators of technology and innovation. Canada

Year	R&D expenditure (% of GDP)	Patents (per mill inhab., res.)	School enrollment, tertiary (% gross)	Researchers in R&D (per million people)
1996	1.65	87.1	88.7	3058.5
1997	1.66	111.5		3119.9
1998	1.76	125.9	59.2	3159.0
1999	1.80	133.2	60.0	3243.3
2000	1.91	136.1	58.9	3515.1
2001	2.09	127.5		3695.5
2002	2.04	126.2		3706.7
2003	2.04	124.0		3900.6
2004	2.07	163.5		4085.3
2005	2.04	160.4		4238.4
2006	2.00	169.5		4313.1
2007	1.96	152.0		4587.7
2008	1.92	152.2		4710.8
2009	1.94	150.7		4317.0
2010	1.85	133.8		4367.9

Source: Author's elaboration from WDI database

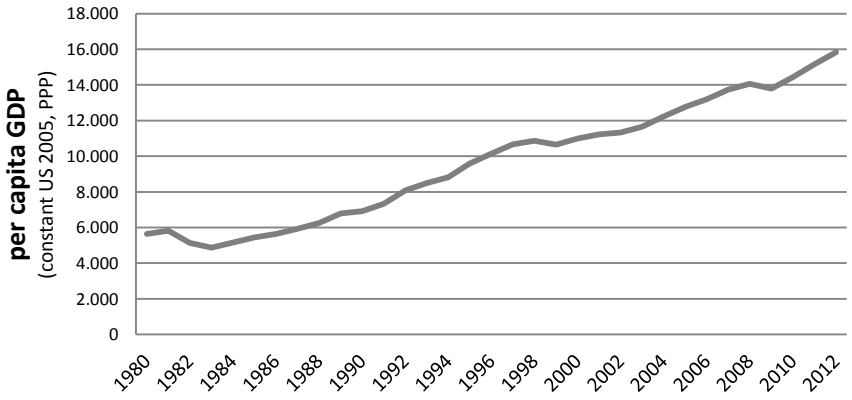
Table G. Overall information of country. Chile

Country	Chile
Capital	Santiago
Population (2012)	17,464,814
Population 15-64 years (2012) (%)	68.9
Surface area (sq. km)	756,096
Agricultural land (% of land area)	21.2
Institution index (2008)	3.63

Data source: WDI database

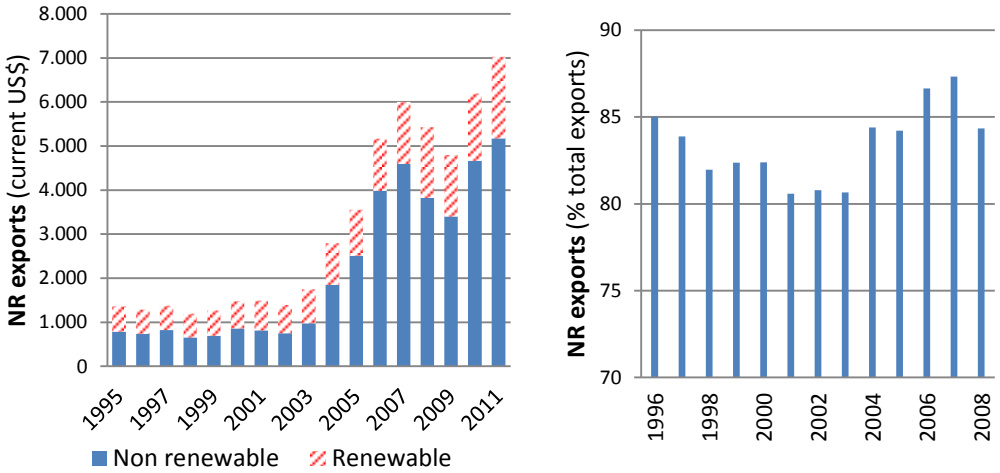
Economic facts

Graph J. Per capita GDP. Chile



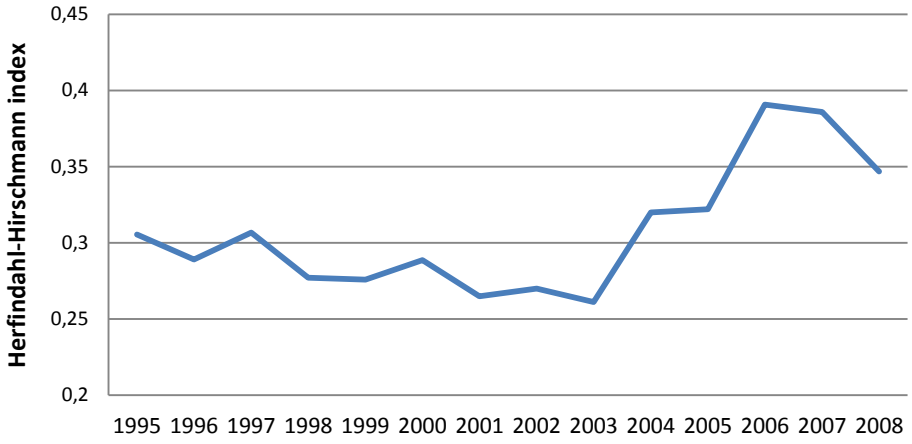
Source: Author's elaboration from WDI database

