# Insights into the performance of Iceland´s ITQ system in the context of sustainable development

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Dissertation submitted in partial fulfilment of a *Philosophiae Doctor* degree in Environment and Natural Resources

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# Abstract

The Individual Transferable Quota (ITQ) approach to fisheries management has been promoted as a way to improve efficiency by reducing biological and economic overfishing. However, ITQ´s have also been challenged from environmental and social perspectives while observed efficiency gains have fallen well below estimated potential. This thesis examines these topics in the context of Iceland´s ITQ system in order to shed light on the potential contribution of ITQ´s to sustainable development. Iceland´s ITQ system is a useful case for studying the impact of ITQ´s since it is one of the world´s oldest and is widely regarded as a success, while the historic importance of fishing to Iceland means that the impact of introducing ITQ´s has been subject to intense national scrutiny.

Paper I applies established indicators of industry concentration and competitive rivalry to quota holdings at company and vessel level across species in order to quantify changes in industry structure following the introduction of ITQ´s. For several species, concentration has reached levels associated with market power and further consolidation is increasingly hampered by regulatory limits. The results suggest that a review of these limits may be overdue.

Paper II investigates the large apparent gap between reported and potential economic rent in Iceland´s harvesting sector by quantifying the contribution of transfers to processing, fishermen and the government. The results indicate that cumulative transfers to these groups between 2002-2014 exceeded reported rent. A speculative explanatory model is presented in which stakeholder representatives cooperate in order to obfuscate resource rent from harvesting and reduce pressure for reallocation to society at large.

Paper III examines the transitional gains trap, a phenomenon claimed to reduce the political scope for reallocation of quota rent due to resistance from harvesters who paid for the quota rather than being granted them as a result of grandfathering. A potential measure of the trap, based on harvesters' cumulative investment in quota, is developed and applied to the Icelandic ITQ system. Illustrative results indicate that the proposed measure was generally below 60% by 2016 and that the extent of the trap may only be partial some 25 years after the current system was introduced, although outcomes are sensitive to assumptions due to the cumulative nature of the measure. Lastly,

it is shown that the proposed measure can decline over time when accumulated profits are set off against cumulative investment costs.

Paper IV analyses historic fuel use patterns by Icelandic harvesters for key segments and species and examines potential drivers. The results indicate that fuel intensity in the demersal sector has declined in recent years to levels which are low relative to other countries and that higher fish stocks have been an important contributory factor. A novel policy instrument to reduce industry greenhouse gas emissions is presented whereby ITQ´s are extended to cover emissions as well catch, with each harvester receiving individual transferable emissions quota in proportion to their catch share and Total Allowable Emissions set by the authorities.

Paper V explores patterns in usage of catch-quota balancing mechanisms in Iceland´s mixed demersal fishery. Panel data analysis indicates systematic behaviour consistent with arbitrage incentives, suggesting a high risk of consistently exceeding TAC limits. Despite this, overfishing has been relatively modest and this is attributed to limits which have been tightened and are particularly stringent for the main target species, cod.

This thesis explores the potential of the ITQ approach to contribute to sustainable development of fisheries along the three established dimensions (economy, society and environment). Results for the Icelandic ITQ system indicate a qualified success in meeting some of the key challenges. The system also exhibited flexibility in responding to emerging issues. Two avenues for further research are highlighted; pathways to carbon-neutral fishing and implications of different allocation methods. Research into the latter topic seems particularly warranted; fisheries economics has been relatively silent on the subject but frameworks can be found in the broader literature that may inform the sustainable development agenda to the extent that it involves creating limited valuable rights to use natural resources which must somehow be allocated.

# Útdráttur

Notkun framseljanlegs, einstaklingsbundins kvóta (FEK) hefur verið hampað sem leið til að auka skilvirkni með því að draga úr líffræðilegri og hagfræðilegri ofveiði. Hins vegar hefur slíkt kerfi hlotið gagnrýni á grundvelli samfélagslegra- og umhverfissjónarmiða, auk þess sem aukning á skilvirkni hefur reynst öllu lægri en áætlaðir hámarksmöguleikar. Í verki þessu er þetta viðfangsefni skoðað í samhengi við íslenskt kvótakerfi til þess að varpa ljósi á mögulegt framlag FEK til sjálfbærrar þróunar. Það er gagnlegt að skoða íslenska kerfið því það hefur verið einna lengst við lýði í heiminum og er víða talið hafa gefist vel, en sögulegt mikilvægi fiskveiða á Íslandi veldur því að áhrif kvótakerfisins hafa verið efni til ítarlegrar skoðunar hjá þjóðinni.

Í grein I eru notaðir vísar fyrir samþjöppun og samkeppni um kvótaeign fyrirtækja og fiskiskipa fyrir einstakar fisktegundir í þeim tilgangi að gera magnbundna skoðun á uppbyggingu sjávarútvegarins eftir að kvótakerfi var komið á. Fyrir nokkrar tegundir hefur samþjöppun kvótaeignar orðið slík að hún gæti verið vísbending um markaðsvald og frekari samþjöppun takmarkast í auknum mæli af reglugerðum. Niðurstöður gefa til kynna að endurskoðun þeirra takmarkanna kunni að vera tímabær.

Grein II fjallar um umtalsverðan mun á uppgefinni og hámarksmögulegri rentu auðlinda í fiskveiðum á Íslandi með því að gera magnbundna athugun á framlagi tekjufærslna til fiskvinnslu, sjómanna og ríkis. Niðurstöður benda til þess að heildartekjufærslur til þessara aðila á árunum 2002-2014 séu meiri en uppgefin renta. Lögð er fram tilgáta að líkani til útskýringar þar sem haghafar vinna saman að því að gera rentu af fiskveiðum ógegnsærri og þar með draga úr þrýstingi frá samfélaginu um endurskoðun á hvernig arði af auðlindinni er deilt.

Grein III fjallar um uppgripagildruna, en vísað er til hennar til að útskýra takamarkaða pólitíska möguleika á að endurúthluta kvóta vegna andstöðu kvótahafa sem keyptu kvóta frekar en að fá úthlutað án endurgjalds. Þróaður er mögulegur mælikvarði á umfang gildrunnar sem byggir á heildarfjárfestingu útvegsfyrirtækja í kvóta og sá mælikvarði notaður fyrir íslenska kvótakerfið. Frumniðurstöður gefa til kynna að mælikvarðinn hafi almennt verið innan við 60% árið 2016, og því kunni umfang gildrunnar að vera takmarkað 25 árum eftir að núgildandi kvótakerfi var komið á, þó að niðurstöður séu næmar fyrir forsendum sökum uppsöfnunareiginleika mælikvarðans. Að lokum er sýnt fram á að mælikvarðinn geti lækkað í gildi með tíma þegar tillit er tekið til uppsafnaðs hagnaðar.

