Norway – a global maritime knowledge hub

by

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Abstract

Knowledge based industrial development takes place in Global Knowledge Hubs or superclusters characterized by a high concentration of innovative industrial actors interacting closely with advanced research institutions, venture capital and competent ownership. The extreme example of a global knowledge hub is the biotech and life science industry in Boston. The greater Boston area has a higher concentration of advanced universities, research labs and specialized biotech firms, than anywhere else in the world. Thus Boston has taken the global leadership position in the high growth biotech industries by capitalizing on their knowledge resources.

In this report, the global knowledge hub model is applied to the Norwegian maritime industry. The Norwegian maritime and offshore industry is characterized by a high number of global actors operating out of Norway, forming subclusters in shipping, technological and commercial maritime services, specialized ship building and ship equipment, energy and offshore industry, maritime and subsea operations. Norway has build a strong global maritime knowledge base, extending from fisheries and governance of marine resources, to shipping, maritime operations, and offshore oil and gas, especially when it comes to deep and arctic waters. Norway combines the knowledge and technology targeting the marine, maritime and energy industries.

For sustaining such a global knowledge position in the maritime areas, Norway needs to develop specialized knowledge infrastructure to attract talent and technology on a global basis. The plans for establishing a new Ocean Space Center at Marintek and NTNU in Trondheim should be understood and analyzed in these terms. The ambition is to create a global knowledge center for Ocean Space Technology, covering a large range of ocean space challenges of the future, including the high priority arctic and climate challenges.

Abstract (in Norwegian)

Norges viktigste ressurser og kompetansefortrinn er relatert til havet. Norge er en stormakt innen shipping, maritim industri og maritime tjenester. Norge er en stormakt innen offshore olje og gass, offshoreteknologi og offshore-industri. Og Norge er en stormakt innen fiskeri, oppdrett og forvaltning av marine ressurser. Dette er de samme områder hvor Norge også har tatt en ledende internasjonal posisjon når det kommer til forskning, teknologi og innovasjon.

Havet er verdens viktigste fremtidige ressursreservoar, ikke minst når vi tar med polarområdene. Havet er en av nøklene til løsning av verdens klimaproblem. Havet og havets ressurser må forvaltes med klokskap og hensynstaking til fremtidige generasjoner. Innen alle disse områdene kan Norge spille en avgjørende internasjonal rolle.

Forskning innen industriell konkurranseevne har pekt på betydningen av industrielle næringsklynger. De virkelig kunnskapsbaserte næringer som bioteknologi og informasjons- og kommunikasjonsteknologi, springer ut av superklynger eller globale kunnskapsnav med en stor konsentrasjon av forsknings- og kunnskapsressurser. Globale kunnskapsnav er i rapporten illustrert med Boston innen bioteknologi. Slike globale kunnskapsnav er kjennetegnet av forsknings- og utdanningsinstitusjoner i verdensklasse, god tilgang på kompetent risikokapital, mange innovative kunnskapsbedrifter, fremragende kunnskapsmessig infrastruktur og et stort antall spesialiserte tjenestebedrifter som opererer globalt.

Nøkkelen ligger i høye kunnskapsinvesteringer, tett kunnskapssamspill, intens rivalisering og sterk forretningsmessig orientering. Innovasjons-konkurranse blir under slike betingelser viktigere enn kostnadskonkurranse. Norge har muligheter til å utvikle et globalt kunnskapsnav innen maritim virksomhet og innen energi. Som liten nasjon med et høyt kostnadsnivå og en smal industriell base, må vi spesialisere oss innen noen få spisse kunnskapsområder hvor vi har spesielle kompetansefortrinn å bygge videre på. Norge har klart å utvikle et globalt maritimt kunnskapsnav gjennom en stor konsentrasjon av internasjonalt konkurransedyktige bedrifter innen shipping, skipsindustri, offshoreindustri og maritime tjenester. Samtidig har Norge klart å utvikle forsknings- og utviklingsmiljøer innen marin og

maritim forskning i verdensklasse, både innen industrien, i instituttsektoren og ved universitetene. Forskingsmiljøet ved NTNU og MARINTEK (SINTEF) i Trondheim er et godt eksempel på dette.

For at et industrielt forskningsmiljø skal kunne tiltrekke seg de fremste talentene og de mest krevende oppdragsgiverne i verden, må det utvikles en spesialisert kunnskapsmessig infrastruktur som gjør fremragende forskning og utvikling mulig. Etableringen av det nye Ocean Space Center ved NTNU og MARINTEK (SINTEF) må forstås i et slikt lys. Det nye forskningssenteret må kunne dekke alle fasene fra grunnforskning til innovasjon og kommersialisering. Dette inkluderer analyse, modellering, simulering, eksperimentering, verifikasjon og implementering. Ikke minst er det mulighetene til fullskala uttesting som skaper de store teknologiske sprangene. Nordsjøen har vært eksempel på det.

Målet er å utvikle et bredt forsknings- og utviklingsmiljø innen havromsteknologi (Ocean Space Technology) som retter seg mot shipping og maritim industri, energi og offshore industri, undersjøisk gruvedrift, samt sjømat, marin bioprospektering og forvaltning av marine ressurser. Det er naturlig å ha et særlig fokus på miljø og arktiske områder.

Ocean Space – The Next Frontier

Norway is in a unique global position, both in terms of its natural resources and in terms of its industrial knowledge. Norway controls one of the largest ocean space in the world, including enormous petroleum and energy resources. Norway has managed its natural resource position so well that it currently ranks higher than all other major economies, both in GDP per capita and in terms of financial resources per capita set aside for the future.

Norway has developed its unique global position by combining three major factors: Ocean, technology and knowledge. No other nation in the world has a similar dominance in combining these three factors. Norway is one of the major maritime nations in the world, controlling one of the largest commercial fleets, and Norway is dominating in maritime services and in many advanced segments of industrial shipping. Norway has a similar leading position in the offshore oil industry, dominating in advanced niches such as offshore oil drilling rigs, supply and production vessels and subsea technology. Finally, Norway is one of the major producers of seafood in the world, dominating salmon fish farming on a global basis. It all relates to conquering the ocean.

In fact, we may stretch the analysis even further by mentioning the strong position that Norway has in hydro power, transforming mountain water to the world's cleanest energy. The hydro power industry formed the basis for the whole industrialization of Norway. Hydro power remains important as renewable energy, but today's knowledge and industrial frontiers are the oceans. Perhaps the most promising ocean space is what so far has been explored the least, the Arctic and Antarctic Oceans. Again Norway is in unique position not only due to its high north location, but also due to its long-term investments in arctic and climate research and to its experience in ocean resource governance and expertise in international marine law and regulations.

It is worth remembering that 70 % of the globe is oceans and water. Where should the future resources and the energy for a rapidly growing world population come from? The answer is the Ocean Space. The oceans have a similar important role in solving the global climate crisis. Ocean transportation is the most energy efficient and climate friendly way of transportation. The oceans are the major absorber of CO_2, and the oceans may also become the major provider of renewable energy in the future. Finally, the oceans are also a major provider of food and valuable protein to a rapidly growing world population.

How can we conquer the oceans? We can do so by pushing the research and knowledge frontiers and by developing new Ocean Space Technology. Ocean space technology is applied to fisheries, their vessels and equipment. Ocean space technology is applied to shipping, its vessels, ports and equipment. Ocean space technology is applied to the offshore oil and gas industry, its platforms, pipelines, vessels, terminals, subsea facilities and equipment. And it does not stop by these industries. All ocean based resources require ocean space technology. Ocean space technology applies to exploration, development and production of ocean resources, including marine bio prospecting for new marine resources. Knowledge into ocean space technology also applies to resource protection, governance and regulation, including international environmental standards and international ocean law.

