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The Dynamics of Resource-Based Economic Development: Evidence from Australia and Norway

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Abstract

Australia and Norway have achieved modern levels of development as resource-based economies, thus avoiding the so-called resource curse. Their ability to achieve this rested heavily upon diversification into new resource products and industries. These processes relied heavily on innovation, confirming the close ties that have existed between resource-based industries and knowledge-producing and disseminating sectors of society. We develop a resource-based diversification model that analyses the interaction between 'enabling' sectors and resource industries and apply it to the historical experience of the two countries.

JEL classification codes: N50; O13; O57; Q01

Keywords: resource curse; enabling sectors; knowledge economy; social technologies

1. <u>Introduction</u>

The notion that natural-resource oriented economies are feted to experience retarded or incomplete development has been around a long time, perhaps half a century. According to this perspective, the 'windfall' associated with resource abundance has brought in its wake cognitive, societal, policy, and economic restraints on development. In the mid 1990s, Sachs and Warner conceptualised this perspective into what is known as the 'resource curse' hypothesis. This concept has been supported by data analysis across a large sample of countries which shows, in many cases, negative correlations between resource intensity and indicators of economic performance such as rates of growth, investment, and human capital (van der Ploeg, 2011).

Recent work has provided something of a counterbalance by indicating that the curse is not inevitable and by investigating what resource-based economies can do to mitigate it. The debate is of much interest to policy-makers in supra-national organisations like the World Bank who are concerned at the belated development of many resource-based Latin American nations and a range of oil-dependent economies (De Ferranti *et al*,. 2002).

Some resource-based economies have avoided the curse altogether, and this includes those which have done so through a long period of economic development although little has been written about them within this context. Our focus is a comparative study of two such successful resource-based economies, Australia and Norway. The comparative approach provides grounds for generalising about the conditions for successful development in resource-based economies. Economic development, by its nature, is a longitudinal process, and yet history has had little to say on this issue of contemporary interest, besides an implicit assumption that truly successful nations will transit from natural resource to manufacturing industries. Australia and Norway have continued to rely heavily upon their resource-based industries. In this paper, we look at how these two economies have continually renewed and extended their resource base by drawing upon the role of learning and knowledge creation to facilitate innovation in these industries and spillovers into others sectors.

The following section briefly reviews the resource curse debate. Section three summarises historical perspectives on the developmental role of resource-based industries and introduces our resources sector model of interaction between recipient and enabling sectors. Sections four to seven apply this model to Australia and Norway to explain the dynamics of their successful resource-based economic development. Some conclusions follow.

2. Resource curse debate

There is a range of economic, political, and socio-cultural strands of argument that seek to link resource-based economies with retarded development.[i] Prebisch (1950) and Singer (1950) alleged the limited opportunities for innovation in resource industries and their tendency to experience a long term decline in the terms of trade. Hirschman (1958) believed manufacturing provided greater growth-inducing linkages between industries and sectors, this being especially the case where profit-repatriating multinationals dominated resource extraction (Baldwin, 1966). Resource production can occur in sudden windfalls, motivated by changes in the conditions of supply such as new mineral discoveries or technologies for exploitation or increases in demand with the entrance of a newly-developing nation with large resource needs. The volatility of supply, demand and prices has motivated concerns that private investment would be discouraged by such uncertainty and that resulting government revenues would be unstable (Nurske, 1958; van der Ploeg, 2011). ‘Dutch disease’ is associated with the idea that a resources windfall impacts negatively on other sectors through an appreciation of the real exchange rate (Neary and van Wijnbergen, 1986) and by causing crowding out in factor markets (Matsuyama, 1992; Sachs and Warner, 1995; Gylafson, 2001).

Socio-cultural explanations also take several forms. Most general, is the idea of slothfulness in the face of plenty, that striving to achieve the best in either public policy or the private sector is muted by easy wealth (Wallich, 1960; Levin, 1960). Alternatively, excessive exuberance has been cited, that private actors are driven by a get rich quick mentality and public policy by unguarded optimism, neither of which provides optimal long term outcomes (Nurske, 1958; Watkins, 1963). The growth-impeding role of dominant elites has been a common argument for the belated economic development of many Latin American nations, the intuition being that their ownership of wealth-generating natural resources constrains policies that favour the relative expansion of other sectors (Mahon, 1992).

A more explicitly political explanation of policy failure in resource-based economies is associated with theories of the rentier state. A heavy reliance upon resource tax revenues, especially from foreign multinationals, in place of general taxation, is perceived as weakening the relationship between a domestic government and its broader domestic constituency, and as a result weakens state institutions (Karl, 1997; Shafer, 1994). The resource curse hypothesis clearly has many elements to it, all of which have been subject to close and critical scrutiny (Ross, 1999; de Ferranti *et al.,* 2002), but at the heart of all of them is the notion that a focus on a particular sector of the economy, natural resource production, provides an explanatory variable for the poor economic performance of many countries.

The plethora of explanations of why there is an inverse relationship between natural resources and growth in the economy indicates the lack of a clear theoretical underpinning of much of the resource curse literature.[ii] In fact, Sachs and Warner argue that there is no accepted growth theory:

> "Just as we lack a universally accepted theory of economic growth in general, we lack a universally accepted theory of the curse of natural resources. ..a complete answer to what is behind the curse of natural resources therefore awaits a better answer to the question about what ultimately drives growth". (Sachs and Warner, 2001: 833)

Nonetheless, most economic analysis still uses growth models to explain the resource curse, particularly endogenous growth models (Romer, 1986) where investment levels as well as knowledge, technology or learning are the main explanatory factors. This is evident in the large number of analyses based on the Dutch disease. The basic idea is that there is more learning (learning-by-doing) or knowledge (human capital) occurring in manufacturing than in other sectors. This is supported by work drawing upon the new economic geography which emphasises the importance of urban agglomeration of manufacturing industry in knowledge creation and dissemination (Greasley and Madsen 2010). Therefore, moving resources away from the manufacturing sector would reduce the capacity for long term growth. The underlying hypothesis of the models explaining slow growth in resource based economies is, therefore, that there is a lower level of knowledge and learning in these economies due to their industrial structure. (Sachs and Warner, 2001; Gylfasson, 2001; Matsuyama, 1992).

Recent work by Ayres and Warr (2009) throws doubt on the assumption that there is a lack of innovativeness in resource-based industries. Borrowing from thermodynamics, they examine the historical role of increases in energy efficiency (exergy, a coefficient, 'U') in terms of the amount of work output generated by a fixed input of energy. They indicate a monotonically rising value of U for Japan and the USA through the twentieth century. The driver of increased U values, they argue, has been the multi-directional feedback processes between energy generating resource industries and downstream user industries that stimulated technical breakthroughs in energy use. The economic benefits have taken the form of lower costs and prices driving increases in demand and production (Ayres and Warr, 2009, 129-30, 168, 297).