Í grein IV eru skoðuð söguleg gögn um eldsneytisnotkun íslenskra fiskiskipa fyrir lykil skipa- og fiskitegundir, og áhrifaþættir notkunar rannsakaðir. Niðurstöður gefa til kynna að eldsneytisnotkun við botnfiskveiðar hafi minnkað á undanförnum árum að því marki að hún er lægri en það sem gerist í öðrum löndum, og að stærð nytjastofna hafi þar ráðið miklu um. Kynnt er hugmynd að nýju hagstjórnartæki til að draga úr losun gróðurhúsalofttegunda (GHL) við fiskveiðar, en það byggir á því að FEK er útvíkkaður til að ná utan um losun GHL auk afla með þeim hætti að sérhvert útvegsfyrirtæki fái framseljanlegan losunarkvóta í réttu hlutfalli við aflakvóta og að heildarlosun sé mörkuð af stjórnvöldum.

Í grein V eru mynstur í tilfærslu kvóta milli fisktegunda í blandaðri botnfiskveiði skoðuð. Margvíð þversniðsgögn gefa til kynna kerfisbundna hegðun sem er í samræmi við hvata til verðmunarviðskipta, en það bendir til áhættu á að ítrekað sé farið fram úr aflamörkum. Þrátt fyrir þetta hefur ofveiði verið hófleg og er það talið vera vegna hertra tilfærsluheimilda sem eru sérstaklega strangar með tilliti til þorsks.

Í þessu verki eru möguleikar FEK á að stuðla að sjálfbærri þróun fiskveiða kannaðir í ljósi hagrænna, félagslegra og umhverfisþátta. Niðurstöður fyrir íslenska kvótakerfið gefa til kynna að það hafi að einhverju marki mætt sumum lykiláskorunum með góðum árangri. Kerfið reyndist einnig sveigjanlegt til að taka á málum sem hafa komið upp. Bent er á tvö viðfangsefni til frekari rannsókna; annars vegar leiðir að kolefnis-hlutlausum fiskveiðum og hins vegar ályktanir sem draga má af mismunandi aðferðum við úthlutun kvóta. Einkum er ástæða til rannsókna á síðarnefnda viðfangsefninu enda hefur lítið verið um það fjallað á vettvangi fiskihagfræði, en leita má í smiðju annarra fræðagreina um ramma um sjálfbæra þróun að því er við kemur tilurð takmarkaðra og verðmætra réttinda til að nýta náttúruauðlindir sem úthluta þarf með einhverjum hætti.

# Table of Contents

# List of Papers

This thesis is based on four published papers and one draft manuscript, which will be referred to in the text as the following chapters:

**Paper I: Chapter 2**

Byrne, C., Agnarsson, S., Davíðsdóttir, B., & Oostdijk, M. (2020). Species-level quota concentration in the Icelandic harvesting sector. *Marine Policy, 121,* 104108.

**Paper II: Chapter 3**

Byrne, C., Agnarsson, S., & Davíðsdóttir, B. (2019). Profit and rent in the Icelandic harvesting sector. *Fisheries Research, 220,* 105349.

**Paper III: Chapter 4**

Byrne, C., Oostdijk, M., Agnarsson, S., & Davíðsdóttir, B.. The Transitional Gains Trap in grandfathered Individual Transferable Quota fisheries. Draft manuscript.

**Paper IV: Chapter 5**

Byrne, C., Agnarsson, S., & Davíðsdóttir, B.. Fuel intensity in Icelandic fisheries and opportunities to reduce emissions (2021). *Marine Policy, 127*, 104448.

**Paper V: Chapter 6**

Oostdijk, M., Byrne, C., Stefánsson, G., Santos, M. J., & Woods, P. J. (2020). Catch–quota matching allowances balance economic and ecological targets in a fishery managed by individual transferable quota. *Proceedings of the National Academy of Sciences, 117*(40), 24771-24777.

# Author Contributions

**Paper I -** CB designed the research. CB and MO collected and analysed the data. CB wrote the paper with helpful feedback from on multiple drafts from all coauthors. SA and BD provided guidance throughout the process.

**Paper II -** CB designed the research, collected and analysed the data. CB wrote the paper with helpful feedback on multiple drafts from SA and BD. SA and BD also provided guidance and feedback throughout the process.

**Paper III -** CB designed the research. CB and MO collected and analysed the data. CB wrote the paper with helpful feedback on multiple drafts from all coauthors. SA and BD provided guidance throughout the process.

**Paper IV -** CB designed the research. CB collected the data with help from BD in obtaining access to confidential company data. CB analysed the data. CB wrote the paper with helpful feedback on multiple drafts from BD and SA. BD and SA also provided guidance throughout the process.

**Paper V -** MO collected the data jointly with CB, MO lead the research design, MO and CB jointly carried out the analysis. PW and MJS also designed the research and GS aided with the methodology. MO wrote the first draft of the paper and all co-authors helped with writing.

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# 1 Introduction

## 1.1 Research focus and structure

Global marine capture fisheries are a significant source of affordable, nutritious food for billions of people, consistently yielding around 90 million tonnes annually since the late 1980´s (FAO, 2020). The sector also supports the livelihoods of hundreds of millions of people, particularly in coastal communities and lower-income countries. While fishing at sea is essentially an economic activity, it relies on access to wild fish stocks which form an integral part of diverse local marine ecosystems. These stocks are finite resources which replenish naturally and therefore have the potential to support continued fishing indefinitely, provided that the rate of extraction is within limits dictated by the stock´s natural ability to replenish and that environmental and ecological conditions remain favourable. Marine capture fisheries have been recognised by the UN as having an important role to play in sustainable development and are highlighted specifically in the Sustainable Development Goals declared by the UN in 2015.

Despite the historic importance of marine capture fisheries to global prosperity and their potential to contribute to sustainable development, the sector faces a raft of challenges. A large and growing number of global fish stocks are harvested at biologically unsustainable levels (FAO, 2020; Sumaila et al., 2015). The resultant depletion reduces the supply of food and can simultaneously increase unit costs due to the lower spatial density of depleted fish stocks. In extreme cases, overfishing can lead to stock collapse and the potentially irreversible loss of productive natural resources. Where stocks are in reasonable condition, the economic benefits can be dissipated due to wasteful fishing practices including overcapacity sometimes exacerbated by government subsidies (Sumaila et al., 2019). Climate change is causing ocean warming and acidification which are disruptive to marine ecosystems and fish stocks while the resultant pressure to reduce use of fossil fuels may require transformation of industrial fishing which currently relies almost exclusively on oil as a cheap and convenient source of energy at sea. Finally, the proliferation of rights-based fishing is raising new issues regarding the allocation of the rights to fish and associated benefits amongst competing and heterogeneous stakeholder groups.

