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The Birth and Development of a Born Global Industry: The Case of Microelectronics in Norway

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Abstract

It seems beyond discussion that nations benefit greatly from having internationally competitive knowledge-based or technology-intensive industries. However, the question of how to create and nurture such industries is still debated, and various schools offer different recipes. This study takes an international entrepreneurship approach to investigate the emergence of an industry that seeks international competitiveness and growth from inception – a Born Global industry. The case is the Norwegian microelectronics industry, which is a successful, profitable and globally competitive industry, but interestingly also an industry that Norway has very few preconditions to have. The purpose of the study is to understand why this industry emerged in Norway and the underpinnings of its international competitiveness and growth. The study adopts a historical multi-level case study approach that tracks the story of the key entrepreneurs, their firms and competitors, and the key institutions they have interacted with. The study concludes that, from a structural condition or path dependency point of view, few factors would suggest the establishment of this industry in Norway. Rather, the emergence of this industry seems to be based on a knowledge platform created by the state, and subsequently turned into robust international business activities through the work of a handful of very ambitious and extremely technically competent international entrepreneurs with global visions for all their business activities. The findings support the pivotal role of the state in building knowledge platforms, but also in nurturing an environment where international entrepreneurs can thrive. Hence, this study justifies the study of emerging industries and the competitiveness of nations within the framework of international entrepreneurship and encourages more research on the societal and economic effects of international entrepreneurship.

Keywords: International entrepreneurship . International business . Born global industries . International new ventures . Born globals . Economic development

Abstracto *(in Spanish)*

Las naciones se benefician enormemente de tener industrias competitivas a nivel internacional con alto contenido tecnológico. Esta afirmación parece fuera de discusión. Sin embargo, la forma de crear y alimentar este tipo de industrias es todavía una cuestión de mucho debate, donde varias escuelas ofrecen diferentes recetas. Este estudio investiga la aparición de la industria "Born Global"—una industria que busca la competitividad internacional y el crecimiento desde el inicio. Nuestro caso es la industria de la microelectrónica noruega. Es una industria exitosa, rentable y competitiva a nivel mundial, y también una industria que Noruega tiene muy pocas condiciones previas para tener. El propósito es entender por qué esta industria se estableció en Noruega y las bases de su competitividad y el crecimiento internacional. Con el fin de hacer esto, el estudio adopta un diseño de estudio de caso de varios niveles históricos que rastrea la historia de los empresarios clave, sus empresas y las instituciones clave con las cuales han interactuado. El estudio concluye que, del punto de vista estructural, hay muy pocos factores que sugieren el establecimiento de esta industria en Noruega. Más bien, la aparición de esta industria parece basarse en una plataforma de conocimiento creada por el estado, y posteriormente se convirtió en sólidas actividades de negocios internacionales a través del trabajo de un puñado de empresarios internacionales muy ambiciosos y extremadamente técnicamente competentes con visiones globales para todas sus actividades de negocio. Los hallazgos no sólo respaldan el papel fundamental del Estado en la construcción de plataformas de conocimiento, pero también en el fomento de un entorno donde los empresarios internacionales puedan prosperar. Por lo tanto, este estudio justifica el estudio de las industrias emergentes y la competitividad de las naciones en el marco de la iniciativa empresarial internacional y alienta más investigación sobre los efectos sociales y económicos de la iniciativa empresarial internacional.

Palabras clave: Emprendimiento internacional . Negocios internacionales . Born global industries . Empresas nuevas internacionales . Born globals . Desarrollo económico

Abstrakt *(in German)*

Nationen profitieren in hohem Maße von international wettbewerbsfähigen wissensbasierten oder technologieintensiven Industrien. Diese Aussage scheint unstrittig. Wie jedoch solche Industrien hervorzubringen und zu fördern sind, ist eine weiterhin viel debattierte Frage, für die verschiedene Fachbereiche unterschiedliche Modelle anbieten. Diese Studie untersucht die Entstehung einer Born Global Industrie - eine Branche, die internationale Wettbewerbsfähigkeit und Wachstum ab der Gründung anstrebt. Unser Fall untersucht die norwegische Mikroelektronik-Industrie. Es ist eine erfolgreiche, profitable und global wettbewerbsfähige Industrie, gleichzeitig jedoch eine Branche, für deren Bestehen Norwegen nur sehr wenige Grundvoraussetzungen besitzt. Ziel dieser Arbeit ist zu verstehen, weshalb sie in Norwegen entwickelt wurde und was die Grundlagen ihrer internationalen Wettbewerbsfähigkeit und ihres Wachstums sind. Um dies zu ergründen, verwendet die Studie den Ansatz einer historischen Multi-Level-Fallstudie, mit welcher sie die Geschichte der zentralen Unternehmer, ihrer Firmen sowie der wichtigsten Institutionen, mit denen diese interagiert haben, verfolgt. Die Studie kommt zu dem Schluss, dass hinsichtlich der strukturellen Bedingungen oder Pfadabhängigkeiten wenige Faktoren auf die Entwicklung dieser Industrie in Norwegen hindeuten würden. Vielmehr scheint die Entstehung dieser Branche auf einer staatlich geschaffenen Wissensplattform zu basieren, aus welcher sich heraus eine solide Geschäftstätigkeit entwickelte, die getragen wurde von einer Handvoll ehrgeiziger und technisch äußerst kompetenten Unternehmern mit globalen Visionen für all ihre Geschäftsbereiche. Die gewonnenen Erkenntnisse unterstützen die zentrale Rolle des Staates bei der Schaffung von Wissensplattformen, wie auch bei der Pflege eines Umfelds, in dem internationale Unternehmer gedeihen können. Daher rechtfertigt diese Untersuchung das Studium der aufstrebenden Industrien und die Wettbewerbsfähigkeit der Nationen im Zusammenhang von internationalem Unternehmertum und ermuntert zu mehr Forschung über die gesellschaftlichen und wirtschaftlichen Auswirkungen von internationalen Unternehmern.

Schlüsselwörter: International entrepreneurship . International business . Born global industries . International new ventures . Born globals . Wirtschaftliche entwicklung

Résumé *(in French)*

Les nations profitent grandement d'avoir des entreprises hautement technologiques ou reposant sur les connaissances, qui sont compétitives hors de leurs frontières. Cette affirmation semble ne souffrir d'aucune contestation. Pourtant, la question de créer et de soutenir ces firmes reste toujours sujette à de nombreux débats, à propos desquels plusieurs écoles proposent différents axes de réponse. Cette étude porte sur l'émergence d'une Born Global industry – une industrie qui recherche une croissance et une compétitivité internationales dès son origine. Nous prenons l'exemple de l'industrie microélectronique norvégienne. Il s'agit d'une industrie prospère, fructueuse, compétitive à l'international, mais aussi une industrie dont la Norvège n'a que peu de raisons de détenir. La question est de comprendre les raisons de son implantation en Norvège et de déterminer les éléments vecteurs de sa croissance et de sa compétitivité. Pour cela, ce cas d'étude adopte une approche résolument historique en reprenant le récit des entrepreneurs majeurs, de leurs entreprises, et des institutions importantes avec lesquelles ils ont interagi. Cette étude conclut que, d'un point de vue des conditions structurelles ou en prenant en compte le poids de l'histoire, peu de facteurs sont en mesure d'expliquer la création de cette industrie en Norvège. *A fortiori*, l'émergence de cette industrie semble reposer sur une base de connaissances fondée par l'état et transformée par la suite en de robustes activités commerciales internationales. Ceci grâce au travail d'une poignée d'entrepreneurs internationaux ambitieux, techniquement très compétents et possédant une vision globale de toutes leurs activités commerciales. Les résultats obtenus confortent le rôle primordial de l'état dans la fondation de connaissances mais aussi dans le maintien d'un environnement favorable à l'émergence d'entrepreneurs internationaux . De fait, cela justifie l'étude des industries émergentes ainsi que de la compétitivité des nations dans le cadre de l'entrepreneuriat et encourage des recherches sur les effets sociétaux et économiques de l'entrepreneuriat international.