Lately, some economists have questioned the empirical basis for the existence of a general resource curse. Within this literature there is a growing acceptance that what matters for long term growth rates is not the existence of large resource based sectors, but rather the quality of institutions in the economy. Mehlum, Moene and Torvik (2006) argue that the extent to which the institutions are "grabber friendly" or "producer friendly" explains why some resource based economies succeed and many fail. The institutional argument is that the "resource paradox" may be explained by the national political system, as all indexes of "institutional quality" relate to political, bureaucratic, and legal aspects of the society. However, the statistical correlation between indexes for the quality of the political systems and long term growths does not explain to us how some resource based economies actually succeed in growing rapidly over long periods of time.

Even though analysis of the resource curse literature uses models where learning, technology or knowledge are explanatory factors, this strand of literature does not empirically investigate how technological development, knowledge creation and use or learning take place in the economies they study.[iii] In this paper we show how the resource-based industries in Australia and Norway historically have been characterised by technological change, learning processes and use of knowledge. This is based on the hypothesis that it is not the differences in industrial structure that matter for long term growth, but rather the rate of technological change and use of knowledge in each sector. As Ferranti *et al*., (2002, p. 49) have observed: "It is not so much *what* is produced, as *how* it is produced".

3. Historical perspectives: Resource based industries as knowledge economy

In contrast to the resource curse hypothesis, most historical work has regarded natural resource abundance as an important factor in the initiation and transition stages to economic modernisation. Thus, the transition from an organic (charcoal, animal power) to a mineral-based energy economy from the late eighteenth century provided for the easy availability of low cost coal and iron ore necessary for the early industrialisation of Britain focussed on resource intensive industries such as iron and steel production and engineering (Wrigley 1988; Pollard 1982; Landes 2003; Clark & Jacks 2007). However, it was implicitly assumed that the process of economic modernisation witnessed the relative decline of resource industries to be replaced by manufacturing and services. Similarly, the staple thesis and vent for surplus theories, which addressed the idea of resource rich economies proceeding through commodity export-led development, focussed largely on early stages of a country's modernisation by exploiting idle resources and frontier expansion (Barbier, 2011, 12-13)

Gavin Wright (1990) offers an alternative argument in relation to American industrialisation a century later than Britain. He argues that there was a close relationship between resource expansion and America's economic expansion during the early twentieth century. In a paper written in collaboration with Paul David (David and Wright 1997), they argued that a country's resource abundance was not given by the natural environment. When the USA became the main producer of many minerals during the late nineteenth and early twentieth century, this was not a result of a specific rich environment for these minerals but rather the ability of American society to discover and extract resources compared with other countries. The resource abundance, thus, was not destined by geology but rather was endogenous to the economy and was a socially constructed phenomenon.

Their analysis of American economic development went further than previous historical research by arguing that the resource-based industries during the early twentieth century bore many similarities with what a hundred years later is defined as the modern knowledge economy:

> "We find … that late nineteenth century American mineral expansion embodied many of the features that typify modern knowledge-based economies: positive feedbacks to investments in knowledge, spillover benefits from one mining specialty to another, complementarities between public- and

> private-sector discoveries, and increasing returns to scale—both to firms and to the country as a whole". (David and Wright 1997: 204-205).

The strength of America's resource based-economy lay in its ability to create new knowledge (learning) and to involve many parts of the society and economy in the development and implementation of relevant and useful knowledge and technologies. The mining industries built links to universities and geological expertise. They collaborated with engineering firms in developing machinery and technology for improving productivity in the mines. New knowledge and technological investments created opportunities for the profitable extraction of lower grade ore. New infrastructure for the transport and distribution of minerals improved the efficiency of commodity markets. Finally, financial institutions supported the large scale investments necessary for such developments in resource-based industries. In contemporary theoretical perspective, we may argue that the dynamic growth of the American resource based economy was linked to the establishment of an efficient innovation system (Nelson 1993, Lundvall 1992) or the creation of a development block (Dahmen 1950). The dynamic was linked to broad-based economic development that included much more than mining (and other resource activities like agriculture), rather it involved a large number of knowledge-intensive sectors and activities, which *enabled* the resource sectors to become driving forces in wider economic development.[iv]

Linkages between natural resource industries and other sectors of the economy enhanced the role of both groups. In particular, resource industries generated a substantial growth in business services including finance, transport, and marketing.

Such demand is evident from many of the properties of natural resource products. The bulky nature of resources motivates a high demand for transport and transhipment services. The volatile and global nature of resource markets requires sophisticated and well-considered marketing strategies. Finally, resource exploitation is a voracious consumer of land and capital goods with consequent financing implications.

Recent analyses involving both Australia and Norway, combine historical studies and innovation systems approaches (Fagerberg, Mowery and Verspagen 2009, Smith 2007). They argue that successful long-term economic growth of these countries is closely linked to dynamics within resource based sectors of the economy. Both studies point to the fact that a central aspect for innovation in resource based sectors depends on the degree to which these sectors interact and cooperate with other parts of the economy.

Smith (2007) argues that there are three main mechanisms involved in successful resource based economies: a) Development through knowledge upgrading and investment strategies in resource-based industries, b) Development through the leveraging of resource bases into downstream industries, and c) Knowledge creation via knowledge infrastructure. These processes involve interaction between resource based firms and companies or knowledge institutions in other parts of the economy in a systematic way constituting 'development blocks' (Dahmen 1970).

The strong interaction between resource based sectors and other parts of the economy as a basis for long term economic development and innovation, is also reflected in Fagerberg et. al. (2009) which argues that

> "Norway's resource based sectors ... have for decades been highly innovative, drawing on domestic sources of innovation, technology transfer from foreign sources ...and Norway's universities and research institutes" (p.435)

The dynamic of resource sectors is based on close collaboration between these sectors and companies and knowledge institutions in other sectors, both domestically and abroad. It is knowledge diffusion and cooperation which characterises innovation processes in the resource based sectors and other parts of the economy. (Fagerberg et al 2010: 438).The companies utilise "localised search" (Nelson and Winter 1982) and engage competent other companies and knowledge institutions in problem solving and in innovation processes. "[T]he dominant approach to innovation within much of Norwegian industry relied on interaction with other actors in the system". (p 440).

The idea that economic development is dependent on linkages between sectors in the economy goes back to Hirschman (1958). He emphasised specifically the role of backward linkages, and argued that resource based industries created fewer backward linkages compared with manufacturing. This explained slow development in many resource based economies. The studies discussed above indicate that resource based industries have created strong backward (and forward) linkages in the national economies discussed.