Underlying many of these issues is the tendency in certain situations to over-exploit common pool resources i.e. resources for which extraction is subtractable (use reduces availability for others) and would-be users are not easily excludable (Ostrom et al., 1994; Stavins, 2011). In the case of wild fish stocks, the populations move around the open sea making exclusion of users

difficult while extraction can significantly reduce the availability for future users if it exceeds the natural ability of the population to replenish itself. Traditionally, harvesters have not owned fish until they are caught; fish in the sea could be acquired by anyone willing to expend the effort needed to catch it before someone else does. In these circumstances, an individual harvester has little incentive to stop fishing in order to conserve the stock and improve future harvests for the benefit of all harvesters. The resultant depletion imposes a double penalty on society, simultaneously reducing output while increasing the effort required to catch each fish. The mobile and migratory nature of some species means that this problem can extend across national boundaries and into the open sea (Sumaila et al., 2015). Achieving better outcomes generally involves the agreement of shared rules regarding resource use and this is arguably the raison d´être for fisheries management.

Many fisheries managers have responded to the above challenges by introducing rights-based fishing in which limited rights to fish are granted to specified individuals or groups to the exclusion of others. While rights-based systems vary greatly, Individual Transferable Quota (ITQ´s) have received increased attention in recent years and are widely regarded as a promising approach, so much so that they have even been described as a panacea (Young et al., 2018). ITQ´s typically confer on the holder the long-term right to catch a fixed percentage share of the total catch allowed by the fishery manager each year and can be sold by the holder. These features are intended to align the incentives of the harvester with the overall policy goals of reducing overfishing and improving fleet efficiency. Despite the theoretical economic benefits of ITQ´s, many commentators have argued that these may not materialize in practice due to the imperfect delineation of rights in fisheries and the multiple margins on which value can still be dissipated (Wang, 1995; Grafton, 1996; Costello & Deacon, 2007; Smith, 2012). ITQ´s have also been criticized as placing too much emphasis on economic benefits at the expense of social and environmental considerations (Degnbol et al. 2006; Bromley, 2009; Pinkerton & Edwards, 2009; Sumaila, 2010; Soliman, 2014; McCormack, 2017; Young et al., 2018).

Case studies of specific systems can improve understanding of the impact of ITQ´s by showing the extent to which theory is borne out in practice and by setting this in the context of implementation and local circumstances which can vary significantly. This understanding can be useful to policy makers considering the introduction of ITQ´s and also as a benchmark for managers of existing ITQ systems. Case studies are also considered a useful method for generating hypotheses for subsequent investigation (Eisenhardt, 1989; Young et al. 2018). In the longer term, as the growing global population becomes

increasingly reliant on scarce and overstretched renewable natural resources and ecosystem services with common pool characteristics, advances in fisheries management may have broader relevance. For example, Daly & Farley (2011) argue from an ecological economics perspective for a hierarchy of three policy goals (sustainable throughput, socially acceptable distribution and efficient allocation via market trade) which mirror the features of ITQ systems (TAC setting, initial allocation of quota and transferability).

The aim of this thesis is to shed light on the potential of the ITQ approach to contribute to sustainable development in fisheries by examining the development of the Icelandic fishing sector since the introduction of the current ITQ system in 1991. Iceland´s ITQ system has a number of features that make it a particularly interesting subject for case studies. Firstly, the system is relatively mature (Hoshino et al.; 2020) which means that there is more scope to observe phenomena that may only emerge in the medium term. Secondly, the Icelandic fishing sector is unusually important to national prosperity, generating revenue from seafood products equivalent to 8% of GDP in 2019 (Statistics Iceland). The industry is also an important provider of employment, particularly in rural communities. The system has therefore been subject to intense national scrutiny and has also been a source of controversy which has sometimes spilled over into the political arena and led to changes in fisheries management (Eythorsson, 2000; Matthiasson, 2012; Kokorsch et al., 2015). The scale of the sector also means that it accounts for a major portion of Iceland´s greenhouse gas emissions and will be important to achievement of national emission reduction targets (Ministry for the Environment and Natural Resources, 2020).

The overarching research question of this thesis is as follows - how has Iceland´s ITQ system addressed key economic, social and environmental challenges associated with fishing? In answering this question, the thesis focuses on specific topics where there are knowledge gaps and which take advantage of the distinguishing features of the Icelandic ITQ system described above. The research is structured as five papers each focusing on a distinct topic: (I) limiting concentration of power; (II) achieving economic efficiency; (III) potential to redistribute resource rent; (IV) reducing reliance on fossil fuels; and (V) cost-effective elimination of discards. The aim of these papers are described in more detail below.

An important property of ITQ´s is transferability since it removes a potential barrier to reduction in excess capacity and facilitates movement of quota to the most efficient harvesters. However, concern that this movement can concentrate ownership of a limited national resource and therefore power over other stakeholders has resulted in limits to individual ownership. Paper I

analyses how concentration has evolved across major species, the extent to which current limits are hampering further consolidation and discusses the relevance of traditional concentration-based measures of market power.

ITQ´s have been promoted as a way to combat dissipation of rent due to biological and economic overfishing. Reported sector performance in Iceland indicates that efficiency has improved under ITQs but has stabilised well below estimated potential. It is important to stakeholders to understand whether this gap is real and due to dissipation that could potentially be eliminated, or apparent and due to transfers of rent from harvesting to other stakeholders. Paper II quantifies the extent of rent transfers to key stakeholders and identifies the institutions and mechanisms involved. Finally, a speculative explanatory model is presented and linked to established concepts drawn from the political economy of rent-generating sectors.

Political uncertainty about whether grandfathered quota will be revoked or taxed more heavily has been argued to undermine the incentives of ITQ holders and associated economic benefits for society. In Iceland, uncertainty has persisted with calls to reallocate quota being met with the argument that quota trade has rendered redistribution impractical due to the implied losses for harvesters i.e. Transitional Gains Trap. Paper III proposes a quantitative measure of the trap and presents illustrative calculations for the Icelandic harvesting sector.

The traditional reliance on fossil fuels threatens the viability of the fishing industry as fuel prices rise and become volatile while governments commit to reduce emissions of greenhouse gases. ITQ´s have been predicted to reduce fuel intensity and therefore facilitate broader abatement efforts. Paper IV analyses historical development of fuel intensity for Iceland´s main fleet segments and species and identifies opportunities to reduce emissions.