Norway combines the knowledge and technology targeting the major marine, maritime and energy industries. It has done so in order to survive as an industrial nation. It has done so from an economy with one of the highest cost levels in the world. Thus we had to develop smarter and more cost efficient technological solutions in order to stay competitive in the maritime and energy industries. Research and development in the maritime and offshore areas has been the major driver, combining the R&D resources of universities, institutes and industrial companies, drawing on a common R&D infrastructure of computer power, labs and test facilities.

Through its specialization in the maritime and energy industries and through its dedication to knowledge and technology, Norway has emerged as a Global Maritime Knowledge Hub. This position has been achieved through centuries of investments in maritime expertise, from the most advanced technological R&D to operational maritime knowledge at ships and oil platforms. In order to make the Global Maritime Knowledge Hub a sustainable position, we need a strong vision and a clear knowledge strategy. It also requires some major investments in people, technology and research and development infrastructure. This report is about creating the Ocean

Space Centre, located at the Norwegian University of Science and Technology (NTNU) and MARINTEK (The SINTEF Group) in Trondheim, Norway. In the following section we will present the strategic foundation for the project.

Global Knowledge Hubs

Studies of industrial competitiveness have identified the important role of industrial clusters. An industrial cluster is a geographical concentration of interconnected companies, customers, suppliers, service providers and research and educational institutions sharing a common field of industrial knowledge, competing in an international market (Porter 1990). 2008 Nobel Prize Laurate in Economics, Professor Paul Krugman (1995) refers to clusters as agglomerations and knowledge linkages. A dynamic industrial cluster requires a critical mass of industrial and knowledge actors at every stage of the value chain or value network of the industry, and there needs to be related industries and knowledge pools to draw upon.

Agglomerations are static systems. Agglomerations become industrial clusters or dynamic knowledge systems when industrial and knowledge actors start to interact. This way knowledge is shared, challenged and upgraded. Thus the cluster becomes the knowledge engine that drives productivity and innovation. Industrial clusters are characterized by a combination of close cooperation and intense rivalry. This fosters innovation and entrepreneurship with a dedication to commercial success. Places like Silicon Valley and Boston have these characteristics in the information technology and biotech industries. Norway has these dynamic cluster characteristics in the maritime and energy industries. Institutionally, Norway is very different from California and Massachusetts, thus, strong industrial clusters are almost impossible to imitate, but they all depend on knowledge and knowledge investments.

Industrial clusters produce positive knowledge externalities. There are knowledge spillovers between actors, and rapid learning processes take place, stimulating both innovation and commercialization of innovation. Industrial actors are able to take advantage of this common knowledge environment by interacting closely with demanding customers, advanced suppliers and specialized R&D institutions. The small specialized knowledge actors are particularly important. They are often the knowledge bridge builders, and they form knowledge networks. Thus strong industrial clusters are characterized by innovation competition. This requires high knowledge investments, continuous upgrading of human resources and large scale direct investment in research and technology development, including heavy investments in laboratories, test facilities and knowledge infrastructure.

In order to obtain the full innovation potential of industrial clusters the government should adapt knowledge based industrial policies in order to stimulate industrial development and innovation outcomes. The reason is simple. Each firm is not able to capture the full economic advantages by investing in human resources and knowledge development within the firm, as there is always a knowledge leakage to other firms by such investments. Thus the social economic benefits of the knowledge investments exceed the private economic benefits of knowledge investments, and the government should make up the difference in order to obtain optimal knowledge investments from a societal or industrial point of view. For further insights into the relationship between knowledge, innovation and economic growth, the reader is referred to endogenous growth theory (Romer 1990). This is perhaps the single most influential field of modern economics, but the implications are only partially understood.

There is one industrial cluster that stands out if we analyze the industrial sectors where Norway has its global competitive strength, and that is the maritime and offshore sectors. Norwegians have been seafarers since the Viking ages. Without conquering the oceans Norwegians would have been starving in their cold north. Thus Norway early became one of the powers in shipping, along with the British, the Dutch and the Greek. The British have lost their shipping empire. The Dutch remain strong in ports. Greek shipping is still highly competitive, but Norway has a much wider and much stronger technological base, and a much stronger position in maritime services.

Norway has built competitive strengths in ship design, specialized ship building, maritime equipment, maritime services, maritime operations and maritime research, as well as in oil rigs, drilling and subsea technology and large scale project management. Rather than closing down its shipyards as Asia became the leading region in the world in ship building, Norwegian yards specialized in the more advanced segments of ship building, embracing the offshore sector which demanded specialized supply ships, anchor handling vessels and advanced drilling and production rigs.

An example from Norwegian ship building is Ulstein, located on an island outside Aalesund, which has become world famous for its innovative X-bow design in supply vessels. The transitions in Norwegian ship yards were from fishing vessels and ferries, to conventional ships, to specialized gas and chemical tankers, to advanced supply vessels and research vessels packed with technology.

The most important segment of the Norwegian ship industry is not in ship building, but rather in ship equipment, from propellers, pumps and deck machinery to dynamic positioning and advanced maritime IT systems. The closeness between ship owners, ship yards, ship designers, ship equipment manufacturers and maritime services has been a major success factors. Today, Norwegian maritime equipment is exported to ship yards and offshore yards on a global basis. An example is FRAMO, the world leading manufacturer of specialized pumps for chemical tankers and offshore, situated outside Bergen, but exporting and servicing maritime equipment on a global scale. Another famous example is Kongsberg Maritime which has delivered the integrated Port control system to Singapore and other major harbors.

An even more impressive story can be told when it comes to maritime knowledge services, both technological maritime services and commercial maritime services. In technological maritime services, NTNU Norwegian University of Technology and Natural Sciences, MARINTEK and Det Norske Veritas (DNV) are among the leaders in maritime research and development, serving the whole range of markets from ship design, ship building and shipping to the large offshore oil and gas projects, including rigs, production vessel and subsea production facilities. DNV is one of the leading ship classification societies in the world, located at Høvik just outside Oslo, only minutes away from the headquarters of some of the leading shipping companies in the world, also being located in Oslo. NTNU in Trondheim hosts CeSOS, Centre for Ships and Ocean Structures, the world's leading research institute in hydro dynamics and maritime technology, and a dedicated Centre of Research Excellence, attracting researchers and PhD candidates from around the world. CeSOS is co-located with MARINTEK which has the leading maritime laboratories and test facilities in Europe.

In commercial maritime services, Norwegian companies control such segments as marine insurance and P&O (Skuld and Gard), ship and offshore finance (DnBNOR and Nordea), ship and offshore brokerage (Platou and Fernleys), and marine law (Wikborg Rein and Vogt & Wiig). The same applies to the more specialized segments in commercial maritime services, including the world largest maritime service network, Wilhelmsen Maritime Services (WMS), serving ships at 350 locations in more than 100 countries.

What characterizes the Norwegian maritime cluster? The firms are highly competitive, and they operate globally. The shipping firms are often privately owned, and they are willing to take risks inherent in the cyclical maritime industry. There are typically at least two firms competing in the same category, often at the same geographical location, and they are intense rivals. They share a common labor market, rely on the same set of advanced suppliers and draw on the same pool of maritime knowledge. They are highly preoccupied with new technology, and they are dedicated to be the most innovative. They have decided to meet the global climate challenge by agreeing on a zero emission vision for Norwegian shipping. It is from such a maritime cluster, a sustainable Global Maritime Knowledge Hub can be developed.

Let us first try to reiterate the difference between an industrial cluster and a global knowledge hub. A global knowledge hub differs from an industrial cluster in terms of its knowledge content, its knowledge investments, and its density of knowledge networks. A global knowledge hub is a supercluster with more weight on advanced knowledge generation through research and development and with closer linkages between the many industrial, commercial and knowledge actors. The availability of competent risk capital is high.