Based on experience from Australian development, Pol, Carroll and Robertson (2002) developed a typology for linkages between sectors in the economy which is useful for analysis of the dynamics of resource-based economies. The economy consists of two types of sectors, *enabling* and *recipient* sectors. The enabling sectors are populated by organisations producing novel efficiency-enhancing products to be used in the same sector or elsewhere. The recipient sectors are the buyers of these products. The idea is that there are flows of knowledge (products) between sectors, where some sectors can enable innovation in other sectors. A central point is that knowledge flows are multi-directional ─ feedback effects from the recipient sectors also influence innovation in the enabling sector (Pol et al 2002: 67). While this original study focussed on enabling-recipient linkages largely in manufacturing, we extend this model of growth to show that it can also be applied to resource-based industries.

This is applied in the model below, which describes the historical interaction between resource industries and enabling sectors. Enabling sectors develop as problem solvers for existing resource industries and contribute to continuous improvements and transformation of these industries. The capabilities developed by the enabling sector through this process become a crucial resource for the creation of new resource industries. In turn, the regularisation of interaction between the enabling sectors and these new resource industries provides scope for a second cycle of new industries. This is the central dynamics of long term growth of the resource based economies of Australia and Norway.

Figure 1. Resource-based economy diversification model

This model is based on a wide consensus in the analysis of long-term economic dynamics in Australia and Norway that linkages between resource based industries and other sectors of the economy have been essential for rapid economic growth as resource based economies. The resource based sectors have functioned as drivers of knowledge development in other sectors, which have become enabling sectors diffusing technology to many parts of the economy. (Rosenberg 1976). In addition, enabling sectors have supported the development of new resource based sectors. This dynamic interaction between firms and institutions in different sectors of the economy contributed to a diverse economy with high innovation capability and "absorptive capacity". (Cohen and Levinthal, 1990)

In the following section, we will describe some of the key historical and comparative features of Australia and Norway as resource based economies, particularly their ability to generate new resource industries throughout their history. We will then explain the nature of the enabling sectors and analyse how they have interacted with recipient resource industries.

4. Australia and Norway as Resource-Based Economies

Australia and Norway share a range of similarities in their economic structure and historical process of development. Both are relatively wealthy economies, measured by GDP per capita (Maddison, 2001: 277, 279), that historically have clustered in export-oriented natural resource and related service industries (primary production, mining, energy, shipping, and mercantile trade) as their principal sources of wealth and economic modernisation. At the same time, Australia has a larger population and one that has grown more rapidly over the last two centuries. Moreover, rates of GDP per capita growth have differed across periods with Australia doing better for much of the nineteenth century and Norway generally ahead for most of the twentieth.

Table 1. Comparative Historical Statistics: Australia and Norway

Each nation has a tradition of small scale cooperative enterprise in many of these sectors, overseen by a positive role for the state, which is now giving way to large scale, corporate enterprise within a highly competitive framework. Both countries have traditionally drawn upon domestically generated new technology in their traditional clusters. While sharing similarities in economic structure and historical development, significant institutional and environmental differences persist between the two nations, particularly in terms of educational and legal systems, migration patterns, colonial history, land mass, climate, and geo-political location.[v]

Irrespective of these differences and similarities, Australia and Norway have both evolved as resource-based economies. There are a number of elements in determining what constitutes a resource-based economy. Resource sectors are not easily defined. In this analysis we use the definition by Sachs and Warner (1995), and attempt to adapt statistical historical data to this categorization.[vi] Measurements of actual exploitation of resources are more important than estimates of potential or known stock, and should be compared with economic activity in other sectors of the economy. This might include the resources sector's share of GDP or net exports or investment. A share of net visible exports of anywhere between 20 and 40 per cent has been variously suggested as defining a resource-based economy (Stevens, 2003; Nankani, 1979).

Table 2: Resource exports as proportion of total visible exports

The resources share of Australian production or employment has fluctuated over time, between about 10 and 25 per cent (McLean 2007: 646), with the rise and relative decline of domestic manufacturing, the expansion of services, and the raw materials demands of various industrialising nations. Resources have dominated Australian exports throughout the last century with a share generally above 70 per cent and sometimes beyond 90 per cent. Norway has traditionally, and still does, export about half of its GDP. The share of natural resources in total commodity exports was approximately the same in the early twenty-first century as a hundred years earlier, about 80-90 per cent. (Statistics Norway 1978, Statistics Norway, 2009). Norway and Australia may therefore be described as highly resource-based economies both in their historic development and current condition.

5. Creation of new resource based industries

Both countries have long exported traditional resources like food, timber, animal skins and furs, and coal. These product sectors remained significant exports at the end of the twentieth century aided by continuous innovations in production and marketing using emerging new technologies, such as remote control mining, futures markets, and electronic selling. The old industries have been transformed into modern production systems.

However, the ability of Australia and Norway to remain resource based economies was mainly the outcome of a different type of process: the repeated establishment and growth of new resource based industries that exploit new parts of the natural environment. This is a well known process in history as humanity gradually introduced new plants and animals or used a wider range of marine organisms for food consumption, or became able to use new types of minerals for production of metals and other materials. Gradually, a wider part of the natural environment has become incorporated into economic activities.

The history of Australia and Norway shows how not only new products created more diversity in old sectors and industries, but also how new resources became the basis for the establishment of new industries of importance for future growth and export specialisation. Table 3 provides stylised historical facts of the nature of the development of the resource industries in Australia and Norway over the last two centuries.

Table 3. Development of resource-based industries in Australia and Norway

Although the table is no more than a broad and approximate timeline of the emergence of additional resource-based industries, it is indicative of the dynamic expansion in their composition, particularly during the second half of the twentieth century when both Australia and Norway generated more new resource industries than at any earlier period in history. This aspect of resource based economic development has been largely overlooked in both economic theory and economic history.

The theoretical basis for this type of dynamics is the difference between *natural environment* and *natural resources*. The environment is given, but natural resources are the outcome of socio-economic processes where the environment is transformed into an economic resource. New natural resources depend on the society's and the economy's ability to create new resources and to build new industries around them. This idea was early expressed by Erik Zimmerman:

> "Resources ... are not, they become, they evolve out of triune interaction of nature, man, and culture. (...) The problem of resource adequacy for ages to come will involve human wisdom more than limits set by nature".
> (Zimmerman, 1951: 841)

This implies that the development of new resource based industries is dependent on the ability of the economy and society to use knowledge and resources to transform the natural environment into economic production. The expansion in technological and scientific knowledge explains the increased number of new resource industries from the second half of the twentieth century.