Graph K. NR exports. Chile



Source: Author's elaboration from UNCTAD database

Graph L. Herfindahl-Hirschmann index. Chile



Source: Author's elaboration from UNCTAD database

Technology and innovation facts

Table H. Selected indicators of technology and innovation. Chile

Year	R&D expenditure (% of GDP)	Patents (per mill inhab., res.)	School enrollment, tertiary (% gross)	Researchers in R&D (per million people)
1996		12.0	30.9	
1997		10.8	32.4	
1998		13.7	34.6	
1999		13.4	37.9	
2000		15.6	37.2	
2001		15.7		
2002		24.7	40.4	
2003		20.6	42.7	
2004		23.6	42.7	
2005		22.1	47.7	
2006		17.6	46.5	
2007	0.31	24.2	52.1	333.0
2008	0.37	31.5	54.9	354.0
2009	0.41	20.2	59.0	286.0
2010	0.42	19.1	65.9	317.2

Source: Author's elaboration from WDI database

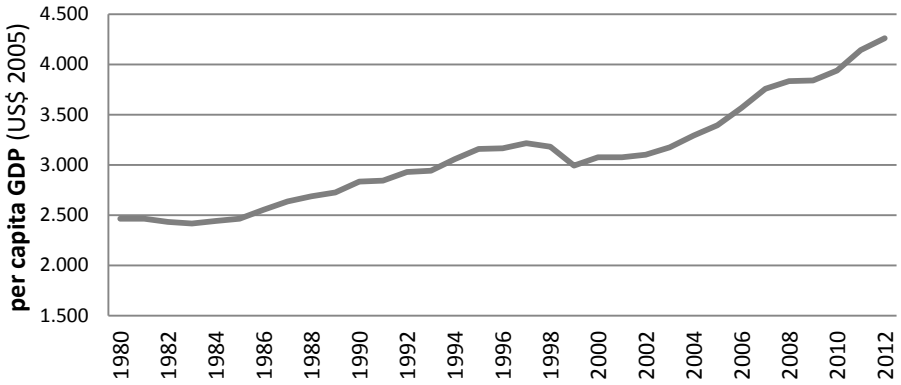
Table I. Overall information of country. Colombia

Country	Colombia
Capital	Bogotá
Population (2012)	47,704,427
Population 15-64 years (2012) (%)	66.0
Surface area (sq. km)	1,141,750
Agricultural land (% of land area)	39.5
Institution index (2008)	2.10

Data source: WDI database

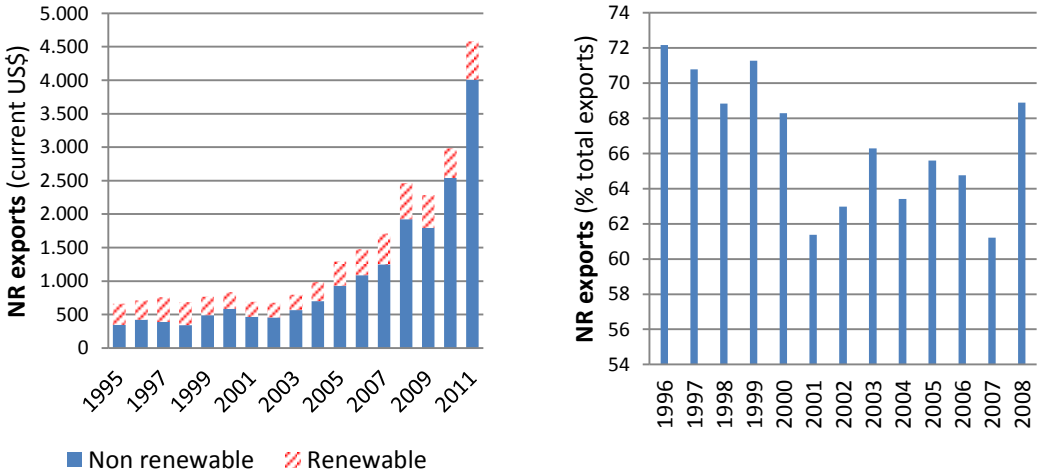
Economic facts

Graph M. Per capita GDP. Colombia



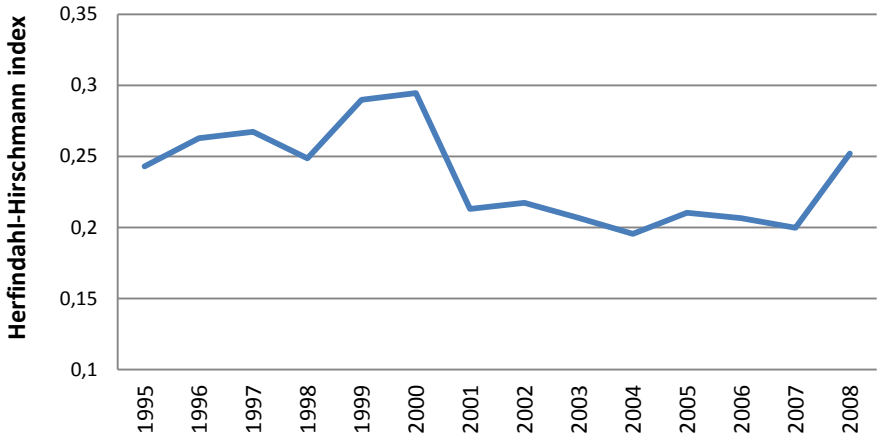
Source: Author's elaboration from WDI database