Discards are considered damaging to fish stocks and are increasingly prohibited, most recently across the EU (Uhlmann et al., 2019). However, there is concern that compliance can be expensive and result in severe underutilisation of quota (Mortensen et al., 2018). Catch-quota balancing potentially offers a cost-effective way for mixed quota-based fisheries to comply with discard bans but can theoretically lead to systematic overfishing. Paper V examines the balancing behaviour of Icelandic vessels in the mixed demersal fishery and the resultant risk of overfishing.

## 1.2 Rights-based fishing and ITQ´s

Rights-based fisheries limit harvesting activity in some way that restricts exploitation below the level associated with open access. The scope to introduce fishing rights increased significantly with the extension of national

fishing boundaries to 200 miles during the late 1970´s (Hannesson, 2005; Sanchirico & Wilen, 2007; Grimm et al., 2012; Bromley, 2015; Standal & Asche, 2018). Since then, a diverse variety of fishing rights systems have been introduced around the world reflecting the many dimensions on which harvesting can be restricted, as well as differences in local circumstances and improved understanding of the performance of alternative approaches (Scott, 1989; Huppert, 2005; Parkes et al., 2009).

One rudimentary approach is to focus purely on the fish stock, limiting the total amount harvested in order to rebuild and conserve biomass at the desired level. In this case, all users have the right to fish until the total catch limit is met and the fishery is closed for the remainder of the season. Setting the desired level is a complex task, depending on the fishery manager´s ability to assess the current status of stocks, predict their development under different harvesting scenarios and then select scenarios that best meet overall policy goals which may involve multiple criteria and be the subject of lobbying. Perhaps the most widely cited method is to limit harvesting so that a fish stock reaches the level predicted to support the highest consistent level of harvest (Maximum Sustainable Yield) or economic rent (Maximum Economic Yield) (Mace, 2001; Finley & Oreskes, 2013; Dichmont et al., 2010; Squires & Vestergaard, 2015). While the logic of pursuing higher stock levels which will eventually lead to higher harvests sounds inescapable, such strategies often involve an initial reduction in harvest levels in order to rebuild stock which may meet resistance from the industry and other stakeholders.

Experience has shown that simply increasing the productivity of fish stocks may not be sufficient to improve economic performance since the potential gains can be dissipated by increased fleet inefficiency, particularly overcapacity coupled with truncated fishing seasons (Homans & Wilen, 1997). This phenomenon, sometimes referred to as economic overfishing (Pauly, 1994), has been attributed to a "race for fish" in which individual harvesters utilise additional inputs to compete with each other for a limited quantity of fish. Harvesters will have an incentive to invest in any inputs that increase their share of this limited quantity provided that the incremental cost is covered by the additional revenue, even though this will reduce the share and therefore catch of other harvesters and overall sector efficiency may decline. This problem is difficult to solve due to the pervasive incentives in the race for fish and the multiple margins on which fishermen are able to compete. Limiting inputs on one dimension, for example vessel length, would simply lead to increased input use on other dimensions, for example broader vessel designs, a phenomenon sometimes referred to as "capital-stuffing" (Townsend, 1985; Casey et al., 1995; Anderson et al., 2019). Wilen (2005)

illustrates the many margins on which rent can be dissipated when harvesters race for fish with the case of the British Columbia herring fishery in which vessels were helicoptered between fishing location.

Policy makers increasingly favour rights-based fishing systems designed to better align the incentives of individual harvesters with overall management goals. For example, the incentive to "race for fish" may be attenuated by establishing individual rights to fish up to a certain quantity which each rights-holder can be confident of achieving in the knowledge that other harvesters will not exceed their permitted catch and there will consequently be enough to go around. It has also been argued that designing rights to have certain characteristics associated with traditional property rights can encourage rights holders to support conservation and fleet rationalization (Scott, 1989). This approach has arguably been best exemplified by Individual Transferable Quota or ITQ systems. In an ITQ fishery, individual harvesters receive quota, typically defined as a share of Total Allowable Catch set by the fishery manager, and are permitted to harvest the corresponding volume and fish type for as long as the quota is valid, subject to further restrictions imposed by the fishery manager (Grafton, 1996; Squires et al., 1995; Squires et al., 1998). The transferable nature of ITQ´s allows holders to realise the capitalized value of their quota and is argued to remove a barrier to the exit of inefficient capacity by compensating the departing harvester for the loss of fishing rights.

The proliferation of ITQ systems since the 1980´s has greatly improved empirical knowledge of their performance (Costello et al., 2008; Branch, 2009; Chu, 2009; Costello et al., 2010; Nowlis & Van Benthem, 2012; Melnychuk et al., 2016; Hoshino et al., 2020). The impact of ITQ management has been found to vary significantly across fisheries and has prompted research into the importance of implementation and local circumstances. One line of inquiry has focused on the extent to which particular ITQ resemble "perfect" property rights based on particular characteristics such as security, exclusivity, permanence and transferability (Stewart, 2004; Arnason, 2005; Grainger & Costello, 2011). Other research has identified a broader range of factors including local stakeholder involvement (Macinko, 2014; Melnychuk et al., 2016; Hersoug, 2018). This growing body of research has shown that introduction of ITQ´s can attenuate both biological and economic overfishing and therefore claim some economic superiority over the alternatives of open access and regulated open access. However, the results are mixed and reported performance has generally fallen well below estimates of potential efficiency, suggesting that significant rent dissipation can persist under ITQ´s.

The literature investigating rent dissipation in ITQ fisheries is extensive and has identified numerous potential causes including imperfect quality and delineation of the associated rights (Costello & Deacon, 2007; Smith, 2012), restrictions on the disposition of rights (Lian et al., 2009; Kroetz & Sanchirico, 2010; Kroetz et al., 2015), strategic behaviour prior to the introduction of ITQ´s (Brandt, 2007), imperfect enforcement (Parslow, 2010), crew share remuneration (Hannesson, 2007), and non-economic incentives (Nøstbakken, 2012). Some of these limitations reflect the fact that fishing rights are not property rights due to practical constraints – it is not feasible with current technology to own and harvest particular fish. The heterogenous nature of fish stocks means that some fish are more profitable to harvest than others, for example due to size or location, while the imperfect delineation of ITQ´s, which are typically defined in terms of harvest volume, creates an opportunity to compete for the most profitable fish. ITQ´s can also be limited by design, featuring limitations on transferability, the amount individual entities may control, and duration which are usually intended to address non-economic concerns.