The creation of modern resource industries often demands complex scientific, technological, economic, political and social processes, and should not be regarded as trivial processes. An example of this type of process is the international development of hydropower during the early twentieth century. It illustrates how part of the natural environment (water-falls) which earlier lacked significant economic value was turned into an energy resource that became the basis for production of both electricity and energy intensive industries (metals, fertilizers, chemicals, paper). The development of electricity required not only new technologies, but also new types of organisations and public regulations, which included the creation of very large socio-technological systems (Hughes 1983, Thue 1994). In a similar fashion, the international development of nuclear energy systems during the second half of the century created demand for Australian-sourced uranium, a mineral which had low commercial value before it became an integrated part of a wider energy producing technology.

New resource based sectors often emerge not because new natural resources are discovered, but because new technologies create the basis for commercial production and marketing of a known resource. The story of natural gas in Australia and oil in Norway illustrates the transforming capabilities of technology to develop a large scale export market for a resource product. In Australia, natural gas was captured from the 1970s. While Australia has long been known to have extensive supplies of natural gas, demand for it has been limited to use within Australia: its large volume as a gas has meant very high transport costs. Twin technological developments have enabled it to become a major export product to serve the growing energy needs of populous Asian nations such as Japan. Liquification is achieved by reducing gas into its liquid form which reduces the volume of the gas by about 600 times. Liquification has been combined with the design and construction of specialist LNG ocean tankers to make it safe and economical to transport. The benefits of the new technologies has motivated the search for additional sources of natural gas which, in the last decade, has led to the adoption of increasingly efficient extraction techniques for Australia's immense reserves of coal seam gas.

In a similar way, the establishment of an offshore oil sector in the North Sea during the 1970s was dependent on the introduction of new methods and technologies for the detection of oil reservoirs, for drilling, new types of drilling platforms, and new regulations and control technologies related to environmental safety (Olsen and Sejersted 1997). This involved large and very expensive concrete platforms with very high levels of security systems. New technologies were introduced to improve the efficiency and volume of petrol which could be extracted. Development of drilling technologies, particular horizontal drilling, made it possible to increase the percentage of the existing oil which could be extracted from the reservoirs, increasing the rate from about 20 per cent in the 1970s to about 50 per cent at the end of the century (Storting 2001-2002).

The historical evidence from Australia and Norway indicates that long term growth in resource based industries was the result of the development of new resource based industries. In both countries the natural environment was exploited to develop new natural resources. The examples above illustrate that the establishment of new resource based industries was the outcome of complex and costly processes involving high levels of capital investment, use of a diverse field of knowledge bases, and the ability to draw on international actors and resources. The resource based industries alone did not embed the necessary knowledge or resources to build-up science-based and knowledge intensive production systems. Their successful development was dependent on close interaction with other sectors of the economy and society involving technology, knowledge, financial resources, and various kinds of expertise. These enabling sectors played a key role in linking the resource industries with available resources in the rest of the economy and internationally.

6. Creation and transformation of enabling sectors

A central aspect of the economic dynamics of Australia and Norway has been the strong linkages between resource based sectors and other parts of the economy. This is a reflection of how innovation processes most often take place within the resource based sectors. Problem solving occurs mainly through the search for knowledge and competence in other parts of the economy. Most of the search processes are localised, that is, companies first search among established contacts in the same economy. In Australia and Norway, which have large resource based industries, this interaction has strongly shaped the wider patterns of innovation and the structure of the national innovation system. (Fagerberg et al 2009)

Through this type of interaction, resource based industries have influenced the direction of knowledge production and technological development in the economy.

In the following sections we will illustrate how production and innovation processes have contributed to the build up of two types of enabling sectors: capital goods industry and science/R&D.

Natural resources and the capital goods industry

Many successful resource based economies, including Australia and Norway, share a common structure regarding specialisation of capital goods industries: There are strong local suppliers of technology-intensive capital goods and specialised services directed towards domestic markets, to a large extent for resource based industries (Thue 2009, Maloney 2002, Bigsten 2001, Hiernesnemi et al 1996). These capital goods industries and the specialised services have been important for problem solving in existing resource based industries as well as for the development and production of new natural resources.

The role of backward linkages is regarded as specifically important for successful industrial development, and historically we find strong links between the resource sector and the capital goods industry, business services, and research and knowledge organisations in both Australia and Norway. The resource based industries have searched for new technologies which made it possible and profitable to improve efficiency, extract a larger percentage of the known stocks or reserves, or to develop areas for production. Producers of capital goods as well as business services have specialised in domestic markets, particularly in developing technologies and services for resource based industries.

This type of interaction between sectors goes far back. Agriculture was from an early period closely linked to advances in scientific and technological knowledge. In Australia, the natural environment faced by primary industries has few parallels in other regions of the world, necessitating domestic solutions to many production problems. Such challenges as drought, poor soil quality and pestilence questioned the viability of farming in Australia and, at any rate, emphasized its vulnerability to low productivity and output vicissitudes that have been marked even for a notoriously volatile sector. Nineteenth-century innovations in the farming sector, therefore, focused on overcoming development obstacles and mitigating cyclical instability. These included the jump stump ploughs to plough cleared fields around tree stumps, drought and disease tolerant wheats, fertilizers to improve poor soils, merino sheep breeding to improve wool quality and yields, dams and artesian wells to mitigate water shortages, and wire fencing and nets to keep livestock in bounds and protect crops from rabbit infestation (Raby 1996).

The transformation of Norway's forestry industry from sawmill production to wood processing (pulp) involved close interaction with local engineering companies, in addition to foreign expertise. The emerging wood processing industry demanded water turbines and other sorts of machines. Modern sawing and planing machinery and energy technologies (steam power and water turbines) also supported the transformation and growth of the sawmill industry between 1860 and 1890. The transformation of the old sawmill industry and the emerging wood production industry became an important market for local mechanical works. Mechanical engineering companies specialised in supplying machinery for investors in the emerging wood processing industries. The engineering industry provided machinery and other capital goods, and they became exporters of machinery for the wood-processing industry (Thue 2009).

The processes that made Australia a technological leader in mining by the end of the nineteenth century similarly involved strong links to the capital goods industry. Orders for pumps, crushers, engines and similar equipment provided good business for local foundries. In the following century a large and highly innovative industry of specialist engineering companies emerged to supply the vast capital equipment needs of the mining companies. The economic impact of these linkages is further emphasised by the substantial export earnings of these companies.

The close relationship between the resource based companies and capital goods industry has made Australia and Norway substantial exporters of production technology and forms of expertise used in the resource based sector. Mining technology has become a major export article for Australia (Maloney 2002). In 2009

Austmine, the industry body for mining technology companies, had over 100 members and predicted that its members would achieve exports to the value of A$3.8bn, which adds more than 10 per cent to the value of coal and iron ore exports. In a similar way, close interaction between oil companies and capital goods industries and business services since the 1970s, have made Norwegian technology suppliers world leading providers of oil services and some types of oil technologies, that is, sub-sea production technology where Norwegian companies control more than half of the world market (Engen 2002, 2009, Intsok 2011).