Mots clefs: Entrepreneuriat international . Commerce international . Born global industry . Nouvelles entreprises internationales . Born globals . Développement economique

Summary Highlights

Contributions: This study investigates the emergence and growth of a Born Global industry – an industry that seeks international competitiveness and growth from inception. Our case – Norwegian microelectronics – has emerged from unfavorable factor conditions, but has overcome its competitive liabilities and become a global success. From an economic perspective, the emergence of Born Global industries are favorable as they contribute with employment, innovation and internationalization. As we present the history of our industry case chronologically, we discuss it from both a structural economic perspective and a behavioral international entrepreneurship perspective, and provide a synthesis with new theoretical and practical insights on the birth and development of Born Global industries that includes key contributions from both the structural and international entrepreneurial perspective.

Research question: How to build new internationally competitive industries – Born Global industries – in absence of favorable structural conditions?

Methods: We adopt a qualitative historical multi-level case study design. The data sources are semi-structured interviews with key entrepreneurs and representatives of key institutions combined with archival data from firms, industry and institutions over a 40-year history.

Findings: The establishment and growth of our Born Global case industry was significantly influenced by the work of a handful ambitious and extremely technically competent international entrepreneurs and the risk-seeking behavior of their firms, rather than favorable structural industry conditions. Furthermore, our findings demonstrate the pivotal role of the state as an entrepreneurial agent that invests in building knowledge platforms and state institutions for nurturing an environment for international entrepreneurs to thrive. Even though the case does not fulfil the criteria of a typical industrial cluster in Porter's sense, we still observe that coopetition between firms and widespread collaboration between the industry and universities have played important roles in the industry development although at various points in time.

Limitations: As a single industry case study, this study suffers from limitations of formal generalization as case studies in general. Even though the micro-processes and causalities that underpin the emergence and growth of the Norwegian microelectronics industry seem quite clear from our case, further research from different industries and national settings are needed in order to establish how commonplace these micro-processes and causalities are.

Theoretical implications and suggestions for future research: We argue that the birth and development pattern of Born Global industries are better described by shifting focus from a structural view of comparative advantage and path dependency, toward a more behavioral view based on international entrepreneurship and path creation. However, we need both perspectives to get the complete picture, as an active state is required to build knowledge and technology platforms from which international commercial activities can spin. Our study shows that international entrepreneurship and the creation of international new ventures is in the core of the establishment of such industries, and hence, falls within the field of international entrepreneurship. Unfortunately, literature on the societal effects of international entrepreneurship is missing in the current literature, and hence, we call for more research on societal and economic effects of international entrepreneurship.

Practical implications: Internationally competitive new firms and industries can emerge even if structural conditions are unfavorable. However, it requires an active entrepreneurial state and it requires ambitious and risk-seeking actions from resourceful and skilled international entrepreneurs.

Policy implications: This study shows the pivotal role of governments, universities and research institutions in building knowledge platforms in early stages of industry establishment. Furthermore, it demonstrates the importance of nurturing an environment in which international entrepreneurs can thrive and ambitious international entrepreneurial ventures might spin off.

Introduction

Many great economists, from Adam Smith and Joseph A. Schumpeter to Paul Romer and Michael Porter have convinced us that nations benefit greatly from having internationally competitive knowledge-based or technology-intensive industries. In Haque's words: "…, it matters a great deal today whether a country specializes in the production of potato chips or micro chips" (Haque 1995, p. 22). The arguments and empirical evidence for this case are so compelling that it seems beyond any doubt. However, the practical question remains - how can one facilitate the establishment and growth of such industries? Moreover, from an international entrepreneurship scholar's point of view, does international entrepreneurship as a field of research have anything to say on the matter?

The discussion has its roots in the work of Adam Smith on absolute advantage and later reformulated and specified in the theory of comparative advantage by David Ricardo. These theories argue that nations should focus their efforts on building industries from which they can draw on a comparable advantage to other nations. The work of Michael Porter (1990) is a prominent example of this tradition and it is extended into the literature of path dependency. Path dependency theory suggests that institutions and policies favor growth of existing industries and incumbents, rather than the creation of new (Pierson 2000). Hence, 250 years of research on international business seems to agree that increased international competition forces nations to specialize on their comparative advantages, and that they will tend to stick to those comparative advantages as they become locked in by path dependence of industry development.

Following this logic, though, contains a considerable risk. If countries only focus on developing industries within the paradigm of comparative advantages, they might end up with a narrow industrial profile and the risk of getting disrupted by emerging economies with 'inferior, but sufficiently good' technologies (Cavusgil et al. 2015). One famous example of this is the Swiss watch industry that was toppled over by the quartz revolution (Landes 2000), or more recently the situation that are currently emerging for petroleum-producing countries like Norway, Russia and countries in the Middle East as petroleum prices are falling and the rest of the world is seeking a shift to renewable energy sources.

The path dependency perspective also offers grim outlooks for transition and developing economies. They find themselves in a situation where rich, developed countries build high profit, technology- and knowledge-intensive industries, while the less developed ones are forced to focus on low profit industries like agriculture or low tech and low-wage labor intensive industries – because this is where they comparatively excel! This phenomenon is well known and convincingly documented by many (see e.g. Reinert 2008) , and it is highly undesired due to the economic inequalities as well as political and security tensions it creates. It should therefore be an increasingly important topic in the field of international entrepreneurship to investigate how new

industries occur in new locations and how nations can establish and grow new industries that extend their platforms of national competitiveness.

This study offers a historical account of the birth and growth of the Norwegian microelectronics industry – a Born Global industry that has sought international growth and competitiveness from inception. However, it is also an 'unlikely' industry in the sense that it has emerged on a location where it had few preexisting structural conditions to emerge. We seek to use this historical account to shed some light on how international entrepreneurs and policy makers can strategically navigate in order to establish and grow new internationally competitive industries. Moreover, we seek to establish a synthesis of how our current understanding of economic development and trade, paired with our growing understanding of international entrepreneurship, can increase our understanding of how new internationally competitive industries emerge, grow and contribute to the international competitiveness of nations.

Theoretical background

There is a broad range of theories applicable to the question of location of emerging and growing international industries. One major strand of research stems from economics and economic geography and deals with structural factors that increase or decrease the likeliness of an industry occurring at any given location. Here, we refer to these theories as the structural perspective. The theoretical roots of the structural perspective originate from Adam Smith's absolute advantage theory, which was later developed into comparative advantage theory by David Ricardo in the early 19th century and Eli Heckscher and Bertil Ohlin extended this theory to also include trade between nations with different factor endowments in the early 20th century. The theories of comparative advantage and factor endowments prescribe that any nation should focus its value creating activities in areas where it has potential to leverage comparable advantages to other nations.

More recently, several studies have added to the theory of comparative advantage by identifying factors that contribute to the establishment of internationally competitive industries. An early contribution came from Raymond Vernon (1966), which introduced the international product life cycle model. He argued that industries arose domestically in the country of invention – predominantly in developed economies – and internationalized in late growth stages when cost competition set in and moved the industry to locations with lower production costs. Interestingly, Vernon pinpointed the value of invention and entrepreneurship for creating new industries, but did not develop the notion in his works.

Other scholars have emphasized the role of economies of scale and trade costs as factors influencing industry location (Krugman 1991; Amiti 1998; Forslid et al. 2002). Opportunities to create economies of scale encourages companies to select only one or a few locations (agglomeration), and the presence of trade costs supports them to locate activities in lead markets or countries that can offer the largest domestic market (Krugman 1980; Smith 1981; Krugman 1991).

We have also seen more studies using broader theoretical perspectives that have found local and global market characteristics to influence the location of industries. Examples of the first are home market effects as mentioned above (Krugman 1980; Amiti 1998; Ottaviano and Puga 1998; Murtha et al. 2001; Forslid et al. 2002; Wan and Hoskisson 2003), but also factors related to global market conditions, such as presence of global customers, are found in Fujita and Thisse (2013), Birkinshaw et al. (1995), and Yip (1989).