Boston in biotech and life sciences is the ideal type of a global knowledge hub. Boston has a higher concentration of universities, labs and specialized biotech firms than any other place in the world. The biotech industry depends more on basic research than almost any other industry, and it pivots on the best talents, the best technologies and the best labs, attracting researchers and PhD candidates, as well as specialized knowledge firms, from around the world. In turn, the large pharmaceutical corporations also locate their centers of excellence in the Boston area, making greater Boston the global biotech knowledge hub.

When drawing a map of an industrial cluster, we typically put the major manufacturers or multinationals at the center, relying on a large network of customers, suppliers, service providers and other institutions. Going back to the maritime industry, a maritime cluster typically places the shipping firms in the middle, surrounded by cargo owners, ports, logistics providers, ship building, ship equipment and maritime services. At the periphery of the cluster one finds maritime R&D and maritime education along with a host of other service providers.

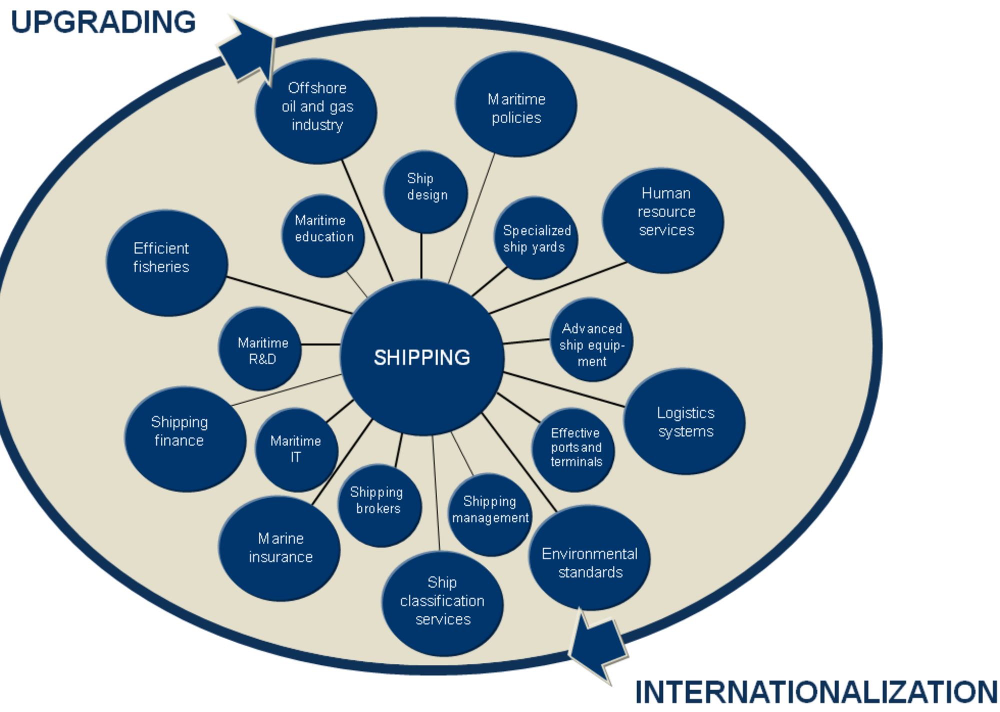

Figure 1: Norwegian Maritime Cluster

In global knowledge hubs industrial development springs out from a core of research, education and innovation, fueled by venture capital and competent investors. It is the combination of knowledge generation and innovation from research and commercialization of innovation from venture capital that forms the core of a global knowledge hub. If we should illustrate the global biotech knowledge hub in Boston, we can illustrate the hub as in Figure 2.

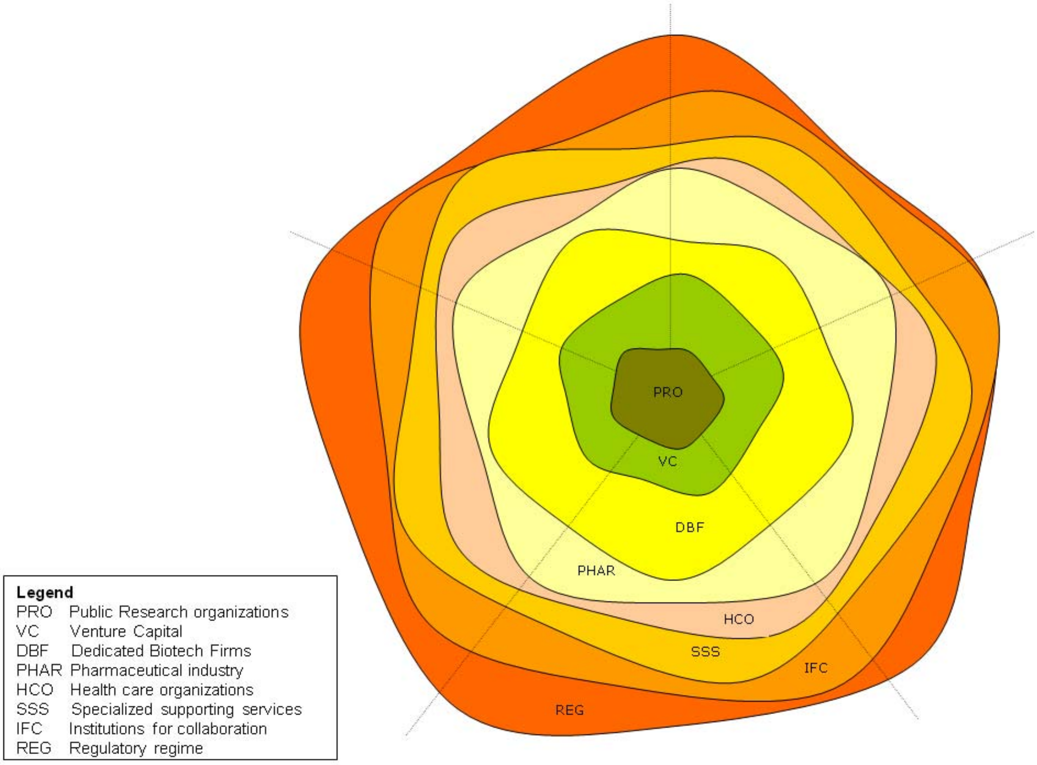

Figure 2: Boston as a Global Biotech Knowledge Hub

At the very core of the global biotech knowledge hub is the public research organizations (PROs). Three world class universities compete to be the leading institutions in the biotech and life sciences; MIT, Harvard and Boston University. This is where basic research is undertaken and made available to the industry through PhD dissertations and industry research programs, and disseminated thorough advanced and specialized educational programs.

The next element of the core in a global knowledge hub is the venture capital firms (VCs) working closely with PROs. VCs have the ability to fund innovative ideas with large commercial potential, but they also have the ability to kill ideas with limited commercial potential.

The outcome of the nexus of R&D and VC is a host of dedicated biotech firms (DBFs). Some of these DBFs are highly successful and become the future leaders of the biotech industry, while other DBFs fail early or become new start ups with an alternative business model. The essence of the coupling of PROs and VCs is to combine innovative ideas with sustainable business models. Thus two logics should be combined, the scientific logic and the commercial logic.

The innovations that are successfully commercialized, create their initial profits by going public (IPOs) raising money on the stock exchange, or the DBFs are acquired by the big multinational pharmaceuticals corporations (PHAR) that have the financial means to do large scale commercialization of the new products and services.