Graph N. NR exports. Colombia



Source: Author's elaboration from UNCTAD database

Graph O. Herfindahl-Hirschmann index. Colombia



Source: Author's elaboration from UNCTAD database

Technology and innovation facts

Table J. Selected indicators of technology and innovation. Colombia

Year	R&D expenditure (% of GDP)	Patents (per mill inhab., res.)	School enrollment, tertiary (% gross)	Researchers in R&D (per million people)
1996	0.30	2.3	17.5	71.7
1997	0.27	2.1	20.6	75.6
1998		4.2	23.1	
1999		1.7	22.7	
2000	0.11	1.9	23.9	100.5
2001	0.11	1.6	24.8	112.3
2002	0.12	1.3	24.9	127.9
2003	0.14	2.0	24.6	139.3
2004	0.14	1.8	27.5	155.5
2005	0.14	2.3	29.9	165.9
2006	0.14	3.2	31.9	176.3
2007	0.17	2.9	33.0	184.5
2008	0.18	2.8	35.4	181.2
2009	0.19	2.8	37.0	163.7
2010	0.19	2.9	39.0	154.2

Source: Author's elaboration from WDI database

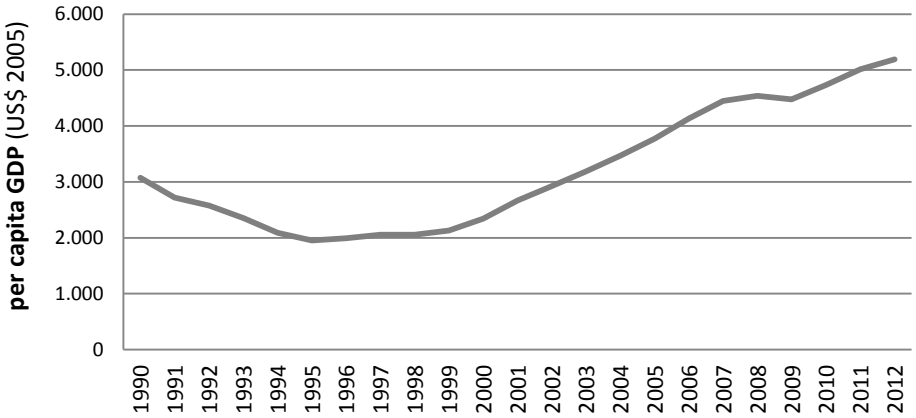
Table K. Overall information of country. Kazakhstan

Country	Kazakhstan
Capital	Astana
Population (2012)	16,791,425
Population 15-64 years (2012) (%)	68.0
Surface area (sq. km)	2,724,900
Agricultural land (% of land area)	77.5
Institution index (2008)	1.98

Data source: WDI database

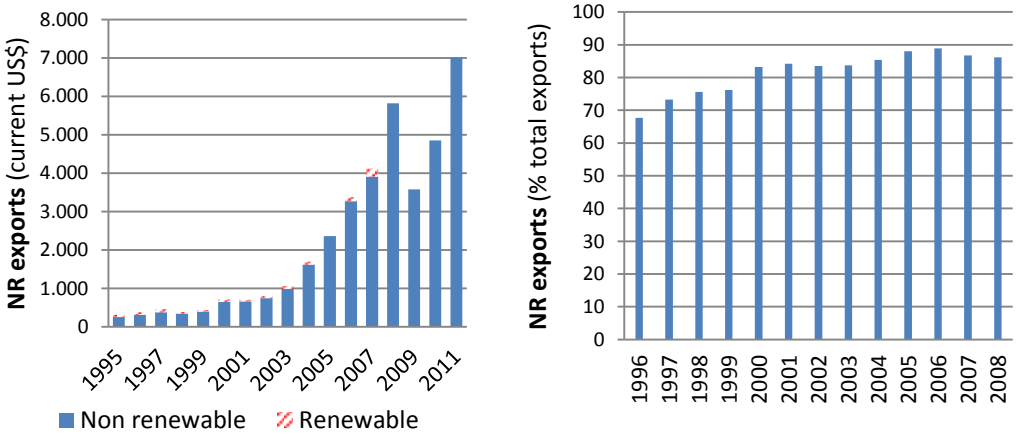
Economic facts

Graph P. Per capita GDP. Kazakhstan



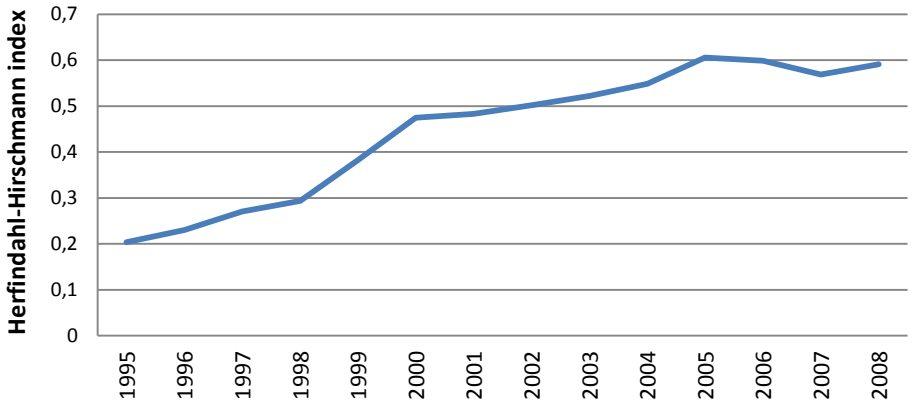
Source: Author's elaboration from WDI database