Natural resources and the direction of science

In a similar way to how the resource sector has shaped the direction of the capital goods industry of both nations, it has also strongly influenced the national science systems. Studies of national differences in specialisation in science show that resource based economies tend to focus on scientific areas relevant to the exploitation of natural resources. This type of specialisation is defined as the "bio-environmental model" where bio- and geo-sciences are strongly represented (Glänzel 2000, Glänzel and Schubert 2003). Australia and Norway are key cases for this specialization, a pattern that has long historical roots.

From the late nineteenth century, new scientific knowledge and technical equipment provided for broad surveys of the natural environment. This enabled a more systematic search for natural resources, particularly linked to geology (mining) and biology. In both Australia and Norway, organisations conducting geological surveys and the mapping of the biological environment were established, and became an important driver for discoveries of new natural resources. The establishment of

Norges Geologiske Undersøkelser (NGU, Geological Survey of Norway) in 1866 became the basis for mapping resources in Norway, and the work by NGU and professors at the University of Oslo established an overview of known minerals by the early twentieth century. Systematic searching for minerals was crucial for the growth of Australia as a major producer and exporter of minerals by the late nineteenth century. Geological surveys were established in each colony (Victoria 1852, Queensland 1868, South Australia 1882), and in addition to the private search for minerals, this gradually became a basis for the documentation of potential mineral sources for the mining industry. The blossoming of Schools of Mines from the late nineteenth century, located in major mining centres at Ballarat (1870) and Bendigo (1873), fostered increasingly effective and efficient exploration techniques. In a similar way, oceanography became an instrument to map marine resources and movement of various fish species in the ocean (Schwach 2002). The increasing sophistication of surveys in the twentieth century, informed by scientific advances in exploration and harvesting of bio-products, laid the grounds for the expansion and diversification of the mining and fishing industry, particularly during the second half of the century.

Both in geo- and bio-sciences strong scientific communities related to resource based industries emerged from an early period. In Norway, the specialization in these scientific fields originated during the formative period for institutionalization of modern science from the late nineteenth century. In marine biology, Norwegian scientists (G.O. Sars (1837-1927), Johan Hjort (1869-1948)) were in the forefront in developing theories on movement of herring and other fish species at specific periods of time. The development of physical oceanography analysing currents, saliency, and other factors of importance for life in the ocean, created the basis for a leading scientific community (H.U. Sverdrup (1888-1957)) in Norway providing data relevant for fisheries. The creation of modern meteorology (Wilhem Bjerknes (1862-1951) was also linked to demand from fisheries for improved weather forecasts (Friedman 1993). In a similar way, researchers in geo-sciences became international leading scientists developing theories and useful analytical data for mining and refining industries. This is exemplified by the emergence of geo-chemistry as a new sub-discipline from this small research community (Victor Goldschmidt (188-1947)), and development of scientific theories related to specific challenges in industry (Johan H.L. Vogt 1858-1932).

A characteristic of these research communities was the strong links to and interaction with relevant industries. The leading scientists actively engaged with firms in many ways. In mining they gave advice or worked as consultants for companies, investors and owners of companies, and developed plans for new investments and technologies (Børresen 2003). Norwegian scientists within marine biology collaborated closely with local fishermen during main fishing seasons, and became an important conduit for the diffusion of new technologies and fishing methods (Schwach 2002). In this way, strong interaction and cooperation between the resource based industries and scientific institutions were established from an early phase. This relationship has been reproduced throughout the 20th century, and the development of a large oil and gas sector in the Norwegian economy strongly strengthened the “bio-environmental” model. The scientific community was more specialized in this type of research towards the end of the 20th century compared to 30 years earlier (Norwegian Research Council 2003).

In Australia the twentieth century similarly witnessed the emergence of government research organisations oriented towards the primary industries, most notably with the creation of the CSIRO (Commonwealth Scientific and Industrial Research Organisation) in 1949 and its predecessor CSIR (Commonwealth Scientific and Industrial Research, 1926) (Schedvin 1987). Designed to foster scientific research for the benefit of both primary and secondary industries, it built upon the work of the state based departments of agriculture, a series of agricultural colleges and experimental farms all designed to link scientific research with farming practices. Through a series of laboratories and field stations it engaged with challenges and opportunities facing the primary industries particularly where national solutions were necessary. On the one hand, this involved counteracting pests such as codlin moth, locusts, prickly pear or rabbits. On the other hand, it worked with the resource exporting industries to enhance their value and sustainability, for example in wool timber, cereals, meat and dairy (Bashford and Hobbins, 2013).

The long term interaction between resource based industries and the enabling sectors, has been an important aspect of how Australia and Norway have experienced rapid growth involving continuous development of new resource based sectors as well as new enabling industries and sectors. The enabling sectors became part of a distributed knowledge based in the economy which formed the basis for further innovations in the resource based sector as well as other parts of the economy (Smith 2002). This gave the economies a specific structure with a combination of strong specialisation in natural resources as well as enabling sectors directed towards problem solving in the resource based sectors.

In the following section, we will look closely at some of the mechanisms which have created the interaction between the sectors.

7. Building linkages between resource based and enabling sectors

The interaction between the resource based industries and the enabling sectors explains how Australia and Norway remained specialised in natural resources but avoided a "resource curse". As we saw above, the main argument is that in both nations the resources sector expanded and diversified by developing new technologies that draw upon and contribute to learning and knowledge broadly across the economy. However, our description cannot offer much insight into *why* these particular two countries historically have developed strong abilities in technological change, promoting learning processes, and utilising acquired knowledge.

In order to address these underlying questions, we need a better understanding of the institutions governing the behaviour and interaction processes of firms and organisations. Douglass North's analysis explains differences in economic development by moving the discussion towards institutions, "the rules of the game" of the economy.[vii] The role of institutions is designed to bring order to production and exchange, and it is their effect on the cost of exchange and production that largely explains their influence on economic performance. Particular codes of conduct will be conducive to low transaction costs, thereby making exchange more efficient. For North and writers in his tradition, institutions are thus central to explaining comparative levels of economic development between nations.

However, he also recognises the inter-relationships between institutions and technological change:

> "Technological change and institutional change are the basic keys to societal and economic evolution and both exhibit the characteristics of path dependence" (North, 1990: 103)

Moving the focus to technological change (here identical to learning and the use of knowledge in the economy) does not take us away from an institutional approach. Rather, understanding why some economies succeed where most fail demands an improved understanding of the specific institutions that promote learning and the ability to use knowledge efficiently. An institutional approach for technological change will have to focus on the "rules of the game" for how individuals and organisations (firms) learn and use knowledge generated by others (Mokyr 2011).