A necessary requirement to succeed both at PRO, DBF and PHAR levels is the availability of large scale, state-of-the-art medical labs and test facilities. In the life sciences and the biotech industry the major knowledge infrastructure is typically the university hospital labs at the large health care organizations (HCOs) along with the university hospital's supply of research patients. Some of the more advanced labs are provided by large commercial actors and by specialized service firms. Many of the lab facilities have investment requirements that are so high that the facilities need to be shared, and the costs have to be distributed across the various industrial actors. In many cases, the government makes the investments in lab facilities, offering lab capacity at marginal costs to the R&D community. It is an integral of the knowledge infrastructure and is part of the core of a global knowledge hub.

The large number of knowledge workers in a global knowledge hub works in knowledge based services. Many of them work in R&D institutions, in R&D based start-up firms and in knowledge functions of the large multinationals that are co-located there. These organizations are large buyers of specialized knowledge services, such as testing, instrumentation, marketing, communication and IT services, and in addition there is a host of administrative and support services that are outsources to commercial actors. Thus the outer layers of a global knowledge hub are the specialized service suppliers (SSS), having the local knowledge industry as their initial market, but often expanding rapidly into other knowledge clusters, both regionally and globally.

Finally, a well functioning global knowledge hub requires institutions for collaboration (IFC) that perform key network functions. Such organizations provide meeting places, facilitate knowledge linkages, represent the cluster externally, manage government relationships, and are active in global brand building. Silicon Valley is a global knowledge brand in the ICT industries, like Boston is a global knowledge brand in biotech and life sciences. Behind the network organizations of San Francisco and Boston are strong knowledge and corporate actors that build their own global brand, all within the context of a common location. Harvard and MIT are immediately associated with Cambridge and Boston, Massachusetts, and they are perhaps the two strongest university brands in the world.

A global knowledge hub functions within a regulatory context (REG) that is supportive of the long-term knowledge development in the industry in focus. In biotech and life sciences the regulatory context of stem cell research is an example. The setting of common industrial standards is another example. The investments in hard and soft infrastructure are critical elements in developing an efficient knowledge hub. So are the innovation policies and the venture capital policies, including the provision of seed capital and other risk capital schemes.

The Boston case in biotech and life sciences is included for illustrative purposes, in order to define what a global industrial knowledge hub is. Let us first summarize the main characteristic of a global industrial knowledge hub, and then the concept is applied to the maritime industry, using Norway as the case.

A global knowledge hub has the following characteristics:

- A concentration of state-of-the–art education, research and development with many international knowledge workers
- A concentration of major international companies with specialized centers of excellence for research, development and innovation
- A concentration of competent venture capital and specialized investors with an ability to commercialize new technology and implement new business models
- A concentration of advanced knowledge-based services covering the major technological and commercial elements of the industry in focus
- Strong and competing research universities with many boundary spanning units and close linkages to business
- Well functioning knowledge infrastructure and the most advanced labs in the world
- Excellent knowledge networks with a global reach
- An entrepreneurial knowledge culture with a drive to succeed commercially

According to Richard Florida (2005) who has studied urban regions and the role of the creative class in the knowledge economy, regions and nations have to win in the global T-battle. The global T-battle is for Talent, Technology and Tolerance. Knowledge regions compete to attract the best talent and the most innovative knowledge firms. Talents in universities, institutes and knowledge based firms are the ones who are best able to develop the new technologies, provided they have the necessary knowledge infrastructure and funding to take ideas through the various development stages into full scale testing and commercialization. Tolerance is a socio-cultural dimension allowing for diversity along many dimensions, such as nationality, ethnicity, gender, religion and behavior. Mono-cultures are found to be less innovative than multi-cultures. Many immigrant groups have strong entrepreneurial skills. Freedom of expressions is another valued dimension. If we place San Francisco and Boston on the three Florida dimensions, the two city regions score very high on all three dimensions.

From an industrial policy point of view, we may add another T to the global T-battle, and that is Tax. We observe nations and regions aggressively pursuing tax competition in order to attract knowledge based industries. Singapore and the Arab Emirates are examples.

Global knowledge hubs are not simply agglomerations of firms, they display dense inter-firm linkages, and they have developed strong knowledge networks. An example from the Boston biotech industry is given in Figure 3, borrowed from doctoral research done at Stanford (Whittington 2007).

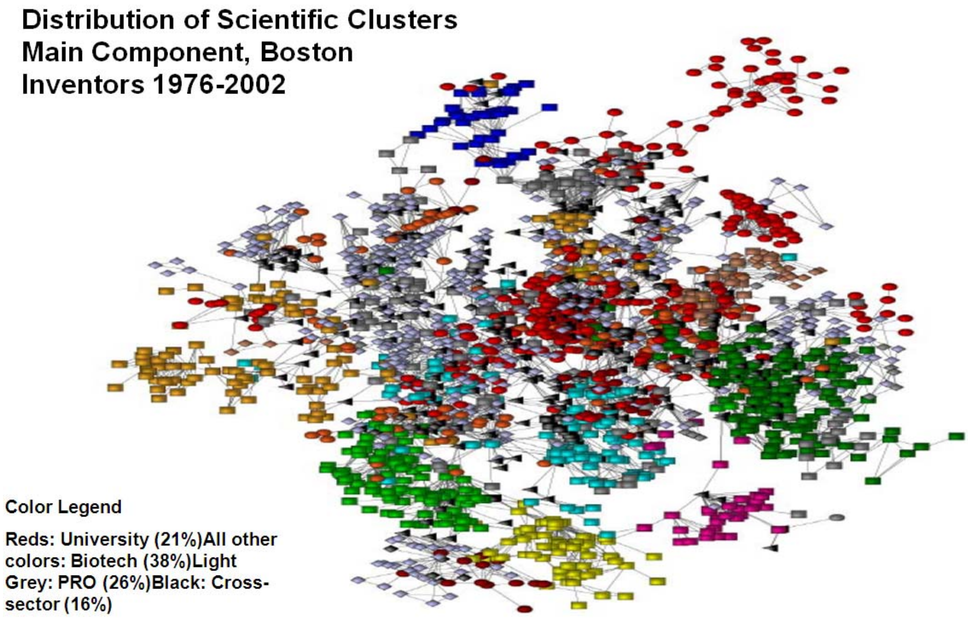

Figure 3: Research and innovation network in Boston Biotech Knowledge Hub

What should be noted from the network map, presented in Figure 3, is the large number of knowledge actors, the density of knowledge interactions, and the central role that universities and public research organizations play in the knowledge network. In some cases new industries can be traced back to one or two professors doing path breaking innovations.

Global Maritime Knowledge Hub

In Figure 1, earlier in this report, we presented the Norwegian maritime industry as a maritime industrial cluster. The concept of a global maritime knowledge hub changes the logics of industrial development from manufacturing logic to knowledge logic. Knowledge based services replace manufacturing as the main industrial driver.

The Global Maritime Knowledge Hub model places research and innovation at the core and links this knowledge base to venture capital and competent investors. From this core of maritime knowledge and competent capital the various industrial sectors of the maritime industry emerge. In Norway the major maritime sectors are shipping, ship industry, offshore industry and maritime services. The transformation from a maritime industrial cluster to a maritime knowledge hub is illustrated in Figure 4.