A practical issue associated with ITQ´s (and rights-based systems in general) is that policy makers must decide who should receive the rights when first created as well as how much, if at all, they should pay. These are usually characterized as political decisions which competing, sometimes heterogenous, stakeholder groups may seek to influence. These groups are likely to have different perspectives and priorities; vessel owners may be interested in the profitability of fishing, crew in the right to work, processors in access to fish, and broader communities in the contribution of fishing to the local economy and taxes. Reconciling such conflicting interests has been described as a contracting problem (Johnson & Libecap, 1982) which must be successfully negotiated before rights-based systems such as ITQ´s can be adopted. The most common approach is grandfathering in which incumbents immediately prior to introduction of ITQs receive allocations proportional to their cumulative fishing history over a specified period and it has been suggested that this is necessary for industry agreement and in order to compensate exiting harvesters (Lynham, 2014; Hannesson, 2014; Grainger & Costello, 2016). While wasteful competition over allocation and rent seeking have been associated with ITQ´s prior to implementation (Edwards, 2001; Brandt, 2007), it is not normally associated with rent dissipation once the system is up and running. The standard view, sometimes described as Coasean (Hoff & Stiglitz, 2005), is that initial allocation is irrelevant to subsequent efficiency since the quota will end up with the most efficient harvesters as they will be willing to pay the most (Stavins, 2011). There is however,

evidence that distributional conflicts over allocation can persist and result in either changes to the ITQ system or the introduction of new measures external to it (Hilborn et al., 2005; Matthiasson, 2008; McCormack, 2017; Danielsen & Agnarsson, 2018; Standal & Asche, 2018).

Beyond their economic impact, ITQ systems have been criticized for focusing too narrowly on the interests of harvesters at the expense of other stakeholder groups including crew, processors, fishing communities and society at large (Matulich et al., 1996; Bromley, 2009; Jacobsen, 2019; Hoshino et al., 2020). These concerns relate to loss of jobs and lower wages, concentration of quota holdings leading to undue influence over the industry and institutions, barriers to entry, and fair distribution of rent derived from publicly owned marine resources. These issues can be particularly challenging since they may not initially be apparent but can be exacerbated over time, creating political tensions that can undermine confidence (Matthiasson, 2008). More generally, as policy goals broaden to include not only social issues but also ecosystem health, environmental pollution, and international cooperation, it is increasingly recognized that ITQ´s can only be part of a broader holistic approach to fisheries management (Grafton & McIlgorm, 2009; Sumaila, 2010; Young et al., 2018). The task is then to determine how large or small a part they should play (National Research Council, 1999; Soliman, 2014; Acheson et al., 2015).

## 1.3 The Icelandic harvesting sector

The research in this thesis focuses on developments in Iceland´s ITQ system. Iceland is an island in the North Atlantic, close to the Arctic Circle. The country is sparsely populated, with an area of 103,000 square kilometers and 368,000 inhabitants (Promote Iceland, 2021; Statistics Iceland, 2021). The economy has traditionally relied heavily on natural resources with export revenue driven primarily by fishing, renewable energy and, more recently, tourism (McKinsey & Company, 2011).

Iceland´s fishing fleet operates primarily within the Economic Exclusion Zone harvesting demersal and small pelagic species, although pelagic vessels increasingly operate in international waters. Cod (*Gadus Morhua*) has dominated demersal landings but haddock (*Melanogrammus aeglefinus*), saithe (*Pollachius virens*) golden redfish (*Sebastes norvegicus*) have also been important. In the pelagic sector, the species mix has changed dramatically since the turn of the century with capelin (*Mallotus villosus*) and herring (*Clupea harengus*) declining in importance while blue whiting (*Micromesistius poutassou)* and, more recently, mackerel (*Scomber*

*scombrus*) have grown (Sævaldsson & Gunnlaugsson, 2015). In 2019, 1,132 active Icelandic vessels landed 1,078 thousand tonnes of fish with a value of € 1,020 million. Demersal species accounted for 48% of this volume but 85% of harvest value, reflecting the lower average price of the pelagic species. Pelagic fishing was dominated by a small fleet of large vessels (18 vessels of average size 2,582 gross tonnes) while the remainder of the fleet, over 1,100 vessels, was focused on demersal fishing and comprised a mixture of small and medium-sized coastal vessels as well as large trawlers, some of which process and freeze catch on board (Saevaldsson & Gunnlaugsson, 2015; Knutsson et al., 2016).

Fisheries management regulations in Iceland were limited until the mid-1970´s when the country unilaterally extended its national fishery boundary to 200 miles, resulting in the third and final cod war (Matthiasson, 1997; Matthiasson, 2003; Arnason, 2005; Steinsson, 2016). This limit was adopted in several other countries and subsequently confirmed with the ratification of UNCLOS in 1982 (Nemeth et al., 2014; Steinsson, 2016)[1]. In 1976, individual quota were introduced for the herring fishery which had previously been subject to a moratorium due a collapse in harvests, and total quota were introduced for cod (Danielsson, 1997). During the following decade the management system developed rapidly but piecemeal, extending to the main demersal and pelagic species and introducing total quota, individual catch and effort quota, usually allocated based on catch history, and some transferability. These developments culminated in the introduction of a unified ITQ system in 1991 which has served as the foundation of Iceland´s fishery management ever since (Runolfsson & Arnason, 2001; Agnarsson et al., 2016).

Although the relative importance of fishing to Iceland´s economy has declined in recent years due to the expansion of energy-intensive and tourism industries, its contribution to national prosperity and wealth remains striking when compared to other countries with ITQ systems. Marine capture harvest in Iceland amounted to 3.6 tonnes per capita in 2018 while exports of fishery commodities were US$ 6,700 per capita (Table 1). The fishing and fish-processing industries together accounted for 4% of all jobs in 2019 (Statistics Iceland) and have also supported business in ancillary sectors (Sigfusson et al., 2013). While information on the market price of fishing quota is sparse (Matthiasson, 2012), the estimates presented in Paper III of this thesis indicate a total combined value for all fishing quota equivalent to around 25% of corporate capital stock in 2016 (Statistics Iceland, 2021).