Apart from market related factors, several studies have pointed to local capabilities that attract industry location. Examples are knowledge and technology bases and specialized skills (Maskell et al. 1998), regional technological activities and collaborations (Dodgson 1993), regional or national systems of innovation (Malmberg 1997), research intensity (Kobrin 1991), international linkages (Makhija et al. 1997), infrastructure and natural resources (Maskell et al. 1998), and governmental drivers such as public policy and state planning (Yip 1989; Birkinshaw et al. 1995; Mazzucato 2013).

Most of the aforementioned structural factors, which increase or decrease the likeliness of industry location, are nicely summarized in Michael Porter's (1990) Diamond Model of international competitiveness. Porter's model is regarded as the most recent comprehensive contribution that makes the link between the behavior of individual firms and the competitiveness of nations (Peng 2009). Interestingly, this is arguably also the greatest weakness of the literature on structural conditions for the location of internationally competitive industries. These theories do a great job in terms of identifying the factors that contribute to the likeliness of an industry occurring at any given location, but they do a poor job in explaining *how* it happens. In most of these studies, entrepreneurship, or the process of turning resources and capabilities into business, is treated as a black box. Michael Porter labels it *chance* in his Diamond Model (1990), though admitting that this type of *chance* constitutes the real competitiveness of nations. He proclaims that "invention and entrepreneurship are at the heart of national advantage", and his research reveals that indeed "neither entrepreneurship nor invention is random" (Porter 1990, p. 125-126).

The theoretical extension and logic consequence of the structural perspective is path dependency. Path dependency theory argues that due to historic decisions related to resource and knowledge development, combined with the development of institutions and policies, any nation is more likely to develop industries based on existing resources and capabilities than creating something entirely new (Pierson 2000). These effects have been extensively studied and also found to apply in the Norwegian industrial setting relevant for this study (Fagerberg et al. 2009).

The alternative to path dependency is path creation (Garud et al. 2010). Path creation occurs when a system is able to break away from reigning institutions and dominant policies to create entirely new socio-technical paths. Hence, the path creation perspective seems appropriate to understand the process of creating Born Global industries, especially if they break away from the path of existing industries or resource endowments. Indeed, the path creation perspective has also been applied to investigate the transition of other Scandinavian economies like Finland's transition from a raw-material-based economy into a knowledge and technology-based economy (Schienstock 2007), and the emergence of Denmark's wind power industry (Simmie 2012). According to Meyer and Schubert (2007) new paths can be deliberately created, but they require resourceful actors.

We argue the path creation perspective is particularly applicable when studying Born Global industries in relation to national competitiveness. In their early study of Born Global industries, Murtha et al. (2001) argue that the traditional assumption of path-dependent historical development in relation to national competitiveness would lead to a complete misinterpretation of the evolution of industry. The reason is that the creation of a new international industry is predominantly concerned with creation of new knowledge and resources. Hence, for emerging industries, it matters more to have access to knowledge creation resources, than ownership of physical assets. In such industries "people and firms, rather than preexisting conditions, determine the structure of industries" (Romanelli 2003, p. 325).

Entrepreneurship is a field that can be said to be complementary to the structural perspective as it predominantly focuses on *how* resources are turned into new business activities rather than *which*. Within entrepreneurship, the emerging field of *international entrepreneurship* (IE) deals specifically with how new firms create international competitiveness and international growth. This literature stream emerged in the early 1990's and has up until now predominantly been dealing with firm level and individual level of analysis (Aspelund et al. 2007; Keupp and Gassmann 2009; Coviello et al. 2011; Jones et al. 2011; Cesinger et al. 2012; Gray and Farminer 2014; Cavusgil and Knight 2015; Zander et al. 2015).

The study of International New Ventures (INVs, also often referred to as Born Global firms) constitutes the core of IE research. INVs are firms that seek a rapid and extensive internationalization right after inception (Oviatt and McDougall 1994) and research from many countries suggest that INVs are growing in numbers in most economies (Aspelund et al. 2007; Cavusgil and Knight 2015). Individual level studies have shown that INV founders are distinguished as highly ambitious and competent entrepreneurs with a high degree of international orientation (Rialp et al. 2005; Keupp and Gassmann 2009; Jones et al. 2011; Covin and Miller 2014; McDougall-Covin et al. 2014). In terms of strategy, international entrepreneurs and their firms are risk-seeking and target international markets in quick succession (Knight and Cavusgil 2004; Aspelund et al. 2007; Cannone and Ughetto 2014; Hennart 2014).

In terms of economic development, INVs are comparable to *kinder surprises* – they contribute with three key elements central to a nation's competitiveness, namely innovation, entrepreneurship and internationalization (Gray and Farminer 2014), and for these reasons one can assume that it is desirable to have a high percentage of such firms in any economy. Unfortunately, studies linking firm level data to macroeconomic measures are uncommon in general (Nasra and Dacin 2010), and even fewer and further apart in the IE literature (Fernhaber et al. 2007; Covin and Miller 2014).

Most recently there has been published a few studies that links international entrepreneurship with societal effects and industry creation. One such exception is Løvdal and Aspelund's (2012) study of the emerging global offshore renewables industry – an industry they labeled a Born Global industry. They argue that the IE perspective is well suited for the study of emerging industries as they find the establishment of offshore renewables industry to be driven by highly internationally mobile new ventures that inhibit international traits even before the commercialization stage of the industry. Subsequent studies of the same industry has investigated pre-commercial internationalization activities (Bjørgum et al. 2013), and the tendency of INVs to build competitiveness through international alliances in emerging industries (Løvdal and Moen 2013).

In this study, we seek to extend our knowledge of the societal and economic effects of international entrepreneurship. We aim to do this by investigating the historical account of the birth and growth of a Born Global industry – in this case Norwegian microelectronics. By analyzing this historical account from a dual perspective of structural factors and international entrepreneurship, we seek to understand the role of international entrepreneurship in new global industry creation.

Methodological considerations

To address our research question we adopted a historical multi-level case study design because it provides us with the opportunity to investigate the empirical underpinnings of key events in the birth and development of the industry. This method has been utilized in several research areas such as change of institutional practices in the U.S. radio broadcasting industry from an interorganizational perspective (Leblebici et al. 1991), creation of entrepreneurial opportunity in a single industry (the US electric power industry) (Sine and David 2003), and more recently within IE domain investigating the role of the state (Dubai–UAE) as an institutional entrepreneur (Nasra and Dacin 2010).

We chose the Norwegian microelectronics industry from convenience sampling (Eisenhardt 1989). We selected the case industry on three criteria. First, because it had the defining properties of a Born Global industry. Second, because its emergence arose despite unfavorable structural conditions. Finally, because the history is sufficiently recent for us to be able to establish a credible and verifiable historical account.

The historical account was build up from two data sources. First, we had primary data from interviews with the key entrepreneurs, managers and institution representatives that all have played a central role in the establishment and growth of this industry. In total, this study included 9 interviews, from which 6 were in-depth and semi-structured (all performed in April 2013, and lasted between 75 and 180 minutes) and the final 3 were focused and structured (held in May 2013, and were shorter than 60 minutes). Second, the online archival data was collected by using Retriever, an online media search tool. This data was combined with information from Forvalt.no, a Norwegian database that includes relevant financial and statistical information about all Norwegian companies.

The data was analyzed by combining data from the different sources to a detailed chronological time line. Appendix A provides a short presentation of the interviewees as well as other data sources collected throughout the case study.

There are some important considerations in terms of the research design, level of analysis, and theoretical framework in multi-level single case studies. Regarding the research design, single case studies have certain limitations and formal generalizability is one of them (Eisenhardt 1989; Verschuren 2003). Single case studies can be a powerful technique to provide detailed investigation of the case in question (Flyvbjerg 2006; Siggelkow 2007; Simons 2015). Specifically, single case studies yield context-dependent type of knowledge and experience, and hence, the level of generalizability depends on generalizability of the context. We will discuss the relevant generalizability of the context in the discussion chapter.