In a recent paper, Nelson (2008) develops the concept of social technologies to describe the set of interactions and coordinations among organisations and actors in the process of developing or deploying a physical technology. The degree to which these social technologies succeed depend, in turn, on the set of institutions that support them. The underpinning institutions can take many forms – belief systems, organisational structures, legal systems, for example. As such, Nelson provides a convincing link between the technology literature, focussed on the physical aspects of innovation, and the institutional literature that looks towards economic development.

Nelson's insights help inform our paper by representing the relationship between enabling and recipient sectors as a form of social technology. We will describe examples of different types of collaboration between resource industries and enabling sectors that we observe from the history of Australia and Norway. They are: local and national networks, supply chains, internalisation, and state direction. The examples illustrate that there are a diversity of institutional settings underpinning the social technologies that forge linkages across the economy. In addition, we will stress that there is a demand for more in-depth and systematic analysis of the institutional arrangements for dynamic collaboration between resource industries and enabling sectors.

Networked interaction – fishery and electricity in Norway

Historically, much equipment and production technology for traditional industries like farming, forestry and fishing, was produced by the farmer or fisherman. Gradually local specialised producers of equipment and input to the primary industries emerged. There was a close social relationship between the user of the equipment and the producer. The local smith or workshop made gear or equipment tailored for the local market. The local user-producer interaction has been important for the direction of Scandinavian industrialisation, where the technology producers became problem solvers for local industry (Lundvall 1992)

This collaboration was common in small scale communities, often in rural areas, between equal social actors who regarded themselves as independent producers. Farmers, fisherman-peasants (combining fishing and farming), and fishermen as well as the smiths or mechanics of the small workshops were entrepreneurs and businessmen with a common economic interest in introducing new technology. Norway also has a tradition of localism (Thue 1994), which implies a strong feeling of common identity for all inhabitants of the local community. The shared ideology shaped a platform for informal interaction in order to improve efficiency in the resource based sectors.

- This type of informal local interaction remained important for economic dynamics in small scale resource industries throughout the twentieth century. Local smiths copied and developed the production of small engines for fishing boats. They adapted the engines to the traditional boats of each region, and a large number of small factories and workshops were erected along the coast before 1920. The informal relationship between the fishermen and local workshops remained important for the technological development of equipment for vessels. Gradually the informal interaction became more formalised, often involving contractual agreements among ship owner, ship designer, and the ship yard in the design and construction of vessels tailored to the demand of the specific user (Nås 200).

This type of localism is also reflected in political initiatives at the level of the municipality. There are examples of local communities which funded travel by local smiths to other countries to look for new technologies that could solve basic problems of local industries. (Sanden 1985). During the early twentieth century a number of municipalities decided to construct relatively small scale local electricity plant to provide small industries and household with energy. This was a large scale cooperative effort creating an infrastructure for more efficient production in both resource industries and enabling sectors (Thue 1994)

Also in larger cities there was close social interaction between representatives from resource industries and enabling sectors. Members from various parts of the national elites – the industrial bourgeoisie, the leading state officials (embetsmenn), and the professors of the university – met regularly at dinners or various associations. The meeting between the entrepreneur Sam Eyde and the professor Kristian Birkeland at a private dinner in Oslo became important for industrial collaboration that resulted in the establishment of the national industrial symbols of the twentieth century, Norsk Hydro, one of the early producers of artificial fertilizers. Collaboration between professors at the university and resource based industries became common from the late nineteenth century. The industrial laboratory formalised the long-term interaction between science and resource based industries. With the establishment of a laboratory in the company, the university professor could communicate with colleagues with a scientific training inside the company.

Informal social networks between individuals with a shared ideological basis played an important role in creating interaction between resource industries and enabling sectors both at the local and national level. The lasting effect of these relations was dependent partly on the existence of the shared ideologies or the formalisation or institutionalisation of the relationships.

Coordinated supply chains: agriculture in Australia

Since most of Australia's resource output has been bulky and destined for export, this required the development of a supply chain stretching from the farm gate or minehead to the wharves of the nation's emerging commercial port cities by the middle of the nineteenth century. In its wake, this shaped the development of radial road and rail systems connecting the two ends of the chain and, along it, the activities of a range of service providers supporting these industries. Information flowed along the supply chain in both directions – market information to producers and technological feedback to equipment manufacturers. A key actor in the supply chain of agricultural products was a class of business service firms unique to Australasia, stock and station agents, who coordinated many stages of the supply chain. These firms organised the local sale or international consignment of produce, especially wool, livestock and rural property. They acted as a go-between in the supply of raw materials and capital equipment to farmers, seeking out good sources of these inputs and forwarding farmer feedback to suppliers. In the 1890s, for example, agents played an important role persuading farmers to produce meat and dairy products for the emerging international refrigeration trade. They argued for the operational flexibility it provided farmers and began the process of establishing freezing works (Ville 2000: 158-9).

Agents began as mostly local firms embedded in farming communities. Some were former farmers themselves and, similar to the Norwegian fisheries example, fostered their local connection with farmers to build strong stocks of social capital. Leveraging relationship marketing strategies, they were able to build up large loyal customer bases. From the late nineteenth century, a process of consolidation began to take hold of the agent industry with emergent large stock and station agents building a national network of branches by acquiring many small local firms. They continued to emphasise their sense of localness through embedded local staff and additionally offered scale economies and a broader sense of expertise through their national standing. About four or five of these firms dominated the industry for much of the twentieth century – Elders, Dalgety, Golsbrough Mort, New Zealand Loan and Mercantile Agency, and Australian Mercantile Loan and Finance Company – handling about half of all wool sales.

At the forward end of the supply chain, local auction markets for Australian products began to emerge, beginning with wool from the last decade or so of the nineteenth century. Agent companies played the key role as commodity selling brokers, as such they laid the foundations for the development of organisations, behavioural norms, and routines necessary for modern markets to operate effectively (Merrett *et al.*, 2008). However, for modern commodity markets to work required high levels of cooperation among firms accustomed to intense competition. Brokers shared auction rooms and infrastructure, while brokers and buyers developed agreements on standard practices and procedures for the wool market. This was achieved through the formation of a set of regional then national trade associations.

Internalisation: mining and sugar in Australia

Linkages between resources and enabling sectors can be launched internally in major corporations. Strategies of vertical integration and product diversification by major Australian resource companies have provided an opportunity to embrace manufacturing innovation. Capabilities initially established in resource industries were often extended forward into processing and final good production through firm-based research capabilities. CSR (originally Colonial Sugar Refining Company Ltd) and BHP (originally Broken Hill Proprietary Company Ltd) are both notable examples of this.