[1] Over 95% of global marine catch is estimated to take place within EEZ´s (Englander, 2019).

| Country | Year ITQ´s introduced | Capture harvest (thousand tonnes) | Seafood exports (US$ billions) | Population (millions) | Harvest/capita (kg) | Exports/Capita (US$ thousand) |
|---|---|---|---|---|---|---|
| Canada | 1983 | 899 | 5.4 | 37.1 | 24 | 0.15 |
| Australia | 1984 | 225 | 1.1 | 25.0 | 9 | 0.04 |
| Netherlands | 1985 | 412 | 5.6 | 17.2 | 24 | 0.33 |
| **Iceland** | **1986** | **1,278** | **2.4** | **0.4** | **3,625** | **6.68** |
| New Zealand | 1986 | 408 | 1.2 | 4.8 | 84 | 0.25 |
| Chile | 1989 | 2,369 | 6.8 | 18.7 | 127 | 0.36 |
| USA | 1990 | 5,353 | 6.0 | 326.7 | 16 | 0.02 |
| South Africa | 1998 | 611 | 0.7 | 57.8 | 11 | 0.01 |
| Estonia | 2001 | 87 | 0.2 | 1.3 | 66 | 0.13 |
| Denmark | 2003 | 789 | 5.0 | 5.8 | 136 | 0.87 |
| Norway | 2004 | 2,664 | 12.0 | 5.3 | 501 | 2.26 |
| Peru | 2009 | 7,208 | 3.3 | 32.0 | 225 | 0.10 |
| Sweden | 2009 | 222 | 4.8 | 10.2 | 22 | 0.47 |
| Argentina | 2010 | 838 | 2.1 | 44.5 | 19 | 0.05 |
| Global fisheries | NA | 98,671 | 165.4 | 7,591.9 | 13 | 0.02 |

**Table 1**. Total and per capita capture harvest volume and seafood export value for countries with ITQ systems listed in Hoshino et al. (2020). (FAO, World Bank). Note that capture volume includes both marine and inland fisheries while seafood exports cover all fish-based products, whether derived from capture fisheries or aquaculture. The latter contributes approximately half of total fish production in Norway and Chile.

The history of ITQ´s in Iceland has been punctuated by conflicts which have led to several changes in fisheries management policy. An effort-based coastal fleet has been established to address concerns about barriers to entry and the impact on fishing communities from the sale of quota has been ameliorated by the introduction of rural quota which can be allocated by the government to support specific communities (Kokorsch et al., 2015; Chambers & Carothers, 2017). Industrial action by fishermen objecting to the effects of quota leasing and transfer pricing of ex vessel fish led to the establishment of a fish pricing bureau and consultative price setting process (Eythorsson, 2000). Finally, popular demand for a share of the resource rent from national marine resources has resulted in the introduction and subsequent increase of profit-based quota fees (Matthiasson, 2008; Gunnlaugsson et al., 2018). In some cases, repeated adjustment has taken place in response to tensions which have flared up periodically, for example relating to resource taxation during government elections and crew remuneration when collective wage agreements are renegotiated.

## 1.4 Sustainable Development in fisheries

This thesis examines specific economic, social and environmental aspects of Iceland´s ITQ system and is therefore set in the broader context of research into sustainable development.

The term "sustainable development" has been the subject of much debate but is generally understood to involve three "pillars"; the economy, the environment, and society (Purvis et al., 2019). The term is perhaps most commonly associated with the United Nations Brundtland Commission of 1987 whose proposed definition continues to be popular[2]. Opinions vary widely on the usefulness of the term; it has been criticised both for being vague (Parris & Kates, 2003) and oxymoronic (Redclift, 2005). Efforts have been made to clarify the meaning of sustainable development by producing more detailed definitions such as the 17 Sustainable Development Goals ("SDG") which are based on 169 targets and were adopted by the UN in 2015, following consultation with governments of both developed and developing economies (Biermann et al., 2017). Despite its conceptual weaknesses, the term has become sufficiently embedded in the academic literature[3] and public discourse that it can be a useful umbrella for subjects which connect economic activity, social well-being and the environment (Sneddon et al., 2016).

The important role of fisheries in sustainable development has long been recognised. Fisheries are referred to repeatedly in the Brundtland Commission report (1987) and highlighted specifically in SDG 14; "Conserve and sustainably use the oceans, seas and marine resources" (Haas, et al., 2019). Analysis of linkages between SDG 14 and other SDG´s finds them to be extensive (for example regarding hunger, poverty, sustainable communities, and economic growth), and to generally entail co-benefits in which the linked goals are mutually beneficial (Singh et al., 2018). The importance of science-based fisheries management is specifically highlighted in target 14.4 with a view to prevention of overfishing and destructive fishing practices.

Marine capture fisheries may also contribute indirectly by offering lessons in the formulation of governance models for other common pool resources to the extent that it has foreshadowed the more general trend towards sustainable development with its early emphasis on maximising yield and managing

[2] "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

[3] Interestingly, a search on Google Scholar for the term "sustainable development" returned 3.6 million results compared to 4.8 million for "economics", 3.4 million for "politics" and 3.8 million for "ecology" (accessed January 2021).

resource usage (Larkin, 1977; Grafton et al., 2010; Finley & Oreskes, 2013). As discussed above, fisheries management has been developing for over four decades guided by principles which also underly sustainable development. Many fisheries have managed to halt over-exploitation of fish stocks only to see new issues emerge including economic overfishing and, where rights to fish have been limited and become valuable, disputes over allocation of those rights. To the extent that sustainable development leads to greater reliance on renewable resources whose throughput is limited to a level that can be maintained, it seems likely that ownership of the rights to use and profit from these resources may increasingly be subject to similar disputes. The importance of allocation for the perceived legitimacy of governance models to limit resource use has received particular attention in the ecological economics literature (Daly & Farley, 2011) and has also been discussed widely in the political economy literature (Acemoglu & Robinson, 2019; Piketty, 2020). Governance has emerged as an important factor in sustainable development and is targeted in two of the seventeen SDG´s, reflecting the need for both differentiated local policies and also for international cooperation to combat global challenges such as climate change. The Brundtland Commission described its eponymous report as a "call for action" in the pursuit of sustainable development (1987). Such action depends not only on the development of clear goals and political will, but also policy instruments with sufficient support from stakeholders and robust to changing circumstances (Sterner & Coria, 2003).

While fisheries can contribute to sustainable development, there are also areas in which the broader trend towards sustainable development may have particular implications for fisheries. Two are highlighted here; climate change and international co-operation. Fishing vessels rely heavily on oil, resulting in greenhouse gas emissions and therefore contributing to climate change. Combating climate change is likely to lead to reduced use of fossil fuels across all sectors, including fishing. While land-based food production may be able to cut emissions by adopting alternative, cleaner land-based energy sources and reducing energy intensity, for example through reduced use of fertilisers (Fess et al., 2011), this could be more challenging for marine capture fisheries, particularly those operating far off-shore or currently benefiting from subsidised fuel prices. A related concern is disruption of marine ecosystems which alters the viability and distribution of fish stocks and may undermine international cooperation which is already challenging due to continued open access on the high seas (Pinsky et al., 2018).

## 1.5 Dissipation in other rent-generating sectors

A large body of literature has examined the general topic of rent dissipation. Two strands are discussed here; one relating to the welfare impact of market power and regulations in which limits are imposed by companies or governments and the other to extraction of natural resources where limited supply is a natural consequence of resource scarcity.