Graph Q. NR exports. Kazakhstan



Source: Author's elaboration from UNCTAD database

Graph R. Herfindahl-Hirschmann index. Kazakhstan



Source: Author's elaboration from UNCTAD database

Technology and innovation facts

Table L. Selected indicators of technology and innovation. Kazakhstan

Year	R&D expenditure (% of GDP)	Patents (per mill inhab., res.)	School enrollment, tertiary (% gross)	Researchers in R&D (per million people)
1996		65.6	31.34	
1997	0.29	76.4		
1998	0.22	82.5		
1999	0.18	90.6	24.9	
2000	0.18	94.0	28.7	
2001	0.22	108.2	34.6	
2002	0.26		39.8	
2003	0.25	113.8	45.2	
2004	0.25		48.3	
2005	0.28	100.5	52.9	
2006	0.24	93.6	52.9	
2007	0.21		50.8	
2008	0.22	0.7	46.4	
2009	0.23	94.0	40.8	
2010	0.15	103.6	39.5	
2011	0.16	85.5	42.2	651.8

Source: Author's elaboration from WDI database

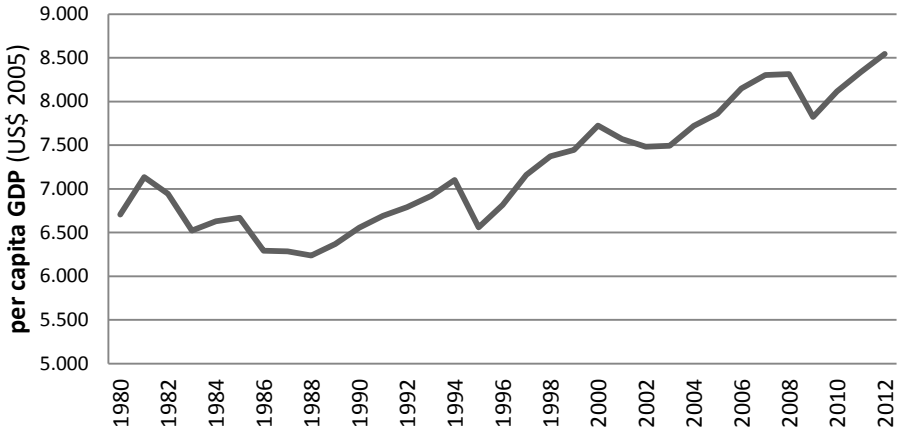
Table M. Overall information of country. Mexico

Country	Mexico
Capital	Mexico DF
Population (2012)	120,847,477
Population 15-64 years (2012) (%)	64.7
Surface area (sq. km)	1,964,380
Agricultural land (% of land area)	53.1
Institution index (2008)	2.33