CSR's initial success in the second half of the nineteenth century rested on being the first company to install technologically advanced sugar refining plants on a scale that dramatically lowered costs. By the 1930s, its research laboratories, supported by foreign licences, visits to overseas plants, and international joint ventures led the firm to new downstream products. Leveraging economies of scope through the use of its by-products of sugar refining enabled it to enter the alcohol and chemicals industries. After World War Two, related diversification into building materials became the focus including the production of vinyl flooring (1949), insulation and hardboard (1959), particle board (1960), and pre-mixed concrete (1965) (Hutchinson, 2001: 109-10). Technical efficiency became the company's watchword. From about the 1970s CSR pursued more ambitious unrelated diversification into the energy and minerals sectors.

BHP had positioned itself as a leading miner of silver, lead and zinc by the beginning of the twentieth century, initially through control of strategic leases but increasingly by technological leadership. It leveraged this powerful position to vertically integrate forwards from mining to become the steel industry leader in Australia by operating major plants in Newcastle from 1915 and Port Kembla from 1935. Subsequently, it diversified into a range of related downstream products which included steel alloys, hot water systems, fence posts, and tools. BHP built up in-house technological capabilities by hiring engineers and metallurgists to follow through on the imaginative strategies of its leaders particularly Essington Lewis and G. G. Delprat. However, it also drew upon outside advice, for example through the Collins House Group of mining companies and by inviting the opinions of overseas experts such as American engineer David Baker who in 1912 provided the company with a report on its plans to commence iron and steel production (Wills, 1962).

Significantly, both companies now leverage their technical leadership overseas, CSR in the American building materials industry as Rinker, and BHP-Billiton, now separated from its steel making capability (Bluescope), in many overseas resource industries including the operation of coal mines in New Mexico, a major copper mine in Chile, and a diamond mine in Canada.

State directed: oil in Norway

The public sector and politics in Norway played a crucial role engaging many knowledge intensive sectors with the large oil and gas sector during the late twentieth century. There was a conscious policy decision to engage the emerging oil and gas sector in research, engineering, services and production of oil rigs, platforms and production equipment. Foreign oil companies were “forced” to relate to Norwegian scientific communities, political authorities, and industry in order to gain permission to drill for oil in the North Sea. This industrial strategy emerged when Norway faced the threat of de-industrialisation 1978-79. Oil companies had to apply for concessions to drill for oil in specific and defined sectors of the North Sea. The regulations used were based on the Concession Laws developed during 1906-1917 and directed to protect national interests and control over natural resources.

The new regulations demanded that foreign oil companies collaborate with Norwegian universities/research institutions and with industry when undertaking investment decisions to drill or produce oil, and also to involve Norwegian service industries in the daily running of the operations. Large oil producers were sceptical of the ability of Norwegian industry and science to solve the challenges of the offshore oil sector. To a large extent it was a forced relationship, and many oil companies regarded the interaction with local firms as a type of taxation. The important aspect was to show that investments had been made in order to be able to participate in the competition to gain new concessions in the future. However, gradually international oil companies developed close relationships with Norwegian companies and research organisations that specialised in the problems and challenges of the offshore oil company. The relationship moved from a "forced marriage" to an equal partnership (Engen 2009).

The demand from the offshore sector created a basis for knowledge intensive sectors, including high-tech industries, focused on demand from the large and profitable domestic sector. Information and communication technologies became integrated parts of production systems and development processes of the resource based industries. Oil and gas production are large process industries demanding control technologies with strong public regulation of the oil platforms in the North Sea both for environmental and health reasons. With underwater production the demand for quality control systems increased, creating new demands for the producers of this type of technology. By the end of the twentieth century the oil and gas sector were the main customers both for the local ICT industry and also for many research institutes, consultancy firms, engineering companies, machinery industry, and other parts of the knowledge intensive business sector (Engen 2009).

The close interaction between oil and gas producers and knowledge intensive organisations in Norway created over time a strong cluster of companies and research institutions, which shaped technological development in the petroleum sector and became potential export sectors. These clusters became important elements of the economy both as producers and as competence centres for other sectors of the economy (Wicken, 2009).

8. Conclusion

Australia and Norway, two nations that differ in many aspects of their historical development, climate and geo-political location, have a common story of successful resource-based economic development. Commonality is that of shared success in taking a route to modernisation often regarded as prone to failure. Common also is the way they succeeded – by continual reinvention and extension of their resource products and industries. This provided them with new sources of growth and blunted the 'curse' blights of volatility and emasculating control of strategic resource assets.

As noted earlier, resource exploitation is much more about society's capabilities than nature's reserves. Our motivation is to explain why these two nations were able to develop broad-based capabilities that permitted resource industry exploitation domestically and in other nations. We have emphasised how the continuous development of enabling sectors created a strong knowledge base distributed in various parts of the economy and society. This knowledge base could be exploited to improve productivity in old resource based industries and to develop new industries. These enabling sectors were themselves developed in interaction with resource based industries and often driven by the demand from these industries. This dynamic interactive relationship between natural resource industries and enabling sectors is regarded as the core aspect of the successful economic development of Australia and Norway. It is this historical development which makes it reasonable to regard the countries today as 'resource based knowledge economies'.

The development of a strong distributed knowledge base in resource economies is not trivial. Relatively few such nations have made the transition to a 'resource based knowledge economy'. In our discussion, we argue that Australia and Norway historically have succeeded in establishing the institutional support for social interaction between resource based firms and actors with 'useful knowledge' (Mokyr 2002, 2011). It is not trivial that this type of linkage is created within a local or national economy. There are specific historical processes underlying the establishment of the 'social technologies' of close interaction between resource based industries and enabling sectors in Australia and Norway. We have illustrated the role of social relations between actors in small local communities and national elites with a shared ideological base in Norway. The development in Australia was more defined by relationships in business chains and by larger companies' ability to incorporate the enabling sectors within the firm. The case studies indicate there are many forms of institutions that can foster collaboration between resource based industries and knowledge organisations or enabling sectors.

Our arguments, therefore, centre around a 'deeper determinant', in this case the role of a knowledge generating and disseminating institutional structure. While a strand of recent work on successful resource-based countries adheres to the role of effective institutions, there has been an unwillingness to unpack this heavily used concept or embed it within the technology literature. We have attempted to address both of these issues by drawing attention to knowledge generating 'enabling sectors' and the ability of these sectors to link with resource industries to achieve innovation into new products and industries. The question of why it is possible to establish this type of interaction in some sectors and countries, but is more difficult to achieve in others, has only been touched upon. This demands a much deeper analysis of the social, political and cultural basis for economic behaviour that extends beyond the scope of this paper.