Two other reasons for using a single-case research approach in this setting is *falsification* and *particularization*. Falsification, or the search for anomalies, is one of the strictest examinations to put scientific theories under scrutiny, and shapes an important part of judgmental reflexivity in social sciences (Popper 1959). Falsification based on a single case study is not to reject the theory discussed in the context of the case, but to provide an opportunity to revise, correct, or complete the theory (Flyvbjerg 2006). Therefore, it significantly contributes to theory building by indicating the fact that the theory is not completely correct (or at least that there might be something missing in the proposition), stimulating further inquiries and research on the theory, and vindicating further refined conceptualization (Flyvbjerg 2006; Siggelkow 2007). This represents the rationale for case selection in our study. We deliberately selected the Norwegian microelectronics case from a list of alternatives. Microelectronics was selected because it represents an anomaly from a structural perspective, which remains the dominant logic for studies of industry location, and hence, provides us with an opportunity to extend or refine the existing theory.

Particularization is the last, but not least, substantial value that can be achieved by performing the single case study research. Stake (1995, p. 8) refers to it as “the real business of case study”, which is to comprehend and grasp the uniqueness of the case itself (Simons 2015). From this view, the merit behind the selected case is not to be representative, but to be particular and in the sense that it provides certain insights that other cases might not be able to yield (Siggelkow 2007).

As explained by Yin (2008), a single case study can include multiple levels of analysis in order to achieve valuable knowledge about the case as a whole. This study utilizes an *embedded design*, which is to have several levels of analysis within a single study (see e.g. Mintzberg and Waters 1982; Pettigrew 1990). In this study, multiple levels need to be addressed as there are multiple levels of likely explanatory variables – such the individual entrepreneur, the firms, the national institutions they interact with, and industry and market dynamics. The notion of such discussion, as considered by Porter (1990), is founded on the implicit assumption underlying the management theories that company competitiveness can be extended to industry, and subsequently nation competitiveness, where the act of entrepreneurship is fundamental in achieving competitive advantage. This point is also highlighted by Smit (2010), and we consider our study in the same theoretical tradition where competitiveness on one level results in competitiveness on the next.

In this study, the interdependent multilevel rationale is exemplified by the international ambition and the advanced technological knowledge and competence of the entrepreneurs that are transferred into the

international competitiveness of the firms. These international new firms, with their competitive products, constitute the globally competitive industry, which finally turn into taxable income and a broader competitive base of the nation. Hence, in this type of framework, it is the entrepreneurs and their companies that are the principal actors, rather than structural factors (Grant 1991; Murtha et al. 2001).

In the field of international entrepreneurship there is a considerable research gap on the contribution of international entrepreneurship on economic development and national competitiveness (Covin and Miller 2014). The use of multilevel research approaches provides the possibility to realistically make a connection between entrepreneurs, firms, industries and institutions (Peng 2009).

The History of the Norwegian microelectronics industry

At the time of writing, the Norwegian microelectronic industry is in a very healthy condition. It is profitable, growing and, within its defined market niches, globally competitive. This development has come to some surprise to Norwegian industrial experts, as it has emerged under the radar in an industrial landscape dominated by industries related to natural resources such as energy, aquaculture and maritime equipment.

The pre-commercial era – 1962-1981

The Norwegian microelectronics industry started with the homecoming of the international entrepreneur Olaf Stavik in the early 1960's. Stavik had been working with microelectronics at the University of Pennsylvania, U.S., and at Northern Electrics in Canada, and he thought the new technologies emerging around the newly invented transistor[1] represented enormous technical and business opportunities. With his exceptional communication skills, he successfully persuaded Norwegian research institutions to develop knowledge resources in this new field and the Norwegian government to fund the activities. In 1962, Stavik and his research team at the Central Institute for Industrial Research (SI) in Oslo managed to build one of the first micro transistors in Europe and followed up the feat with Norway's first integrated circuit a few months later.

For the next 20 years, activities in the microelectronics sector in Norway were almost exclusively research-based. Research grants were exclusively given to projects with possible future industrial application, but there was little absorptive capacity for new microelectronic innovations in Norwegian industry at the time. Still, the government were patient and granted resources to build a platform of knowledge that qualified a large number of researchers and students in the practical use and development of state-of-the-art technologies within microelectronics. The receivers of the grants were predominantly the two major scientific universities – the University of Oslo (UiO) and the Norwegian University of Science and Technology (NTNU) in Trondheim – and the three leading independent Norwegian research institutions, which all established microelectronic laboratories - ELAB at SINTEF in Trondheim, SI in Oslo and the Norwegian Defense Research Establishment (FFI). Only towards the end of the 1970's the research activities started to attract some domestic commercial interest.

The commercial start – Nordic Semiconductor

In 1982, 20 years after Stavik's first Norwegian integrated circuit, chief executive officer (CEO) at ELAB Åsmund Geitnes thought they were ready to spin-off an independent commercial entity to leverage their technological competence accumulated over 20 years of research. He turned to four of his most talented staff to establish the venture. Two of them were experienced and had been a part of the industry almost since the beginning – Oddvar Aaserud and Jan Meyer. The other two were Trond Sæther and Frank Berntsen, at the time 25 and 26 years old respectively and considered technical geniuses. The spin-off was named Nordic VLSI (later Nordic Semiconductor), and their initial business model was to offer Application-Specific Integrated Circuits (ASICs). Nordic chose this business model because it brought limited business risk, and in addition, the opportunity to leverage the vast network of potential industrial customers they had gained through the work at ELAB. This strategy paid off and during their first years, Nordic got customers in a broad range of sectors such as automotive, aquaculture, medicine and defense. Another important source of income came from the Norwegian Research Council that sponsored some of Nordic's more experimental development projects.

Nordic also sought international customers from inception. Norwegian customers were valuable in terms of collaboration on development, but too small and few in numbers to be significant in an industry where profit lies in volumes. Hence, Nordic set their sights abroad and found MAC Digital TV – a project that aimed to build a new standard for European digital TV. The MAC Digital TV consortium consisted of several large

[1] The first silicon-based semiconductor transistors were developed by Shockley Semiconductor Laboratory in 1956.

European telecom and electronics companies. Nordic took leadership in the development of the technical solution and developed a decoder microchip for household decoders across Europe. Distribution was secured through license agreements with Plessey Semiconductor and Phillips Semiconductor that used their extensive distribution network to sell the solutions internationally. Not only did this project boost Nordic's international sales, but it also professionalized management of the company and gave Nordic the first taste of the tempting role as a supplier of standardized components.

Nordic was the only significant commercial actor in Norway for more than a decade and grew rapidly. As there were few firms in related industries, recruitment of engineers and designers became difficult. To address this issue, Nordic entered into a close collaboration with NTNU – the technical University in Trondheim - in order to recruit students directly into their growing business. This arrangement was beneficial for Nordic, NTNU and the students, but in 1991, two students arrived at Nordic with international entrepreneurial ambitions that even stunned fast-growing Nordic.

New Start-ups: Atmel Norway and Chipcon

The two students, Vegard Wollan and Alf-Egil Bogen, met at NTNU in 1988 as they both studied at NTNU's engineering program in physical electronics. They bonded on their common interests for science and engineering, and chance had it that they both ended up in the Nordic-NTNU master student collaboration in 1991. More than that, they ended up working on the same project at Nordic – a development project for a micro RISC processor (µRISC).

The µRISC was designed by Nordic co-founder Frank Berntsen as a part of Nordic's collaboration with Phillips on the MAC project. Current standard components could not meet the requirements Phillips had set for the decoder chip's technical performance, so Nordic invested in the design of a new RISC processor that could. Wollan and Bogen worked in sales and marketing when Nordics µRISC were released and the two entrepreneurial-minded young engineers immediately saw the huge market potential in delivering standardized microcontrollers to the global market based on the µRISC design. They proposed this business opportunity for Nordic, but Nordic hesitated, as it would imply they had to refocus away from their lucrative ASIC business.