Data source: WDI database

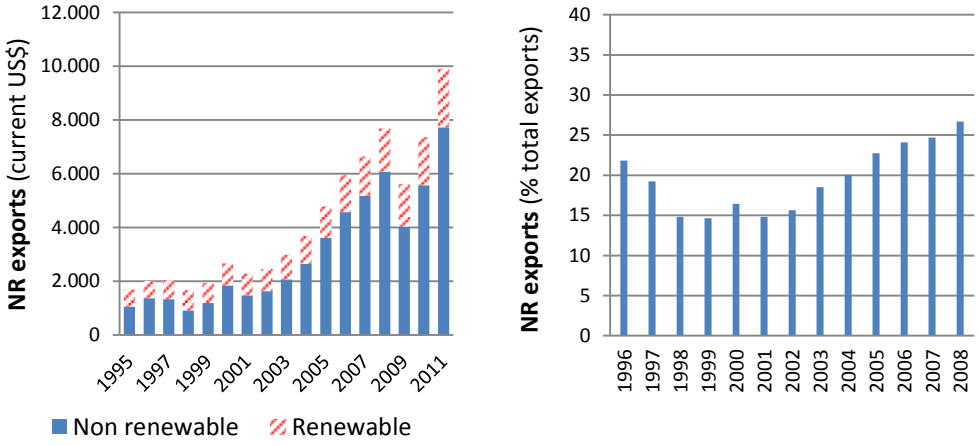
Economic facts

Graph S. Per capita GDP. Mexico



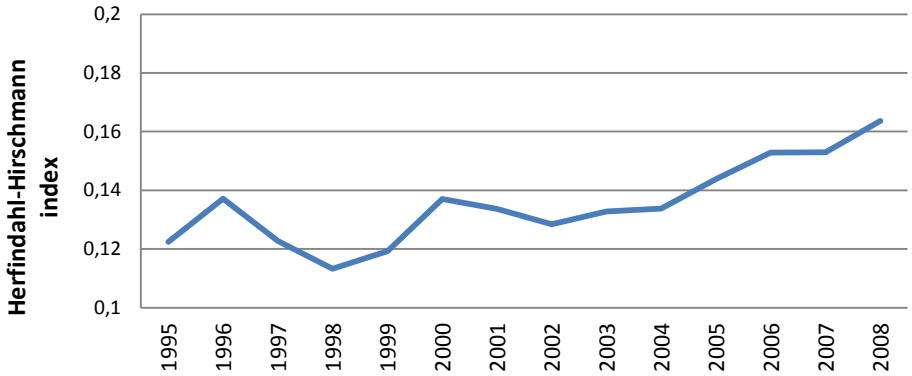
Source: Author's elaboration from WDI database

Graph T. NR exports. Mexico



Source: Author's elaboration from UNCTAD database

Graph U. Herfindahl-Hirschmann index. Mexico



Source: Author's elaboration from UNCTAD database

Technology and innovation facts

Table N. Selected indicators of technology and innovation. Mexico

Year	R&D expenditure (% of GDP)	Patents (per mill inhab., res.)	School enrollment, tertiary (% gross)	Researchers in R&D (per million people)
1996	0.31	3.97	14.86	204.7
1997	0.34	4.24	15.69	216.4
1998	0.38	4.50	16.91	206.9
1999	0.43	4.45	18.05	213.8
2000	0.37	4.15	19.30	214.0
2001	0.39	5.07	20.10	222.0
2002	0.44	4.93	21.07	291.7
2003	0.40	4.33	21.94	310.6
2004	0.40	5.17	22.77	363.2
2005	0.41	5.27	23.31	396.7
2006	0.38	5.12	23.79	323.4
2007	0.37	5.54	24.39	334.1
2008	0.41	5.96	25.10	327.4
2009	0.44	7.06	25.65	369.1
2010	0.48	8.07	26.74	382.1

Source: Author's elaboration from WDI database

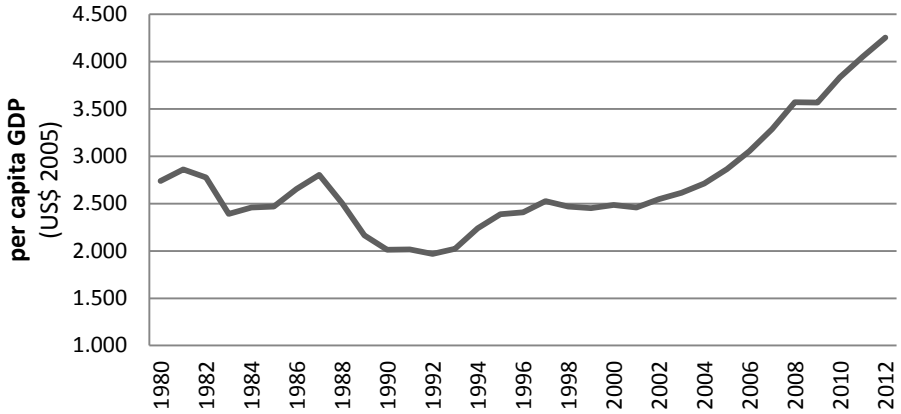
Table O. Overall information of country. Peru

Country	Peru
Capital	Lima
Population (2012)	29,987,800
Population 15-64 years (2012) (%)	64.6
Surface area (sq. km)	1,285,220
Agricultural land (% of land area)	16.8
Institution index (2008)	2.20