Table 1. Comparative Historical Statistics: Australia and Norway

Population growth rates (% annual compound)					
	1820-70	1870-1913	1913-50	1950-73	1973-98
Australia	3,4	2,36	1,44	2,21	1,32
Norway	1,17	0,8	0,78	0,84	0,45

GDP per cap growth rates (% annual compound)					
	1820-70	1870-1913	1913-50	1950-73	1973-98
Australia	3,99	1,05	0,73	2,34	1,89
Norway	0,52	1,3	2,13	3,19	3,02

Urban population (%)								
	1861/65*	1875/81	1900/01	1930/33	1947/50	1960/61	1980/81	1996/01
Australia	39,4	45,8	49,4	63,8	68,7	81,9	85,7	81,8
Norway	19,6	24,4	35,7	47,3	52,2	57,2	70,3	77,3

*First year (1861) = Australia, (1865) = Norway
Norway: urban areas defined as communities with more than 2000 inhabitants

Sources: Maddison, World Economy, 186,188, Vamplew ed, 40; 'Century of population change' ABS 1301.0 – Year Book Australia 2001; Historical Statistics, Statistics Norway, table 3.1; Historical Statistics Norway 1978, table 164,165, 166; Statistical Yearbook Norway 1981, table 209.

Table 2: Resource exports as proportion of total visible exports

	1871/3	1881/3	1888/90	1898/00	1900/1	1910/11	1920/1	1930/1	1940/1**
Australia	86	90	92	83	94	94	94	96	91
Norway	92	89	92	91		95	91	93	95
	1950-51	1960-61	1970-71	1980-81					
Australia	94	86	78	73					
Norway	88	85	73	85					

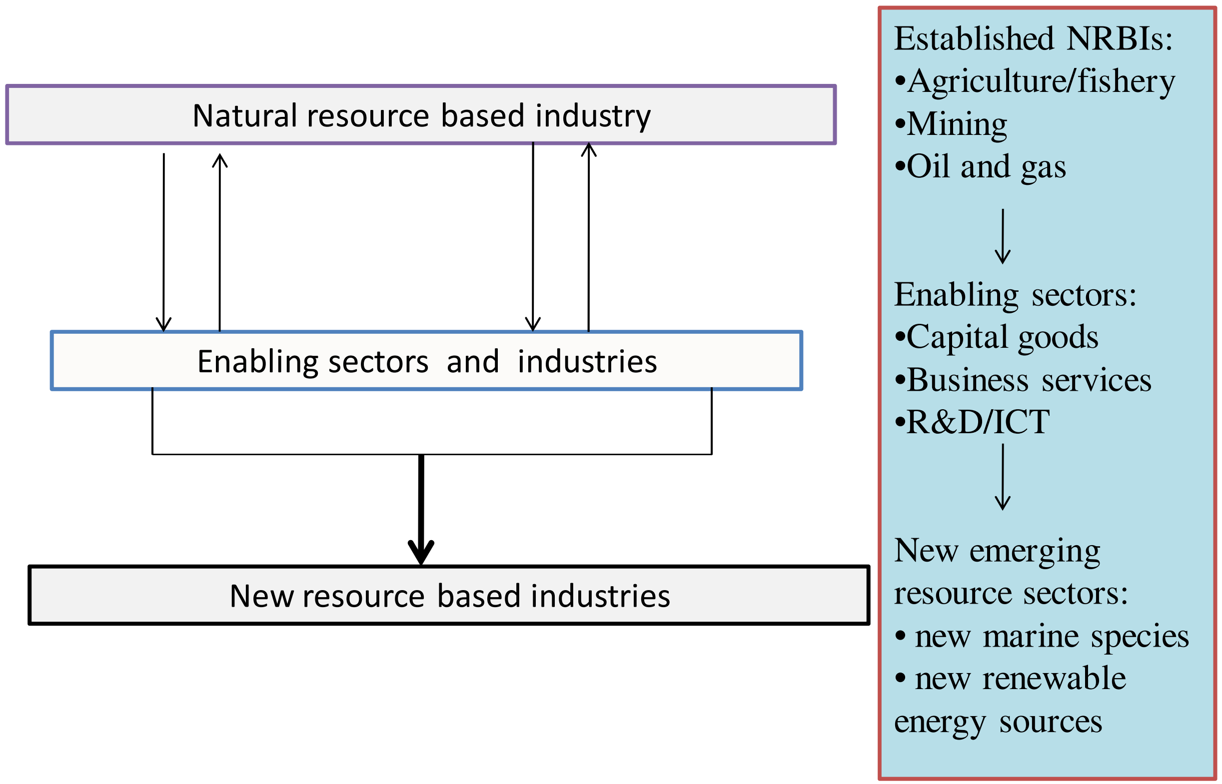
Norway – calendar year (1871, 1881 etc)
** Norway = 1939

Sources: Vamplew ed, 188; Freebairn 160; Butlin (1962), 410-11, Historical Statistics, Statistics Norway, table 3.1; Historical Statistics Norway 1978, table 164,165, 166; Statistical Yearbook Norway 1981, table 209.

Table 3. Development of resource-based industries in Australia and Norway

Period	Australia	Norway
- 1850	Sealing and whaling Pastoral land boom: wool Coal mining NSW	Fisheries Timber Mining
1850-1900	Gold (Victoria 1850s, WA 1890s) Mining (1870-1890) Wheat (SA)	Wood processing
1900-1950	Refrigerated food (meat, butter 1920s) Sugar	Electricity (from 1900) Metals Fertilisers Mining (1880-1920)
1950-2000	Oil (1950s) Rutile/ilmenite (1950s, 1960s) Aluminium (1960s) Natural Gas (1970s) Uranium (1980s) Fish farming (1990s?) Coal seam gas (1990s) LNG (2000)	Frozen fish (1950s) Fish oil/meal (1950s) Electricity- metals (1950s, 1960s) Oil (1970s) Fish farming, marine resources (1980s) Natural gas (1990s, 2000)

Figure 1. Resource-based economy diversification model



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[i] For a very recent survey of much of this literature see Van der Ploeg (2011),

[ii] Exceptionally, Dutch disease has been subject to more formal modelling, particularly Neary and Corden (1982) but with no universally agreed model.

[iii] In part of the literature using the Dutch disease model (Sachs and Warner, 1995) the natural resource sector is assumed to have no learning or use of knowledge at all. The assumption is that there is no labour or capital used in this part of the economy. In this way, the model discusses the consequences of windfalls (free financial gains) for economic growth.

[iv] Greasley and Oxley (2010) use patents data to argue that a more narrowly-based development block drove New Zealand's economic development through the interactions among gold, meat, printing & publishing, butter, and cheese.

[v] For Australia, the key works of synthesis are Meredith & Dyster; White (1992); Maddock and McLean (1987). For Norway Hodne (1975, 1983, Sejersted (2011), Thue (2009). There is no worthwhile comparative study of the development of the two economies.

[vi] Regarding definitions, see http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=14

[vii] Of particular importance are: Hirsch & Lounsbury (1996); North (1990); North (1993); North (1999).