Wollan and Bogen, on the other hand, were positive about the market potential for the standardized µRISC microcontroller, but the domestic market was not attractive. Norway had neither potential customers, related industry, nor venture capital firms that could invest in such an adventure. Anyway, Bogen and Wollan's ambitions were global and they rather looked for partners and investors abroad. Where else to start looking than in Silicon Valley?

Atmel Corporation, based in San Jose, CA was a pioneer in non-volatile memory in the 1980's. In the 1990's Atmel started to look for opportunities to extent their product portfolio beyond memory. Nordic's µRISC processor was already on their radar and Bogen and Wollan saw Atmel as a perfect investor for their new venture. After a short meeting with Atmel CEO George Perlegos in 1995, Bogen and Wollan travelled back to Norway with the funds they needed to establish Atmel Norway and develop the product.

Atmel Norway transformed the original µRISC into a flash-based microcontroller - the AVR. An agreement was signed with Nordic for the transfer of the intellectual property and even though they knew they were helping a newborn competitor, Nordic contributed heavily in the development of the first AVRs. Actually, the first two versions of the AVR were developed by Nordic on specifications given by Atmel Norway.

Atmel's AVR was a great innovation when launched. It featured more processing power and less energy consumption than anything offered anywhere at that time, and it went on to become a great global market success for Atmel. Currently, 20 years later, 36 AVRs are produced every second – the world's most sold 8-bit microcontroller, accounting for sales well above US$ 1 billion[2].

Chipcon

Atmel Norway's success with the AVR inspired other ambitious international entrepreneurs. Among them was three friends from their university days. Geir Førre, Sverre Dale Moen and Svein Anders Tunheim graduated at the same time as Bogen and Wollan, but started their careers as researchers at SI. The three ambitious engineers quickly got tired of the slow life as researchers and started seeking more action. Fueled by great international ambitions as well as money and support from the Atmel Norway founders, they established the firm Chipcon. The Chipcon founders had their key competence in the design of integrated radio frequency (RF) circuits and in the mid 1990's there was a large unmet global demand for high performing, low energy RF chips as the mobile revolution was picking up pace. Trond Sæther at Nordic evaluated the situation thus:

[2] Atmel Corp was acquired by Microchip Technologies in 2016 and the AVR is now marketed under the Microchip brand.

"Back then, radio was associated with mobile phones and GSM, and larger things that could cost thousands [], but we saw that with the proper use of technology one could get the price of such a gadget [RF chips] down to a much lower price than that --- maybe down to a few dollars. (…)"

Both Nordic and Chipcon saw this as a great opportunity. Nordic got on the case of developing their first low energy RF solutions in 1997 and introduced it to the market in late 1998 only narrowly beaten by Chipcon that introduced theirs in May 1998. At the same time, other leading international IC companies such as Motorola, SGS Thomson and RF Micro Devices released similar offerings, but the Norwegian designs proved highly competitive in global markets and the Norwegian companies gained market shares.

Atmel Norway's definite international break-through came in March 2000 with a contract with Sony quickly followed by a contract with Ericsson for cell phone microprocessors. Atmel Norway gradually became the most important design center in the global Atmel Corporation and featured annual growth rates up to 40 %.

Even though the AVR business was consistently growing its global market share, Atmel Norway continued to look for global business opportunities that could expand their product portfolio. A good opportunity arose when Apple introduced the iPhone in 2007 and actors in the mobile handset industry needed high resolution screens with touch capacity. Atmel Norway thought they could be the firm to deliver it. Almost one third of the development resources in Atmel Norway were assigned to the task and Atmel's maXTouch product suite was introduced in May 2009. It was an immediate success. Initially, more than 30 handset models would use maXTouch including models from Samsung, Motorola, HTC and Nokia. According to the PC World Magazine, 8 out of the top 10 smartphones in 2010 would have maXTouch and the maXTouch generated US$ 100 million in revenues the first year and doubled that figure the year after. Already in 2010 the Atmel CEO, Steven Laub, referred to maXTouch as "our most important product". In 2013, the business unit for microcontrollers and touch in Trondheim, Norway represented about 67 % of the annual revenues in the global Atmel Corporation.

Chipcon's real international break came one year after Atmel Norway's, in 2001, with the introduction of an innovative new RF chip, the CC1000. Chipcon exploited a technology shift to CMOS technology that allowed lower power consumption, higher packaging density, lower production costs and easier chip integration. The CC1000 was a tremendous international market success that gave Chipcon sales growth rates exceeding 100 % in consecutive years. Like Atmel, Chipcon was targeting reference customers globally that could provide them with credibility and volumes and soon Chipcon's chips were almost standard in gamepads such as Nintendo, PlayStation and Xbox as well as in alarms, security and smarthouse solutions.

Nordic was slower to mass markets than Chipcon and Atmel due to their more extensive and lucrative ASIC business. However, like Chipcon, Nordic exploited a technology shift – this time from low to high frequency bands to break into global mass markets. High frequency bands (2,4 GHz) was defined as an open license-free band with a promising market potential as one assumed global standardization on this frequency and technically is allowed a range of applications to be integrated on one chip. The definitive break-through came in 2003 when Nordic signed a contract with Logitech to equip their whole range of wireless PC peripherals with Nordic radio chips. The growth continued into industrial applications, sports equipment and toys, and more recently, as the leading global supplier of ultra-low energy Bluetooth RF chips.

Coopetition: inspiration, collaboration, new firms and competition

Semiconductor firms in Norway continued to keep strong ties with the state universities in the new millennium, but primarily for recruitment and educational purposes. They needed the universities to provide them with competent talent. The role of the state universities and research institutions in R&D were diminishing and state research grants the same. The microelectronics industry became self-sufficient, and support from the state was no longer required.

However, the international success of the firms continued to inspire young ambitious entrepreneurs and the university fed them into the student-industry collaboration program. This program might seem a small thing in the big picture, but the fact is that the two Atmel Norway founders, the three Chipcon founders and two of the four Nordic founders all graduated under this arrangement. And more was coming.

In 1998, two NTNU computer science students – Borgar Ljosland and Jørn Nystad – started to discuss a new design for a graphical processing unit (GPU). They were intrigued by the fact that the clock speed for central processing units (CPUs) had increased many times faster than GPUs. The graphical performance of mobile units just could not keep up with the computational power. They took the issue to their Professors and were given free reigns to develop their solutions as a part of their master program.

In April 2001, Ljosland and Nystad established the firm Falanx Microsystems with three fellow students – Mario Blazevic, Robert Mæhlum and Edvard Sørgård. The establishment was challenging for both technical and business reasons. On the technical side, the development required use of expensive tools that was far beyond the budget of the startup. The solution was an agreement with Nordic and the two Nordic co-founders Sæther and Berntsen that gave them access to Nordic's tool chain as well as international marketing support. They also

received assistance from Atmel Norway's Wollan, Bogen and Myklebust. The result was the introduction of a new low-energy GPU named Mali in 2004. In terms of technical performance and power consumption, Mali was superior to anything offered in the international market at the time, and already in August 2004 Falanx secured license agreements with Emblaze Semiconductor, Zoran Corporation and Agere Systems that gave them a solid platform for further international growth.