Data source: WDI database

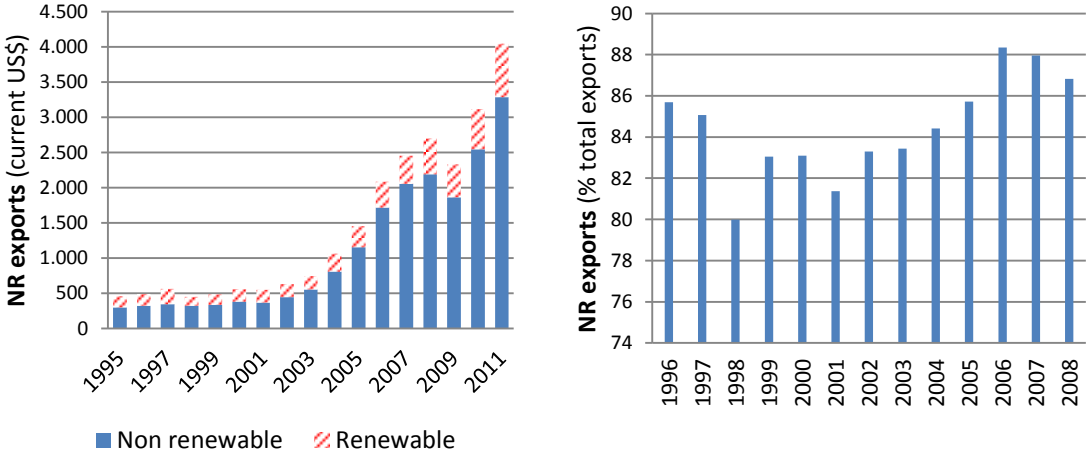
Economic facts

Graph V. Per capita GDP. Peru



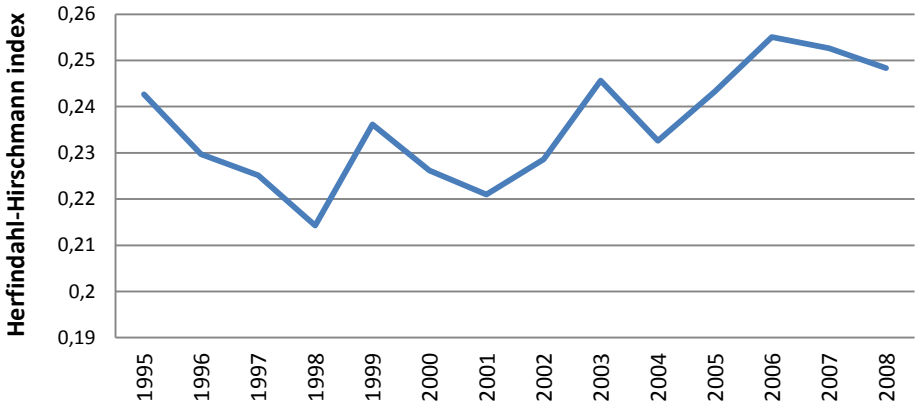
Source: Author's elaboration from WDI database

Graph W. NR exports. Peru



Source: Author's elaboration from UNCTAD database

Graph X. Herfindahl-Hirschmann index. Peru



Source: Author's elaboration from UNCTAD database

Technology and innovation facts

Table P. Selected indicators of technology and innovation. Peru

Year	R&D expenditure (% of GDP)	Patents (per mill inhab., res.)	School enrollment, tertiary (% gross)
1996		2.13	25.6
1997	0.08	1.94	25.7
1998	0.10		28.4
1999	0.10	1.87	
2000	0.11	1.54	
2001	0.11	1.37	31.4
2002	0.10	1.08	31.5
2003	0.10	1.18	31.6
2004	0.15	1.39	33.3
2005		0.97	33.4
2006		1.39	34.6
2007		0.99	
2008		1.08	
2009		1.28	
2010		1.33	42.6

Source: Author's elaboration from WDI database

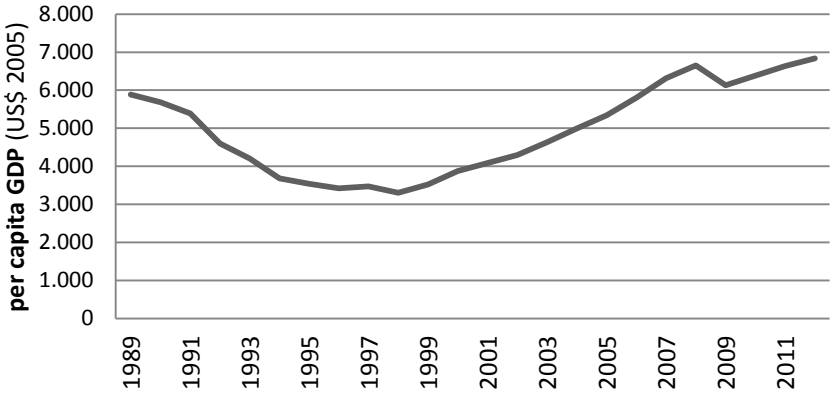
Table Q. Overall information of country. Russian Federation

Country	Russian Federation
Capital	Moscow
Population (2012)	143,533,000
Population 15-64 years (2012) (%)	71.6
Surface area (sq. km)	17,098,240
Agricultural land (% of land area)	13.1
Institution index (2008)	1.75