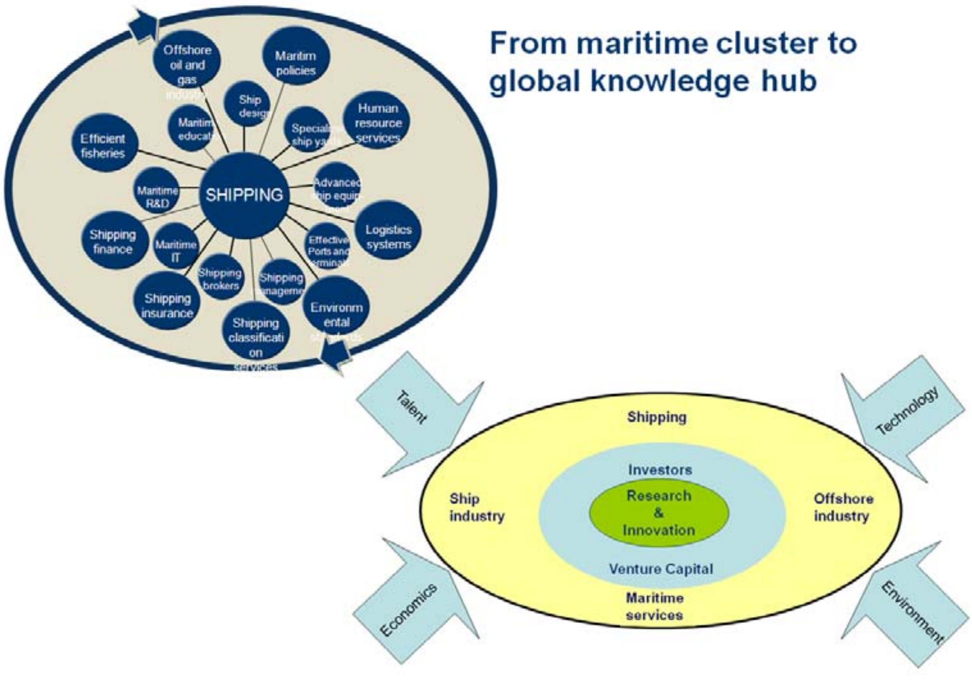

Figure 4: From maritime cluster to maritime knowledge hub

In Singapore the major maritime sectors are port, shipping, maritime services and marine offshore engineering. The conceptual model used by the Maritime Port Authorities of Singapore (MPA) to illustrate Singapore's strive to become the Global Maritime Knowledge Hub in Asia within 2020 is presented in Figure 5. The maritime metaphor used is a propeller with research, innovation and education as the axis and the four major maritime sectors as the blades.

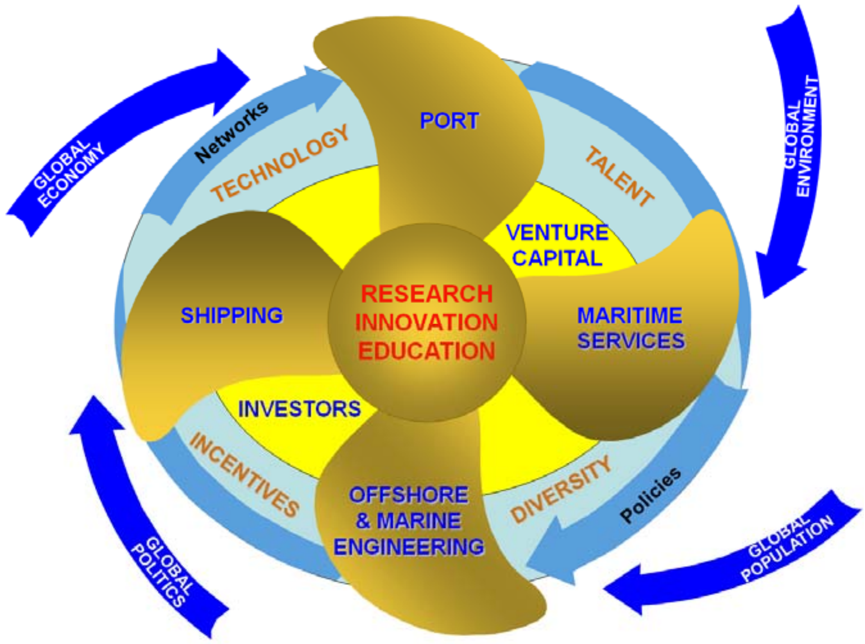

Figure 5: Singapore as a Global Maritime Knowledge Hub

In the previous section the global knowledge hub model was applied to the Boston biotech and life science industry. Here we will translate the global knowledge hub model from the biotech context to the maritime and offshore industries that are the relevant industries for our analysis.

A global maritime knowledge hub is based on research and innovation, as institutionalized by Public Research Organizations (PROs) such as NTNU CeSOS, NTNU Institute for Marine Technology and other R&D institutes. PROs could have public or private ownership.

Next level in the research – innovation cycle is represented by such organizations as MARINTEK (The SINTEF Group) which is co-located with NTNU in Trondheim and by Det Norske Veritas (DNV) and other maritime R&D organizations. These are also PROs as they work for different constituencies and clients.

Some maritime R&D organizations are independent entrepreneurial knowledge organizations, and some are part of larger corporations in the maritime and offshore industries. The Statoil's R&D centers at Trondheim and Bergen are examples of the latter. Such R&D centers primarily target corporate R&D needs, but they also to some extent serve as PROs, exchanging ideas and people both with universities and industry.

At the intersection between Public Research Institutions (PROs) and the maritime and offshore industry there is need for a modern knowledge infrastructure, represented by several educational institutions, state-of-the art research labs, test facilities, simulation centers, IT centers, design, communication and business development units. Let us refer to this layer as Research and Development Infrastructure (RDI). The proposed Ocean Space Center at NTNU and MARINTEK in Trondheim falls into this category. It is an integral part of Public Research Organizations (PROs), but it also offers its research and development services to the maritime, offshore and marine industries and to commercial actors worldwide. The knowledge infrastructure is different in the maritime and offshore industries compared to what is needed in the biotech and life sciences. The extreme case for a specialized RDI is found in nuclear physics where scientific experiments require a linear accelerator of enormous dimensions, like that at CERN in Switzerland. In that particular case, the research and development infrastructure (RDI) is funded by a consortium of European nations.

The third level of a global knowledge hub is represented by Competent Risk Capital (CRC). In the United States this is mostly venture capital firms specializing in various high tech industries. In the maritime and offshore industries competent risk capital is provided by ship owners, oil companies, risk capital firms, investment banks and specialized investors. There is also early stage risk capital provided by the government, while later stage risk capital is provided by the Stock Exchange. Oslo Stock Exchange is not very large in international terms, but it has a strong position in the maritime and energy sectors.

From the inner core of research, innovation, capital and investors we see the emergence of many newly established Maritime Knowledge Firms (MKFs), finding new market opportunities for new technology and new services. Most of these firms are in knowledge based services. Some of them are spin-offs from large and established firms. Some are start ups after divestiture of companies, e.g., when a company has been sold to a new foreign investor. Some companies are entrepreneurial start-ups. These small maritime knowledge-based companies (MKFs) represent much of the innovation dynamics in the maritime industry, but they are often times constrained by risk capital limitations.

Thus any maritime knowledge hub depends on Global Maritime Corporations (GMCs), either within shipping, ship building, ship equipment, offshore industry or maritime services. GMCs are larger, employ more people and have stronger capital base than the other maritime companies. They are mainly driven by a commercial logic. In many respects, the maritime industry circles around the major shipping companies, in the same way as the offshore oil and gas industry circles around the major oil and gas companies. The GMCs are the most visible industrial actors in the maritime and offshore global knowledge hub, but even the multinational corporations critically depend on the fabric of more specialized knowledge firms in the maritime and energy clusters. Multinational actors in the maritime and energy industries, such as BW Shipping and Shell, have used knowledge hub arguments when making large acquisitions or placing centers of research excellence in Norway.

The maritime and offshore industrial cluster attracts a large number of Specialized Service Suppliers (SSS) that provide the various operational activities and support services demanded by the industrial cluster. In the maritime industry, almost every functions and services can be outsourced. Thus there are numerous service suppliers at every level of the value chains or value networks. Actually, the service and support firms are often the ones that provide the highest number of jobs in many industries.