The cases we have followed so far shows that there was outspread collaboration between actors in relation to the establishment of new firms. Established entrepreneurs invested time, money, technological resources and goodwill in new ventures in their early phases, but as the new firms entered market introduction and growth this altruistic behavior rapidly turned into fierce competition. For example, in the RF market, two Norwegian companies (*i.e.* Nordic and Chipcon) were taking the global lead in low energy RF chips, but their relationship was far more characterized by competition than cooperation. The two companies, Nordic in Trondheim and Chipcon in Oslo, existed virtually isolated from each other. However, they both drew considerable inspiration from the competition. Chipcon founder Førre commented the relationship thus:

> *"The fact that we [Chipcon] were successful probably made Nordic step it up. There was intense rivalry between the two environments - extreme competition between Nordic and Chipcon in the course of ten years, and this was probably an important reason for why both companies ended up doing so well. The competition between two companies that are located in geographical proximity – it contributed in making the companies world leaders in slightly different areas."*

The firms also drew inspiration from the fact that they were operating in the periphery of the global microelectronic market. Jo Uthus, senior director at Atmel Norway, did not think that outsidership as a Norwegian supplier necessarily was a liability, but definitely required a clear competitive edge:

> *"You are in an underdog position where you want to prove something, and when you want to prove something you can achieve quite a lot. (…) You don't limit yourself to operate only in Northern Europe, or Scandinavia, or regionally in Europe, but you open up and offer yourself to the world. (…) With regards to the AVR, when it was launched in the 90s, it was a factor of 1 to 4 on performance, which was what counted back then. Then we became a world leader in power consumption and system integration. Without such a differentiated offering, we wouldn't have succeeded."*

Buyouts and New Opportunities

Even though the emerging firms' international market performance was impressive, their financial situation was fragile considering the size of the contracts and customers. In 2005, Chipcon was acquired Texas Instruments (TI) and turned into a TI subsidiary in Oslo responsible for TI's low energy RF business. The founders were initially reluctant to sell, but industrial complementarities and opportunities to scale the franchise convinced them to agree a US$ 200 million take-over. Through the deal, Texas Instruments Norway became a global player pairing the specific design knowledge embedded in the Chipcon staff with the industrial capabilities and sales, marketing and distribution network of Texas Instruments.

The same situation was apparent for Falanx. The mobile handset market was already mature and now the smartphone revolution was approaching with substantial need for GPUs in cell phones. This trend put Falanx in a very attractive position in terms of technological solutions, but with considerate size of the contracts made it difficult for a small new actor to close deals with considerable larger and demanding customers. They started to look for an industrial partner and found it in the British semiconductor company ARM, the leading supplier of mobile CPUs. The partnership ended up with ARM acquiring Falanx for an undisclosed fee establishing ARM Norway in Trondheim. The entrepreneurs were given central positions, but the management team was complemented by more personnel from ARM. The acquisition also gave Falanx the opportunity to leverage ARM's global marketing and sales capabilities. Falanx co-founder Ljosland remembers:

> *"We kept the team structure as it had been, and so we had a company that looked a lot like Falanx in which ARM invested. We hired a lot of new employees and a lot of things that had been a problem earlier were resolved. Now it wasn't money that was the problem anymore, now it was to create business."*

New Firms Emerging and the Persistence of Entrepreneurs to Stay Entrepreneurs

The continued success inspired even more entrepreneurial activities in Trondheim and Oslo. Some of them centered on entrepreneurs that refused to become 'just' managers in established multinationals.

One notable example was the spin-off of the data converter business in Nordic. By 2007, the RF business was by far the largest business unit in Nordic and the RF business took most of managerial attention and investments. However, Nordic still had a very strong business unit on analog-to-digital (A/D) converters

from the ASIC era. Initially, Nordic decided to sell their converter business, but after a string of unsuccessful industrial take-overs, former Nordic engineers took matters into their own hands and started Arctic Silicon Devices (ASD). ASD designed data converters and targeted the market for mobile ultrasound medical scanners. Within a year, ASD had developed their first products characterized by the typical differentiator for Norwegian microelectronics players – high performance combined with low energy consumption. ASD was acquired by Hittite Microwave Corporation in 2010 and has shown consistent growth after.

Another entrepreneur that found corporate life quite boring was Chipcon founder Geir Førre. After the TI take-over of Chipcon, he pondered various career paths, but was drawn back to microelectronics. His contract with TI prevented him from starting competitive ventures in the RF business so he opted for ultra-low energy microcontrollers and started Energy Micro in 2008. Energy Micro launched their first product – a 32-bit microcontroller called EFM32 Gecko – in October 2009. The product attracted considerable attention due to its extreme technical features. It was at that time by far the most energy friendly microcontroller ever produced and exceeded design specifications of battery time by a factor of four. By 2013, Energy Micro had established a global marketing and distribution capabilities and became an attractive target for acquisition. Silicon Labs acquired Energy Micro in 2013 in a US$ 170 million deal that created Silicon Labs Norway and gave the Gecko product suite access to Silicon Labs global sales and marketing capabilities. History repeated itself once again.

The current state of affairs

Today, Norway has a vibrant microelectronics industry represented predominantly by Nordic, Microchip, TI Norway and Silicon Labs Norway, but with a broad range of smaller, but still notable actors. They are technologically very competitive, profitable and strategically well positioned to take further growth with the current market trends in global microelectronics markets. According to industry experts, the total revenues from the related product lines are approximately US$ 4 billion. This is a small fraction of the global microelectronic industry, but significant for a small country with 5 million inhabitants and where the largest non-petroleum related sector (fisheries and aquaculture) accounts for approximately US$ 10 billion in exports (Teknologiradet 2015). The emergence of the microelectronics sector has broadened the national competitive profile and provided a new opportunity as Norway is looking to diversify away from the petroleum sector. However, the interesting discussion remains. Why did Norway end up with this industry and what can we learn from this story to replicate it?

Discussion

The Norwegian microelectronics industry is a good example of "path creation", where a new industry has emerged and grown despite structural disadvantages. From a structural viewpoint, few arguments suggest that Norway should emerge as a location for an internationally competitive microelectronics industry. Considering, for example, local conditions and input factors as suggested in Porter's (1990) Diamond Model. For a semiconductor design company the most important input factor is engineers and design competence. In terms of access to these key resources, Norway stands at a significant disadvantage due to high labor costs and limited access to related industries. Norway probably has the most expensive engineers in Europe, maybe even in the world, where engineering wages have been driven up to extraordinary levels over the years by a super-profitable petroleum sector. According to Norwegian labor statistics, a Norwegian engineer is typically paid twice as much as a German engineer and approximately 10 times the wages of a Chinese engineer.

Nor does the emerging industry get any pull from related or complementary industries. They do not exist in any significant numbers in a small country where petroleum, maritime equipment, aquaculture and fisheries, machineries and metals dominate. The latter is also the case for domestic customers. All the firms in this study export close to 100% of their output. Hence, there is no home market effect in this case as suggested by Krugman (1980), Amiti (1998), Forslid et al. (2002), and many others.

Nor have we been able to identify any transaction-specific or global market conditions that should favor location in Norway. The global market for the products in question has indeed been favorable in terms of growth, but then again, global competition has been fierce with a broad range of resourceful actors from the U.S., Europe and Asia battling for design and market dominance. In other words, as the structural perspectives provide little explanation, we need to take a closer look at the development of the industry to see which factors contributed to this new path creation and at which point in time.

The early development of the industry – the pre-commercialization era 1962 to 1982

The defining moment of the new path creation was the homecoming of Olaf Stavik. Stavik ended up becoming a successful entrepreneur himself by founding several Born Global firms, but in a related industry (electronic sensors). Stavik's contribution in the establishment of this industry rather laid in successfully convincing

resourceful state actors such as the Research Council of Norway (NRC), research institutions and national universities to start investing in a knowledge platform. Clearly, the major contributor in the early years was the state. Porter (1998) has shown how states can make a significant impact on firms' competitiveness by providing firms with required research and development (R&D) facilities and research grants that in turn increase the firms' productivity. In our case, the state had no established firms to support, but contributed by building the knowledge platform from which international commercial activities and entrepreneurs could spin out. The state did this in two ways. First, it funded large-scale R&D programs through NRC that allowed research institutions and universities to build capacity within the new area of expertise. Secondly, they invested in building capacity and graduate level programs at Norwegian universities[3] to make sure the emerging industry had sufficient and qualified new talents to recruit. This way the state took the role of the entrepreneur by assuming the risk of initial investment that we normally attributed to entrepreneurs and investors. This story is well in accordance to Mariana Mazzucato's (2013) story of how the entrepreneurial state (in her case the U.S.) built the corresponding industry in Silicon Valley a few decades earlier through the DARPA program.