Data source: WDI database

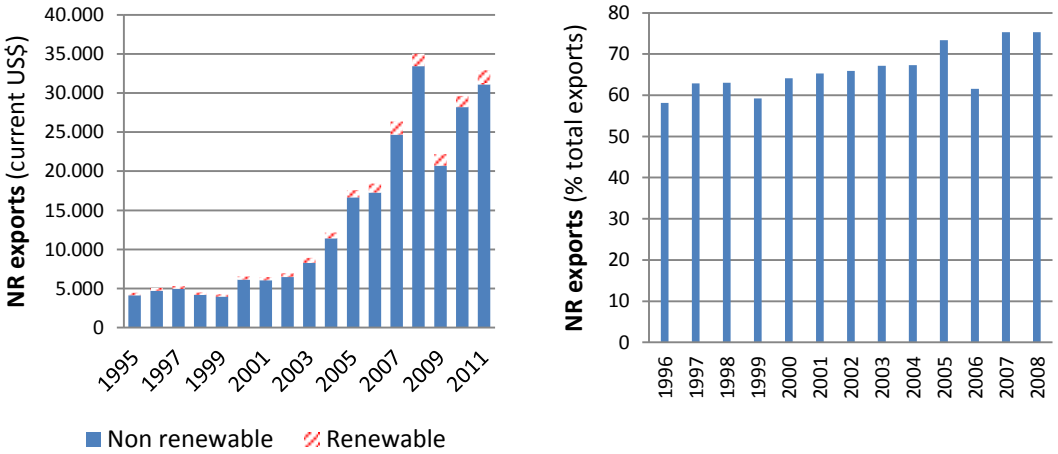
Economic facts

Graph Y. Per capita GDP. Russian Federation



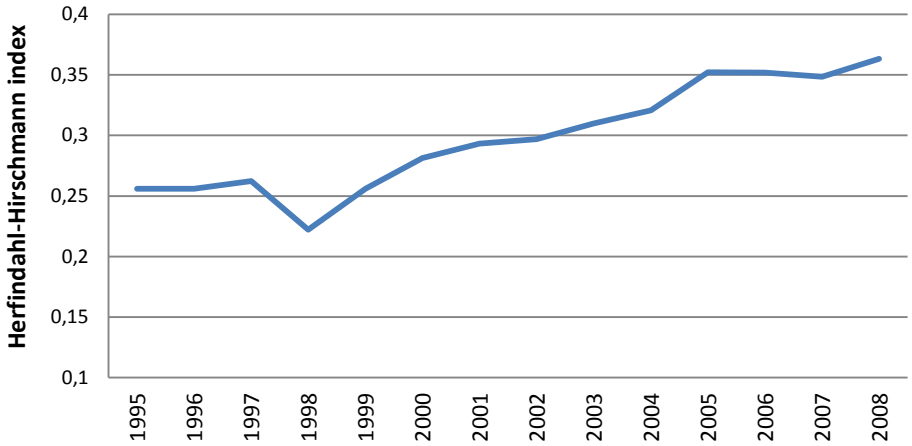
Source: Author's elaboration from WDI database

Graph Z. NR exports. Russian Federation



Source: Author's elaboration from UNCTAD database

Graph AA. Herfindahl-Hirschmann index. Russian Federation



Source: Author's elaboration from UNCTAD database

Technology and innovation facts

Table R. Selected indicators of technology and innovation. Russian Federation

Year	R&D expenditure (% of GDP)	Patents (per mill inhab., res.)	School enrollment, tertiary (% gross)	Researchers in R&D (per million people)
1996	0.97	121.9	44.3	3788.2
1997	1.04	102.5	45.8	3595.8
1998	0.95	112.0	47.9	3334.1
1999	1.00	136.0	51.4	3374.8
2000	1.05	159.8	55.4	3450.6
2001	1.18	169.8	61.3	3460.2
2002	1.25	163.2	66.7	3380.6
2003	1.29	172.7	66.5	3364.7
2004	1.15	159.8	70.5	3309.4
2005	1.07	165.2	72.6	3227.7
2006	1.07	195.7	72.9	3231.1
2007	1.12	193.6	74.1	3265.4
2008	1.04	195.2	75.0	3140.5
2009	1.25	180.4	75.5	3077.9
2010	1.16	201.7		3078.1

Source: Author's elaboration from WDI database

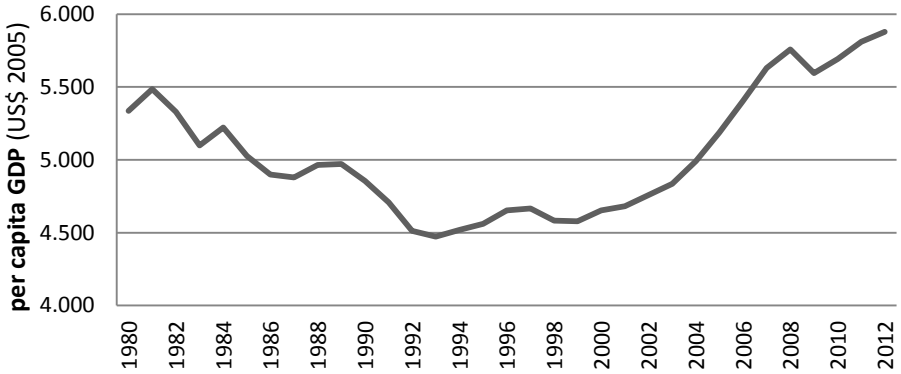
Table S. Overall information of country. South Africa

Country	South Africa
Capital	Pretoria (administrative)
Population (2012)	52,274,945
Population 15-64 years (2012) (%)	65.0
Surface area (sq. km)	1,219,090
Agricultural land (% of land area)	79.4
Institution index (2008)	2.80