At the outer levels of a maritime knowledge hub we find the Maritime Network Organizations (MNOs), providing meeting places, developing knowledge networks and representing the industry in external relationships. These organizations are the institutions for collaboration. Norway has a number of these organizations, such as Norwegian Ship Owners Association, Maritime Forum, Oslo Maritime Network, Global Maritime Knowledge Hub, NCE Maritime, etc.

Finally, there are the regulatory bodies at the national and international levels, developing and implementing Maritime and Environmental Policies (MEP). Norwegian Ministry of Trade and Industry has the national responsibility for the overall maritime policies, Norwegian Maritime Directorate has the responsibility for safety, while much of the maritime and environmental policies are determined at EU level or at International Maritime Organization (IMO). Similar structures are found in the oil and energy industry and in the marine and seafood industry.

A summary of the global maritime knowledge hub, as discussed above, is presented in Figure 6, using the same graphics as when the concept was introduced in a previous section of the report.

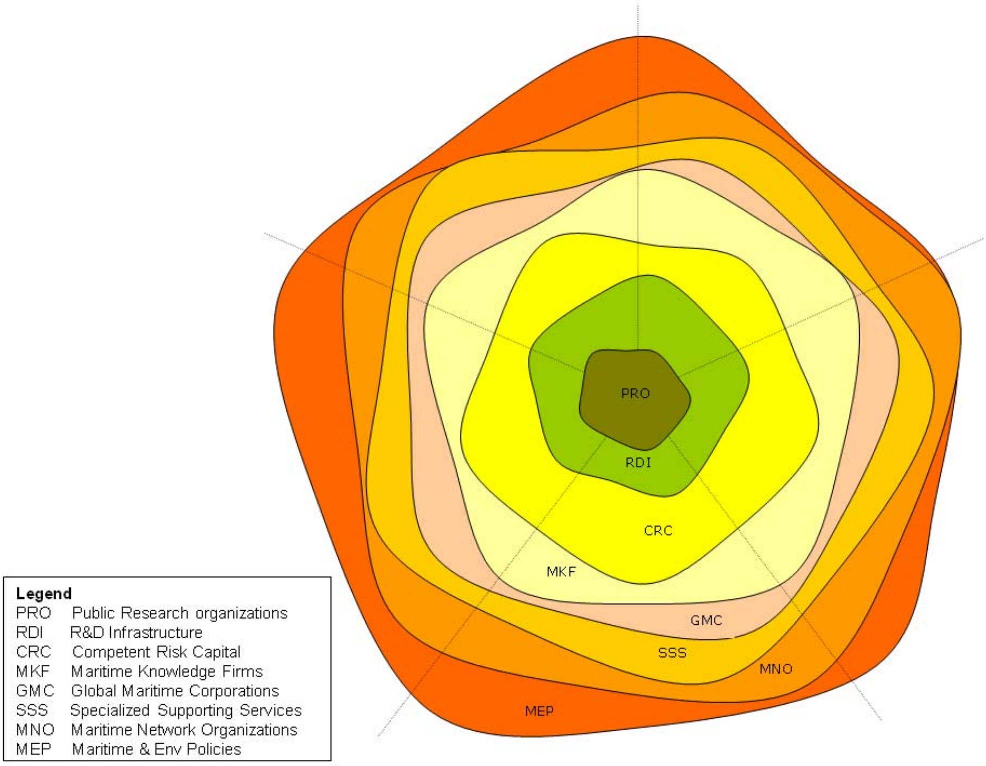

Figure 6: Global Maritime Knowledge Hub

In the next section we will place the new Ocean Space Center into the global maritime knowledge hub model. The Ocean Space Center does not only provide the major Research and Development Infrastructure (RDI) in the global maritime knowledge hub. The Ocean Space Center is required for the global maritime knowledge hub to be sustainable as innovation competition increases. Without a well functioning RDI there will be little R&D, and there will be limited possibilities to model, test and verify new technologies.

Ocean Space Center

The Ocean Space Center has its foundations in basic scientific research as it takes place at NTNU, and in applied research as it takes place at

MARINTEK and at the many industrial customers using the research facilities at Trondheim. The Ocean Space Center provides the specialized knowledge infrastructure for maritime research, attracting top research talents, and allowing for advanced research and development projects. The Research and Development Infrastructure (RDI) does not only facilitate basic and applied maritime research, it provides a knowledge bridge between academia and the maritime, energy and marine industries. The Ocean Space Center is where the new Ocean Space Technology is developed, and the center also allows ocean technology to be tested and verified in order to take it into commercial implementation.

The research and development to implementation cycle has five phases:

(1) Analysis

(2) Modeling and simulation

(3) Experimentation

(4) Verification

(5) Implementation.

These are the phases that most technological projects go through, but there is certainly no linear process of innovation and commercialization here. Rather the Ocean Space Center should allow for open innovation models (Chesbrough 2003)

There are four main areas of industrial applications for the R&D services provided by the Ocean Space Center:

(1) Shipping

(2) Energy

(3) Ocean Mining

(4) Food

Shipping, ship designs, ship building and ship equipment are the traditional sectors of industrial applications for Ocean Space Technology. Today, offshore oil and gas and new forms of renewable energy have become the most important areas of industrial applications for Ocean Space Technology, especially as oil and gas move into rougher, colder and deeper waters. Future applications are in the areas of ocean mining and other types of natural resource exploration and development. Finally, there is the traditional seafood sector and new sources of food from the oceans. All these areas require deep knowledge into oceans and ocean technology.

There are currently three focus areas which are of particular strategic importance for the new Ocean Space Center:

(1) Environment

(2) Arctic climates

(3) Remoteness

Research on the environment and climate change is one of the major knowledge drivers of our time, including research into more energy efficient modes of ocean transportation and new form of renewable energy. The Arctic and Antarctic regions represent the new frontiers in ocean research and ocean technology, especially as the oil and gas industry moves into the high north waters. The gradual melting of arctic ice opens new possibilities for Northern Sea Routes. Arctic shipping may be commercial viable in the near future, and arctic mining is beginning to emerge. Norway, along with Russia, is in a strong position to take a knowledge lead in this area, due to our high north location and its strong presence in the Antarctica.

When it comes to subsea operations, the essential technology is remoteness, which is the ability to operate facilities without human presence on site. Remoteness requires many types of new technology and combination of technologies.

Figure 7 summarizes the strategic picture of the new Ocean Space Center.