The early commercial era – 1982 to 1996

In the early years, Norwegian microelectronics probably did not stand out from any country in Western Europe, North America, or any of the developed countries in Asia. They all had governmental sponsored R&D and emerging new companies within this sector. It was after the establishment of Nordic that things became interesting in terms of international commercial activities. In this regard, Covin and Miller (2014, p. 34) argue that "where entrepreneurial companies in an industry adopt a strong international entrepreneurial orientation and its concomitant internationalization behavior, there may be a contagion effect as other companies follow suit. The impact of such mimetic behavior on international entrepreneurial orientation may help explain why some industries and some geographic centers quickly become highly entrepreneurial while others lag far behind". This has definitely been the case in Norwegian microelectronics. Furthermore, together with R&D, the high presence of human capital, especially experts and engineers, are of most important sources of generating new economic knowledge (Audretsch 1998)**.** Our case study tells the story of a set of technically competent entrepreneurs with clear international ambitions for all their business activities from the start. Rather than aiming for small contracts with domestic firms, they instantly sought global leadership in strategically defined market niches. Without this level of ambition, we assume the firms might be able to compete domestically for some time before they eventually would be outcompeted by larger international actors. Moreover, pursuance of a niche (product-market) strategy, especially within the high-tech sector, is recognized to be an important factor enabling new ventures to reach and succeed in international markets. It is also a key distinguishing feature of Born Global firms (Andersson and Wictor 2003; Baronchelli and Cassia 2014; Cannone and Ughetto 2014; Hennart 2014). The international strategy might involve higher levels of business risk, but seems to be required for the establishment of an internationally competitive industry in the longer term.

By the mid-1990s, the role of the state was almost negligible. Now it could harvest from the investment of building the knowledge platform. In this case, the technical knowledge and ambitious international entrepreneurial culture embedded in the firms, research institutions and universities became a platform from which ambitious international entrepreneurs could spin their ventures. The entrepreneurs were highly technologically competent, and exploited technological shifts to establish themselves in fast-growing global market niches. This is also a distinguishing feature of international entrepreneurs as we know it from the IE literature (Jolly et al. 1992; Knight and Cavusgil 2004; Cannone and Ughetto 2014). The university's role in this regard is noteworthy. All entrepreneurs mentioned in the history above got their diplomas at the same faculty at NTNU, and all but three even came from the same department. It seems the culture for entrepreneurship and industry collaboration at this department triggered some very exciting international entrepreneurial activities that should be a subject for further research. Why is it that this particular institution has been able to deliver such international entrepreneurial talent? The culture of the environment in which business activities take place is a missing element in studies covering competitive advantage of nations. This is while it is argued that the foundation of models describing firms and industries prosperity in relation to national competitiveness rests on the base of culture of the environment (Van Den Bosch and Van Prooijen 1992). Empirical research investigating culture in a macroeconomic view with relation to international entrepreneurial orientation is also very limited, and there needs to be further research conducted in this context (Covin and Miller 2014).

Finally, one more observation from this era deserves attention. Norwegian microelectronics might not be called a cluster according Michael Porter's (1990) definition. For that, the firms are too few, too geographically spread, and engage in few transactions of knowledge. However, there is one aspect frequently associated with clusters – coopetition – that definitely has been outspread in early phases of firm formation. During new firm establishment, incumbents voluntarily lent firm resources, technology development

[3] The state funds and owns all universities in Norway and university education is 100% state sponsored.

capabilities, marketing and sales resources, and even funding in order to get the new ventures going. They did this even though they knew they would become fierce competitors in the same product markets in the longer term. Later on, however, as firms became established, fierce competition in all segments became the norm and very little cooperation or exchange of resources, technologies or personnel took place. Hence, coopetition was outspread, but shifted in time as cooperation only occurred at firm start-up, before the natural state of fierce competition took over.

The growth and consolidation era – 1996 to present

The growth of the firms was a result of deliberate risk- and growth-seeking international strategies – defining features of Born Global firms (Rennie 1993; McDougall and Oviatt 2000; Moen and Servais 2002; Aspelund et al. 2007; Jones et al. 2011). The entrepreneurs were driven by their high ambitions, competitiveness, and the inspiration that comes with being an underdog in the international arena.

In order to realize global market ambitions, all but one (Nordic) also chose to become a part of a larger multinational corporation to leverage international sales and marketing capabilities of a larger actor. The IE literature is full of examples of Born Global firms that actively use larger actors in their international marketing activities (McDougall et al. 1994; Oviatt and McDougall 1994; Berg et al. 2008). Hence, this is also a typical feature of Born Global firms, but in this case most of the firms also gave up ownership to gain access to resources and capabilities of established global actors. This strategy secured continuity and security of development and design work in Norway, in addition to a more reliable economic platform and more capable global distribution. It is hard to say whether the growth of the Norwegian microelectronics industry would be the same without foreign investments, but it is little likely.

In summary, this study has focused on the emergence and growth of the Norwegian microelectronics industry – a Born Global industry that has been successful in the face of structural liabilities. We have studied the entrepreneurs, firms and state institutions they have interacted with from a historical perspective, and an interesting pattern emerges. The role of the state, combined with recurring international entrepreneurial behavior have created an industry that broke the typical path dependency of industrial development predicted by dominant theories of economic development and international trade. Instead, it created a new path to an internationally competitive, high growth industry in a country that has few preconditions to host it. These findings suggest a promising synthesis between economic development and international entrepreneurship that could lift the focus of international entrepreneurship as a field out of the individual- and organizational level into the domain of societal effects and economic development in general.

We conclude that the emergence and growth of the Norwegian microelectronics industry has come about due to the consistent actions of a few ambitious, extremely technically competent, risk-seeking individuals with an international perspective for everything they have built. To connoisseurs of the IE literature this description comes to no surprise – these international entrepreneurs and Born Global firms have simply acted in the manner we know from the IE literature. The contribution is the societal and economic effects that result from their actions and how they, through their international entrepreneurial behavior, have been able to overcome significant competitive disadvantages represented by their location in Norway.

However, it should be noted that none of these events would come about if it were not for the strategic and entrepreneurial role of the state. The state financed and built the knowledge platform from which all the entrepreneurs and their commercial activities could spin off. The state also did this without forcing institutional pressure that might have limited growth or in any other way directed development away from the industry's own path. Moreover, credit goes to the state owned institutions that supplied the international entrepreneurial talent. Throughout this story, the university has continuously delivered the entrepreneurial talent that has in turn created the industry through their actions. They have done so by providing students with state-of the-art technological knowledge, embedded in an entrepreneurial culture and in real industrial settings where students were given the opportunity to develop their ideas into commercial activities in collaboration with leading firms in the industry.

We conclude that the foundations for the new path were created by deliberate, risk-seeking behavior from the entrepreneurial state (Mazzucato 2013) paired with typical international entrepreneurial behavior as known from the IE literature. In early stages, the state created a socio-technical platform from which commercial activities could spin. The global commercial potential was in turn realized through the actions of ambitious and technologically competent international entrepreneurs.

However, what made this industry truly international was the international orientation of the entrepreneurs. This shows the latent value of international new ventures as nations seek to increase their international competitiveness and simultaneously broaden their competitive base.

Limitations and further research

The present study is an exploratory study that addresses a research gap in the international entrepreneurship literature. To the best of our knowledge, the first Born Global industry study in the literature was the flat panel industry (Murtha et al. 2001). There have also been two more recent studies investigating the offshore renewable industry (Løvdal and Aspelund 2011; 2012). These studies suggest that an international entrepreneurship approach may offer valuable complementary insight to explain the emergence of new international industries, but it has not established a research framework that proposes the role of international entrepreneurship in new industry formation. As such, an exploratory case study approach seemed appropriate for this study (Eisenhardt 1989; Yin 2008).