Data source: WDI database

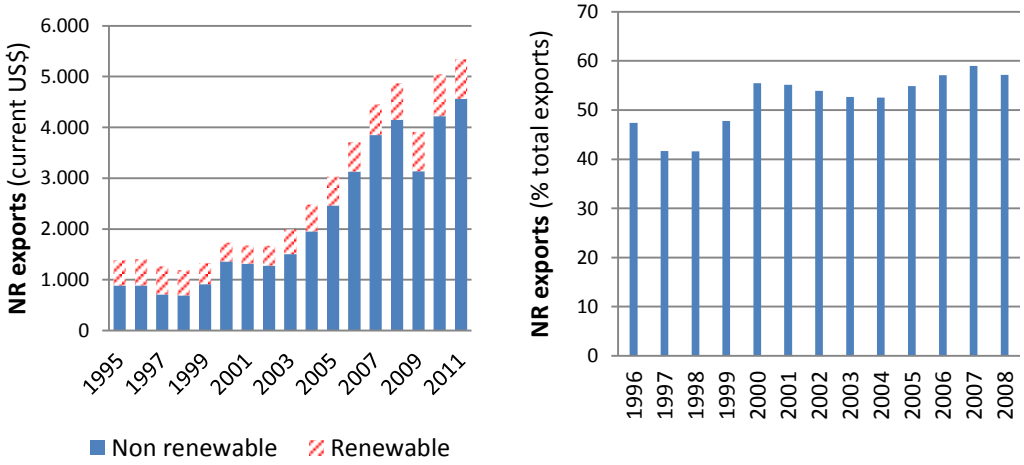
Economic facts

Graph AB. Per capita GDP. South Africa



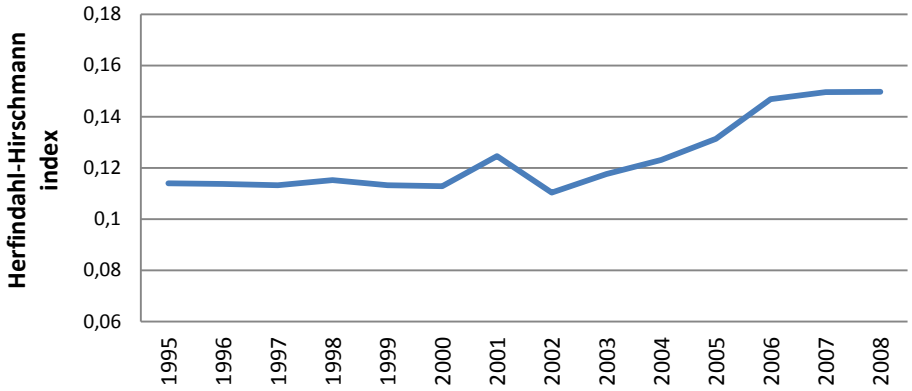
Source: Author's elaboration from WDI database

Graph AC. NR exports. South Africa



Source: Author's elaboration from UNCTAD database

Graph AD. Herfindahl-Hirschmann index. South Africa



Source: Author's elaboration from UNCTAD database

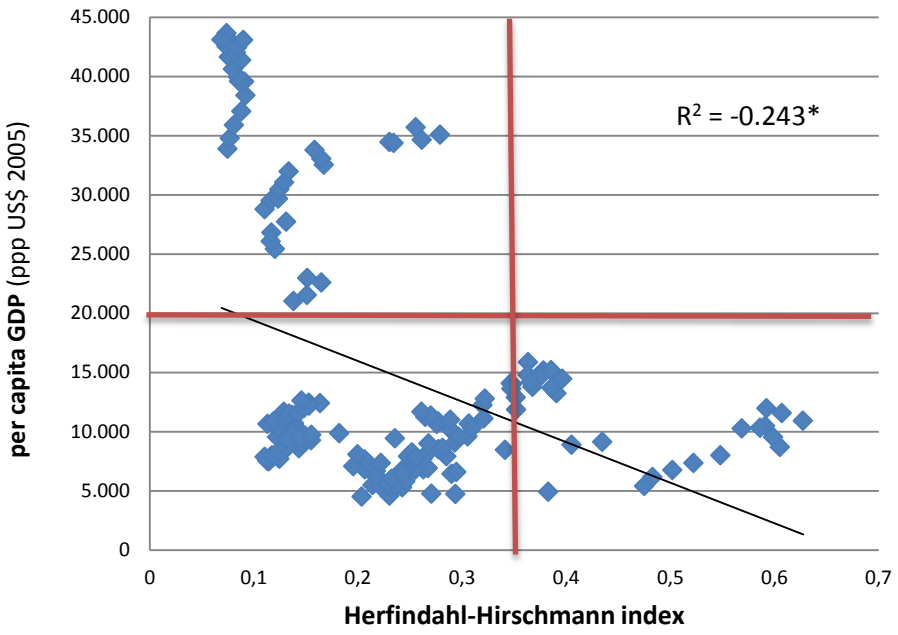
Technology and innovation facts

Table T. Selected indicators of technology and innovation. South Africa

Year	R&D expenditure (% of GDP)	Patents (per mill inhab., res.)	Researchers in R&D (per million people)
1996		18.92	
1997	0.60	8.67	198.9
1998		4.77	
1999		3.22	
2000		20.34	
2001	0.73	21.51	311.6
2002		21.46	
2003	0.79	19.87	301.5
2004	0.85	20.33	376.7
2005	0.90	21.05	358.7
2006	0.93	17.94	379.7
2007	0.92	18.71	389.5
2008	0.93	17.35	385.6
2009	0.87	16.37	388.9
2010		16.13	

Source: Author's elaboration from WDI database

Annex 11. GDP (per capita, US$2005) and economic concentration (Herfindahl-Hirschmann index). Period 1995-2012



Source: own elaboration from WDI data.
Note: Herfindahl-Hirschmann index correspond to a measure of merchandise export concentration