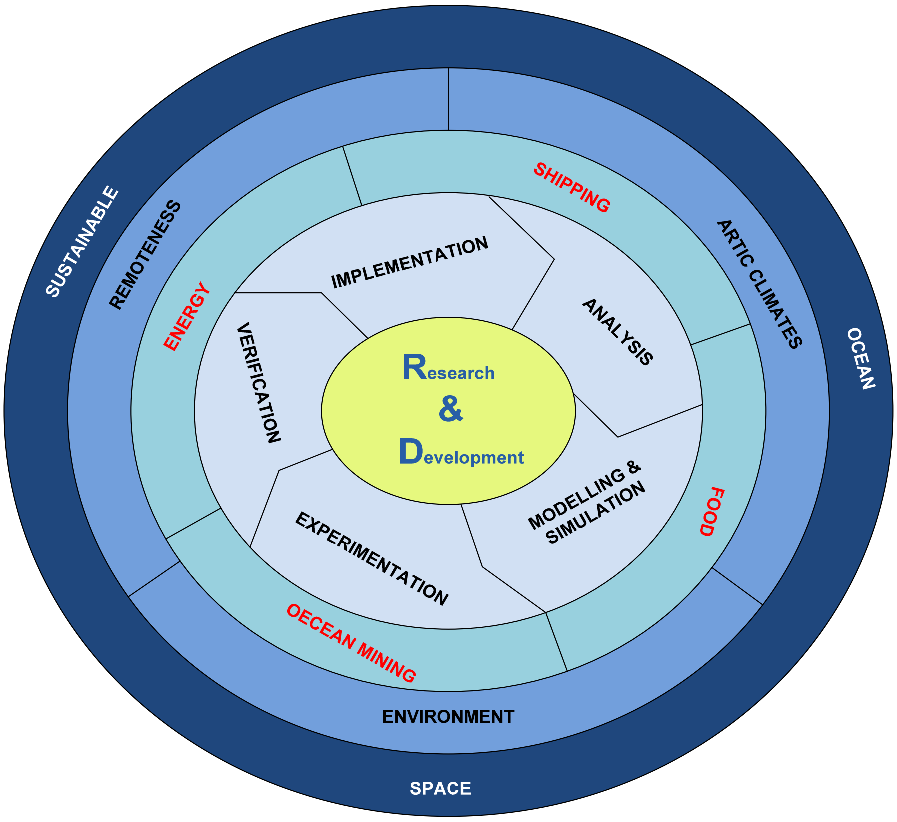

Figure 7: Ocean Space Center

The Ocean Space Center should provide critical ocean space knowledge and technology to maintain a sustainable ocean space. This represents the mission statement for the Ocean Space Center.

To transform the strategic mission statement of the Ocean Space Center to a strategic slogan, the idea is to go from a Center of Excellence to a Center of Gravity. This is essentially what a Global Maritime Knowledge Hub is all about. A Center of Research Excellence is already in place. The challenge is to make it a Center of Knowledge Gravity, attracting top research and entrepreneurial talents, developing cutting edge Ocean Space Technology, and attracting a critical mass of global companies that are able to transform the ocean based industries. To take such a strategic position it might be necessary for NTNU to create an Integrated Marine Faculty which can take a leading role in the European Institute of Innovation and Technology within the marine and maritime sectors.

The proposal for an Ocean Space Center illustrates the important element of Research and Development Infrastructure (RDI) in creating a sustainable Global Maritime Knowledge Hub. There will always be uncertainties associated with such a major RDI project, but it is probably what it takes to create the maritime knowledge industries of the future.

The Norwegian Global Maritime Hub Initiative

In 2007, Oslo Maritime Network was established organizing the main maritime actors in the Oslo area. The shipping industry had been trough a turbulent period of discussion over taxation, and the focus had to be changed to the more fundamental drivers of competitiveness. What drives innovation, and what shapes the future maritime industry? The current maritime clusters seemed to be loosing some of its innovative and competitive power, and Norway was among the nations where the maritime industry was severely challenged by Asia.

How could the global competitive forces be countered? The answer was to develop a maritime supercluster, combining the maritime and offshore industrial clusters and strengthening the research and innovation knowledge base. The concept of a Global Maritime Knowledge Hub was adopted.

The initial analysis showed that a global maritime knowledge hub would require a stronger core of top international research talent, and a campaign was initiated to get the maritime industry to fund new maritime professorships at Norwegian universities, in the areas of highest research and development relevance to the maritime industry. In less than a year, the first 10 maritime professorships were in place, and today, the goal of 20 new maritime professorships is within reach. More than half of these new maritime professorships have been given to NTNU in Trondheim. The Global Maritime Hub Initiative will build active research networks between the companies funding the new professorships and the academic institutions where the maritime professors work, as well as bridging the various research areas.

The main knowledge mechanism for the professorships is the development of new research based knowledge through PhD candidates. If each professor at any time is the academic advisor for at least 3 doctoral candidates, we suddenly have a pool of 60 doctoral degrees, and the pool is renewed every third or fourth year. In addition, the same milieu will educated a large number of new MSc candidates that go to work in the maritime industry.

Phase 2 of the Global Maritime Hub Initiative has been to take an active role in the development of a large maritime research program. Currently, the Norwegian Ministry of Industry and Trade (NHD) and the Norwegian Research Council (NFR) are planning to launch a new maritime research program, Maritime 21, building on the research experience from the oil and energy sectors where similar research initiatives have been implemented. The research program will fund maritime research projects involving researchers from industry and academia. Finally, there are similar maritime research programs at the EU level. These programs require the formation of strong research networks, in order to capture important knowledge externalities.

The Global Maritime Knowledge Hub Initiative was mentioned by Norwegian Prime Minister Jens Stoltenberg in his keynote address to the 100 years Anniversary of the Norwegian Ship Owners Association (NR) in September 2009, and the Global Maritime Hub Initiative was seen as a major shaper of the maritime industry, ranking second after world free trade. Next on his list of shapers was the environmental challenge.

A Global Maritime Knowledge Hub requires high performing international research and development networks. Multinational companies play an important role in forming such networks, and so does international research cooperation between top level academic institutions. Often times such networks boil down to close cooperation between key professors, and such research interaction often goes back to successful doctoral programs.

In some cases, there is need for more extensive formal research and development agreements between nations that are leading in the various fields of the maritime industry. Research and development agreements between Norway and Singapore may serve as an example. Both nations are dedicated to develop a global maritime knowledge hub, but they have different profiles, strengths and weaknesses. In some areas, Norway and Singapore are competitors, and in other areas we are partners. Knowledge development is driven by a combination of rivalry and cooperation.

To create a Global Maritime Knowledge Hub in Norway that is sustainable and internationally attractive, Norway needs to have the highest quality Research and Development Infrastructure (RDI) in the world. Especially important is the specialized RDI, such as ocean lab and test facilities that require economies of scale and scope. Such facilities cannot be economically set up in every maritime R&D environment. They need to be shared to get full capacity utilization, and they need a considerable number of highly qualified R&D personnel and knowledge support services. There is only room for two or three of these RDI investments in the world, and these R&D locations are likely to be the global centers of gravity when it comes to maritime research and innovation.

In the space industry, United States and Russia are the two centers of gravity. In the ocean space industry, Norway has the potential to play a similar role. In Europe, Germany and the Netherlands are probably the strongest competitors over this position. In Asia, Korea and China are clearly the two strongest competitors, especially when it comes to ship building and maritime technology. In offshore technology, the United States remain the strongest competitor, and when it comes to arctic technology, Russia is the runner up.

The proposed Ocean Space Center located in Trondheim will serve two important functions in the development of a Global Maritime Knowledge Hub in Norway. It will be a strong counterforce to the industrial and knowledge erosion that takes place in small industrial nations, due to the economies of scale favoring the largest industrial and knowledge markets, most notably Asia and the United States. The new Ocean Space Center will also be a force of gravity when it comes to attracting talent, technology and maritime knowledge firms. This is exactly the kind of forces required in building a sustainable maritime knowledge hub.

A Knowledge Based Norway: Policies for the knowledge economy

At BI Norwegian School of Management a large national research project, titled "A knowledge based Norway", mapping the major knowledge based industries, has just started. The research project has mobilized 'the Norwegian industrial corporate management', which includes Norwegian Employers Federation (NHO), Norwegian Trade Unions Federation (LO), Norwegian Ship Owners Association (NR), Norwegian Ministry of Industry and Trade (NHD), Norwegian Ministry of Oil and Energy (OED), Norwegian Ministry of Fisheries and Coast (FKD), Norwegian Ministry of Environment (MD), Norwegian Ministry of Research (KD), Norwegian Research Council (NFR), Innovation Norway (INVANOR) and Norwegian Industrial Development Corporation (SIVA). The project will be analyzing all the major knowledge based industries in Norway, trying to unravel their knowledge dynamics and the international competitive positions. The objective is to identify existing and emerging global knowledge hubs, and important knowledge policy implications will be drawn.

The study is based on three simple premises. For industries to be competitive and sustainable at a high cost location like Norway, industries have to compete globally, industries have to be knowledge based, and industries have to be environmentally robust.