As a single industry study in a single country context, the present study suffers from limitations of formal generalization. We should consider at least two limitations to generalization – the characteristics of the industry and the characteristics of the national context.

In terms of industry characteristics, the present study is based on convenience sampling (Eisenhardt 1989) and one of the criteria we used for case selection was unfavorable factor conditions. This criterion was introduced on the assumption that unfavorable factor conditions would make the role of international entrepreneurship more pronounced. It is likely that new industry foundation with more favorable factor conditions would be driven by diversification of existing actors, rather than new entrepreneurial firms. The mentioned studies by Løvdal and Aspelund (2011; 2012) on the offshore renewables industry serve as an illustration. The offshore renewables industry renders itself well for diversification from both land-based wind energy companies (such as Vestas, Siemens and Wattenfall) and offshore oil and gas companies (such as Dong and Statoil). Løvdal and Aspelund collected their data in 2006 – in a very early phase of industry development – and observed a vibrant community of mostly new ventures (about 96 % new firms in the total population of firms). Today the offshore renewables sector is booming, but the major players are large, established multinationals such as MHI Vestas, Siemens and the large European energy and petroleum companies. Hence, it is likely that new industries with more favorable factor conditions (such as the existence of related industries) would to a greater extent be driven by corporate innovation and diversification of existing actors than it is found in this study.

A second consideration is the global nature of the microelectronics industry. Shortly after the invention of the micro transistor, the microelectronics industry internationalized and a massive industry network of production hubs, development centers and efficient distribution was set up globally. The actors in this study actively leveraged this structure to rapidly internationalize their businesses. We are likely to conclude that internationalization of the Norwegian microelectronics industry was more rapid than most other industries, as they could launch their products into an already well functioning globalized distribution network.

Finally, some limitation might come from the fact that the present study was performed in a Norwegian context. Norway is a small, open economy with strong institutions, a resourceful state, and advanced universities, which are state sponsored and tuition free, and the labor market benefits from a generally well-educated population. It is a legitimate question of whether findings from this study would travel to other national contexts. Few particularities of the Norwegian context render the findings idiosyncratic and case specific in comparison to the context of other rich, developed countries. The findings also echoes well with previous research in international entrepreneurship and the role of the state (see e.g. Mazzucato (2013) and her treatise of the development of the same industry in California, U.S., a few decades earlier). However, there are definitely limitations to the practical replication of the strategies found in this paper. Arguably, less resourceful states, with weaker and less advanced institutions, and a less qualified labor market would find it hard to replicate this development. As such, practical replicability would be limited to developed countries, and how these processes occur in less developed countries should be a theme for future research.

The mentioned limitation of this study and the research gap on the societal and economic effects of international entrepreneurship in general represents promising venues for further research. Recent reviews of the IE literature (Aspelund et al. 2007; Keupp and Gassmann 2009; Coviello et al. 2011; Jones et al. 2011; Cesinger et al. 2012; Gray and Farminer 2014; Cavusgil and Knight 2015; Zander et al. 2015) describe a research field where studies predominantly deal with individuals or organizations as units of analysis. Societal and institutional effects of international entrepreneurship remain a significant gap in this literature (Nasra and Dacin 2010) and the concept of Born Global industries (Murtha et al. 2001; Løvdal and Aspelund 2011; 2012) seem to be an interesting bridging concept that ties international entrepreneurship to international trade theories and theories of economic development.

Conclusions

This study departed from the question of how to build new internationally competitive industries – Born Global industries – when structural conditions are not favorable. The findings in this study suggest that a synthesis of the structural perspective and international entrepreneurship theory provides a promising venue for explaining the emergence of Born Global industries. More specifically, this study concludes that the Norwegian microelectronics industry was established as a result of the initial actions of an entrepreneurial state combined with characteristic actions of international entrepreneurs and typical strategies of international new ventures.

We find that international entrepreneurs, that exhibit behavior and international orientation in line with previous findings from the IE literature, consistently drive the creation of the industry. Furthermore, the firms they establish implement niche oriented, aggressive international market strategies that are typical for international new ventures. Consequently, the firms internationalize rapidly after inception and, in order to survive in international markets, develop resources and capabilities that are required to stay internationally competitive. The birth and growth of a Born Global industry is the natural consequence of successful actions on behalf of these entrepreneurs.

However, it is also a story of how institutional factors contribute significantly in the early phases of industry establishment. In the case of Norwegian microelectronics, none of this would probably happen if it were not for the risk-seeking, long-term commitment of the state in the earliest phases of industry establishment. Directly, through making available generous research grants, and indirectly through state universities and research institutions, the state contributed by building a knowledge platform, and nurturing an environment where international entrepreneurs could thrive, from which the Born Global industry could spin out. Later, as the industry grew independent and matured, the state would stop supporting the industry with research grants and turn to harvest its investments in terms of taxable income and a broadened technology and knowledge base.

It seems from this study that an active entrepreneurial state and presence of international entrepreneurs are sufficient factors for the establishment of a Born Global industry, even with unfavorable factor conditions. In Murtha et al.'s (2001, p. 38) words, "you had to be there … but it could have been anywhere".

Even though these conclusions seem fair in the case of Norwegian microelectronics, more research is called for in order to investigate the role of international entrepreneurship in new industry emergence and growth. As a single industry study, the present study suffers from limitation of formal generalization. There are contextual factors and idiosyncrasies that might not travel very well to other settings. Therefore, we call for more research on the societal and economic effects of international entrepreneurship in general and on the emergence of Born Global industries in particular.

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Appendix A

Presentation of the interviewees

Name and date	Company and position	Major topics covered in the interview
Jo Uthus [02.04.2013]	Atmel, director of Applications	In-depth interview topics Historical review of Atmel
Svein-Egil Nielsen [03.04.2013]	Nordic Semiconductor, director of Emerging Technologies and Strategic Partnerships	In-depth interview topics Historical review of Nordic, targeted at partnerships and standardization work
Borgar Ljosland [04.04.2013]	Falanx Microsystems, co-founder and former CEO	In-depth interview topics Historical review of Falanx Microsystems
Geir Førre [08.04.2013]	Energy Micro, co-founder and CEO Chipcon, co-founder and former CEO SI, former researcher	In-depth interview topics Historical review of the whole industry Historical review of Chipcon and Energy Micro
Karl Torvmark [09.04.2013]	Texas Instruments Norway, Strategic Marketing	In-depth interview topics Historical review of Chipcon, targeted at standard components and standardization work
Trond Sæther [12.04.2013]	Nordic Semiconductor, co-founder and director of IPR ELAB, former researcher	In-depth interview topics Historical review of the whole industry Historical review of Nordic
Øystein Moldsvor [13.05.2013]	Hittite Microwave Norway, co-founder and CTO Nordic, former R&D director	Historical review of data converter activity at NTNU, ELAB, Nordic and Hittite Microwave Norway
Frank Berntsen [14.05.2013]	Nordic Semiconductor, co-founder and chief scientist ELAB, former researcher	Historical review of P-RISC / μRISC
Oddvar Aaserud [15.05.2013]	Nordic Semiconductor, co-founder and former CEO ELAB, former researcher	Historical review of the industry, targeted at the first decades

Sources of evidence collected throughout the case study

Sources of evidence	Type of information	Retrieved from
	Archival Data	
Documentation	News clippings	Retriever, newspapers' websites
	Employment statistics	LinkedIn
	Annual reports	Company websites
	Company information	Company websites
	Industry technical information	Books, reports
	Other general historical information	Web, key insiders of companies
Archival records	Archival company data	Proff Forvalt
	Official company announcements	Bronnoysundregistrene
	Interviews	
Semi-structured interviews	In-depth interviews	Key insiders of companies
	Focused interviews	Key Insiders of companies