### 1.5.1 Market power and regulations

Modern research in this field can be traced back to seminal work by Harberger who estimated the welfare cost of monopolies to be around 0.1% of GDP (1954). This conclusion was based on the premise that excess profits earned by monopolists were simply a transfer from buyers to sellers, so that the welfare impact was simply the decline in the combined producer and consumer surplus, commonly referred to as deadweight loss or Harberger´s triangle (Fig. 1). This and similar results, considered surprising at the time, prompted new research into alternative forms of welfare cost associated with rent-generating industries. An important product of this work was the development of rent seeking theory during the 1960´s (Tullock, 1967; Congleton & Hillman, 2015). In essence, rent seeking involves parties competing for a valuable prize by expending costly effort on the basis that this will increase their expected reward. The implicit assumption is that contestants can influence governments and regulators in the allocation process, for example through lobbying or political donations. This behaviour, if successful, can result in "regulatory capture", whereby industries exhibit demand for government regulations that are favourable to the industry but costly to society and which self-interested actors within government supply in return for political or financial support (Stigler, 1971; Grafton & Williams, 2020). An analogous term, "administrative capture", has been coined to describe similar self-interested behaviour by scientists involved in public policy-making (Pielke, 2007; Colloff et al., 2021). These efforts do not increase the value of the prize and are therefore costly to society. Gordon Tullock (2001) later illustrated the rent seeking approach using a Contest Success Function which defined the relationship between effort and likelihood of success and showed, under a range of assumptions, that the combined cost of competing in equilibrium could equal or even exceed the value of the prize, effectively dissipating the entire rent to be allocated. This result led the area associated with rent transfer and potentially dissipation to be referred to as "Tullock´s rectangle" in contrast with the smaller Harberger´s triangle (Fig. 1).

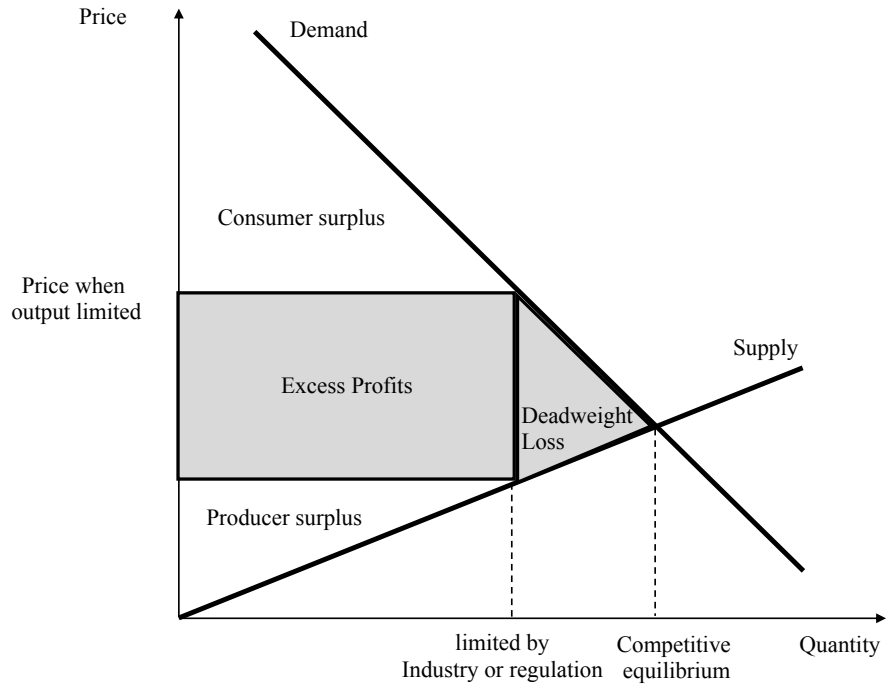


**Figure 1.** Harberger´s triangle and Tullock´s rectangle.

The basic rent seeking model has now been extended in many directions in an extensive literature, illustrating the broad applicability of the model (Congleton, 2019). The distinction is now made between rent seeking activity prior to the creation and allocation of rent and subsequent activity directed to protecting or reallocating that rent (Congleton & Hillman, 2015; Vachris, 2019). Empirical research into the actual cost of rent seeking has nevertheless proven problematic. One issue is that the activity is likely to be opaque by design. A second, possibly related, issue is that the observed cost of rent seeking has been much lower than theoretical predictions which can involve full or even excess dissipation. Tullock (1997) described this as a paradox which several researchers have subsequently attempted to solve (Dari-Mattiacci & Parisi, 2005). While rent seeking is often associated with attempts to influence governments and institutions charged with representing the broader public interest by exploiting the self-interest of actors, as described above, the framework has also been used to characterise the common pool resource problem and the dissipation of rent due to biological or economic overfishing. Combining these perspectives, rent seeking in the context of fisheries can be seen as potentially operating at three levels. The third, in

rights-based fisheries where rent is generated, may thus be termed a "race for rights" or "political overfishing".

An alternative form of rent dissipation was proposed by Leibenstein (1966) and referred to as X-inefficiency. In this model, the behaviour of individuals within rent-generating firms can result in dissipation. Leibenstein presented empirical research in support of his claims and attributed the phenomenon to a combination of incomplete employment contracts and the absence of external competitive pressure. While this theory has spawned extensive research, it has not achieved the same degree of acceptance as rent seeking[4]. One line of criticism is that X-inefficiency lacks a theoretical basis and that empirical studies in support of its existence simply measured the wrong thing, although Leibenstein dismissed this argument as circular (Leibenstein, 1982). Other critiques have included the argument that X-inefficiency will not persist due to the competitive discipline imposed by the threat of take-overs or new entry. Interestingly, the kernel of the idea for X-efficiency was articulated some three decades prior to Leibenstein by John Hicks who wrote that "the best of all monopoly profits is a quiet life" (1935). The resulting "quiet life hypothesis", that a lack of market discipline in concentrated markets can reduce efficiency, has been investigated with researchers finding supporting evidence, for example in the banking sector (Berger & Hannan, 1998).

### 1.5.2 Extractive industries

The finite availability of natural resources means that their extraction can result in the generation of economic rent, sometimes termed resource rent. Countries with substantial natural resources might be expected to benefit from this endowment due to the increased scope for investment in enhanced productive capacity, for example relating to education or infrastructure. This has not always turned out to be the case; many resource-rich countries have exhibited lower growth rates, a phenomenon described as the "Resource Curse" (Sachs & Warner, 1995). Several explanatory theories have been proposed (Frankel, 2010; Van der Ploeg, 2011) although the ultimate effect is usually the same; crowding out of some activity which is conducive to economic growth (Sachs & Warner, 2001). Many researchers have suggested political mechanisms whereby weak institutions can result in rent seeking or

[4] This is surprising to the extent that X-inefficiency can be viewed as a relaxed form of rent seeking behaviour within the firm, in which employees pursue private non-pecuniary benefits at the cost of firm rent which has some of the characteristics of a common-pool resource.

other forms of unproductive behaviour (Deacon & Rode, 2015). Mehlum et al. (2006) found evidence to support this and claimed that it explained why some resource-rich economies thrive but others fail; the temptation of significant resource rent stress tests institutional quality. The countries which pass this test have institutions that are not friendly to rent seekers (or "grabbers") who detract from economic growth (Baumol, 2004).