Nations and regions compete to be the most attractive locations for knowledge based industries, and those locations that have the strongest knowledge hubs are also the ones that are most likely to succeed in the long term. Knowledge hubs have higher innovation and commercialization capacity than other industrial locations, due to their knowledge generation capacity, their ability to innovate, and their ability to commercialize through the availability of competent risk capital. This may offset the effects of relatively higher factor costs. On the other hand, most international corporations will exploit factor costs differences by reconfigurating their value chains, value shops or value networks, locating units of development, manufacturing, marketing and service to many different countries. Similarly, multinational corporations reconfigurate their knowledge networks on a global basis, setting up centers of excellence in favored knowledge locations. The objective is to make these centers into Centers of Knowledge Gravity.

The Knowledge Based Norway project includes ten different industries that are global, knowledge-based and environmentally robust. The maritime-offshore industry is on the top of this list. It has four major industrial pillars: Shipping, ship equipment, maritime services and offshore industry, and the industry has research, innovation and capital in the middle. None of the other Norwegian industries studied have a similar concentration of industrial actors and knowledge resources. It is the industry where Norway has a global brand of quality. The maritime-offshore industry is perhaps the only industry where Norway can maintain a global knowledge hub in competition with the major powers of the world. In other industries, Norway is limited to take global knowledge hub positions in niches only. The full empirical results of the study will first be ready for publication in 2011.

One objection that can be raised against the knowledge hub framework, is that it merely applies to the most knowledge intensive industries. Thus there may well be global knowledge hubs in biotech and life sciences, but it is rare to find global knowledge hubs in the more traditional manufacturing and service industries. I would strongly disagree with this position. I also reject the idea that some industries are high tech industries and other industries are low tech industries. It is not correct to look at the technological and knowledge content of the product. We also have to look at the manufacturing and process technologies applied the systems integration, and the business models. Examples from retailing and transportation illustrate the point. Swedish IKEA is one of the most knowledge intensive retailing systems in the world, having created more wealth to the owners than high tech Finnish Nokia. Walenius Wilhelmsen is one of the most knowledge intensive shipping companies in the world, having optimized ocean transportation of cars using specialized Ro-Ro ships and tailor made logistics systems. The company is currently pioneering green shipping in close cooperation with its customers such as Toyota.

Where should companies in an industry like shipping get their industrial knowledge from? Much industrial knowledge is, of course, generated within the companies themselves as the companies move up the learning curves. Much industrial knowledge is generated when a firm interacts with its customers, suppliers and service and knowledge providers. New industrial knowledge is sometimes generated when firms hire new employees with experience from other parts of the industry or from related industries. Educational institutions play an important role, and so do R&D institutions. Brokers, banks and consultants are important knowledge providers, creating knowledge externalities between actors. Learning and knowledge transfer most effectively take place in knowledge networks, especially when internal knowledge is confronted with external knowledge, like what typically takes place in research and development projects or in open innovation processes.

Global knowledge hubs facilitate innovation and upgrading processes. There is a critical mass of industrial knowledge actors at all levels of the value chain or value network. There is active exchange of ideas and personnel between the knowledge actors. There is a large amount of investments in research, development, innovation and commercialization. There is intense rivalry in the industry, but the actors are also able to cooperate. There is the necessary knowledge infrastructure to undertake large scale innovation projects and to do full scale implementation of new technology.

For Norway to maintain its leading knowledge position in the maritime and offshore industries, we need a clear vision, big hairy goals and some lead knowledge project to be implemented. When Norway became an offshore oil and gas nation, developing the North Sea oil and gas fields, each new oil and gas field provided new technological challenges that pushed innovation and performance to new frontiers. Ekofisk, Statfjord, Gullfaks, Troll, Aasgard, Ormen Lange and Snøhvit were development projects for full scale implementation of new technology. Today, the Mongstad CO2 capture project is the current Norwegian moon landing project, trying to solve some of the most difficult climate challenges. The project has considerable technological and commercial risks, and it represents very large investments.

In the maritime sector, there is not the same tradition for mega projects or investment in disruptive technology. Historically, the major disruptive technologies in shipping were the transitions from sail to steam vessels and from steam to diesel engine vessels. In both cases, Norwegian ship owners were early movers. Similar disruptive technologies at sector level were the introduction of chemical tankers, gas tankers and LNG tankers. The most radical innovation in changing shipping, was the introduction of the container along with the associated port and logistics technology that go with container shipping. What are the new maritime technology frontiers? We are probably not able to tell, but we should prepare for it by making the knowledge investments for the future today.

Conclusions and recommendations

The world is at the nexus of some major challenges. There is a climate crisis facing us due to global warming. There is a resource crisis facing us due to a rapidly growing world population, and this crisis includes the lack of food and clean water. Currently, there is also a global economic crisis, and many countries are in recession with record high unemployment. We all loose in this game, but the poor are always the ones that suffer the most. How can we meet these global challenges without at the same time destroying our environment?

There are two answers to this. We have to develop new knowledge and new technology, and we have to develop the resources of our oceans. 70% of the world's natural resources are ocean resources, and we have merely started to develop these resources.

Norway is a highly favorable position both when it comes to natural resources and when it comes to industrial knowledge which is necessary to help solve the world crises. In addition, Norway has the financial resources needed to invest heavily in knowledge development. A small high cost economy like Norway has to specialize in a few areas where there is a competence advantage. The maritime and offshore sector and the energy industries are the key industrial areas for Norway, and these industries also need to be the key areas for research and innovation.

In order to analyze Norway as an attractive industrial and knowledge location, the global knowledge hub model was introduced. A global knowledge hub is a supercluster of industrial and knowledge actors, driven by research and innovation, and fueled by competent risk capital and investors. Research and innovation, taking place at Public Research Organizations (PROs), form the core of a global knowledge hub, but it also requires world class Research and Development Infrastructure (RDI).

The concept of a global knowledge hub was illustrated using Boston and its position in biotech and life sciences as an example. Norway has a similar position in the maritime and offshore industries. In order to make the Global Maritime Knowledge Hub in Norway sustainable, we need to make sure that the two core elements remain strong and vibrant. First and foremost, we need a human resource pool of top quality research talent at the Public Research Organizations (PROs). Secondly, we need to have world class Research and Development Infrastructure (RDI) to attract the best talent and the global industrial customers. Investing in a new Ocean Space Center located in Trondheim is the critical element in a specialized research and development infrastructure needed to succeed in research and innovation in the maritime and offshore fields.

The Norwegian maritime industry stands behind the Maritime Global Hub Initiative where maritime companies and organizations intend to fund 20 new maritime professorships, and stronger R&D networks are being formed. A new long-term maritime research program, Maritime 21, is under development, and new international research cooperation is being formed. What remains to be done is to develop, fund and implement a new Ocean Space Center for the future knowledge frontiers in Ocean Space Technology. Investing in Research and Development Infrastructure (RDI) at this scale requires close cooperation with the maritime and energy industries, as well as strong participation by the Norwegian government when it comes to funding and implementation. Norway has a leading international role to play when it comes to ocean resource governance, especially in the high north. Such an international position also requires Norway to take the leading role in Ocean Space Technology

References

Chesbrough, Henry W. (2003), Open Innovation, Boston: Harvard Busines School Press

Florida, Richard (2005), The Flight of the Creative Class, New York: Harper

Krugman, Paul (1995), Geography and Trade, Boston: MIT Press

Porter, Michael E. (1990), The Competitive Advantage of Nations, New York: Free Press

Romer, Paul (1990), "Endogenous Technological Change", Journal of Piolitical Economy, Vol. 98, No 5, S71-102

Whittington, Kjersten Bunker (2007), "Employment Sectors as Opportunity Structures," PhD dissertation, Stanford University, Stanford, CA

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