The rent generated from natural resources depends not only on the rate of extraction but also the cost of extraction and prevailing market prices. Commodity price booms therefore present a particular form of stress test on institutional quality. Evidence suggests that high commodity prices can undermine the resource property rights of private extractive industries in the mineral and fossil fuel sectors due to the increased propensity of host governments to raise taxes or even expropriate the rent-generating assets (Duncan, 2006; Guriev et al., 2011; Hajzler, 2012; Stevens et al., 2013). Interestingly, this behaviour, sometimes referred to as "resource nationalism", is not restricted to developing economies and has been observed in relatively advanced economies including the U.S., Canada, Norway, Australia and U.K., suggesting that either these countries actually have weak institutions or, alternatively, that reallocation of rent due to exogenous price shocks can be consistent with strong institutions, for example due to socio-political norms regarding fairness.

It is widely accepted that insecure property rights to resources can result in rent dissipation due to the attenuated incentive to invest in long term assets whose future return becomes less certain. In extremis, discounting of future benefits is equivalent to open access in which extractors have no incentive to conserve a resource. This might be expected to lead to over extraction of resources, as has been observed in the fishing sector. Bohn & Deacon (2006) investigated the impact on different resource sectors and found evidence that insecure property rights can indeed lead to over-extraction provided that capital intensity is low. In contrast, sectors with high capital requirements were associated with under-investment, suggesting that firms were deterred by the risk of not having sufficient time to earn an acceptable return on their investment.

The association between rent seeking behaviour and lack of transparency observed by Tullock is mirrored in resource-rich countries with weak institutions; hiding resource rent can reduce the cost of defending it. For example, Durnev & Guriev (2008) link the risk of expropriation due to higher oil prices with increased opacity on the part of corporations. Andersen et al. (2013) observe a link between petroleum rent and resident bank deposits in

offshore tax havens that is conditional on the host country having weak political institutions.

## 1.6 Summary of methods and results

This section provides a summary of the research questions, methods and results pertaining to each paper.

### 1.6.1 Paper I

Byrne, C., Agnarsson, S., Davidsdottir, B., & Oostdijk, M. (2020). Species-level quota concentration in the Icelandic harvesting sector. *Marine Policy,* 104108.

Received: 31 March 2020 / Accepted: 19 June 2020 / Available online: 11 September 2020



The motivation for this paper was to examine the extent to which the introduction of transferable quota in 1991 has led to increased concentration in quota ownership. The potential for changes in concentration due to trade is an important feature of ITQ fisheries; it can be seen as a favourable development reflecting shedding of excess capacity and economies of scale which improve efficiency. However, it also has negative connotations due to the association with undue power within the industry or more generally, and increased barriers to entry. These conflicting considerations imply a trade-off which is often crystallised in the setting of limits to quota holdings for individual companies. The paper extends previous work by Agnarsson et al. (2016) in several directions by analysing concentration since the introduction of the current ITQ systems in 1991, exploring differences across species associated with distinct fleet segments and adding measures relating to vessel-based concentration and competitive rivalry not previously explored in the ITQ literature.

This paper addresses the following research questions:

1) How has concentration of company quota holdings evolved since the introduction of ITQ´s for commercially important species?
2) How does concentration based on vessels compare to companies?
3) To what extent has concentration reached levels associated with market power?
4) What has been the extent of competitive rivalry?
5) Are regulatory limits hampering further increases in concentration?

The analysis undertaken was entirely quantitative, applying the standard Concentration Ratio and Hirschman-Herfindahl measures to data comprising historic permanent quota shares of individual vessels and ownership details for each vessel. Competitive rivalry was gauged using the Hymer-Pashigian Instability index which is based on changes in market share, treating quota shares as a proxy. Given that new entry necessarily involves a change in market share, this index also represents an upper limit to the extent of new entry. The potential for market power is assessed by comparing the results to threshold levels used by competition authorities in Europe and the United States.

The results highlight structural differences between demersal and pelagic fleet segments, with markedly higher concentration of pelagic species and, to a lesser extent, demersal species caught offshore such as redfish and Greenland halibut. Vessel-based concentration measures were generally well below those based on companies and prevailing limits for several species, particularly cod, haddock and saithe, indicating that the largest quota holders spread their quota over multiple vessels and that vessel-level efficiency considerations may not justify the quota holding limits in these species. For several species, company-based concentration has increased to levels associated with market power while further consolidation is increasingly hampered by regulatory limits, suggesting that a review of these limits may be appropriate. Particular attention is drawn to the importance of distinguishing between the efficiency benefits of concentration in harvesting as opposed to processing, and considering the implications of power in terms of new entry and influence over domestic stakeholders and institutions rather than simply the scope to increase prices.

### 1.6.2 Paper II

Byrne, C., Agnarsson, S., & Davidsdottir, B. (2019). Profit and rent in the Icelandic harvesting sector. *Fisheries Research,* 220, 105349.

Received: 16 May 2019 / Accepted: 20 August 2019 / Available online: 11 September 2019



This paper investigates the large and relatively stable gap (around 40-50%) between the efficiency of the Icelandic ITQ system based on reported economic profits and estimates of potential efficiency. This gap is surprising given that ITQ´s are generally viewed as one of the best ways to reduce rent dissipation when there are multiple users and that the Icelandic system is considered a successful implementation[5]. One possible explanation is that significant rent continues to be dissipated, a phenomenon that has been studied extensively. This paper examines an alternative explanation which has received relatively little attention; that rent is incorrectly measured due to transfers to other stakeholders. In particular, the Icelandic harvesting sector exhibits significant vertical integration with the processing sector which increases the scope for transfer pricing and the shifting of resource rent to the processing sector (Steinsson, 2011). The analysis estimated the extent of transfers between the harvesting sector and the processing sector, fishermen and the government, examined the processes involved and presented a speculative explanatory model in which stakeholder representatives cooperate in order to obfuscate harvesting profitability and reduce pressure for reallocation of rent to society at large.

[5] This question has been raised in the literature in relation to ITQ systems in Iceland (Nielsen et al., 2012) and New Zealand (Hersoug, 2018).

Research questions were as follows:

1) How much rent is transferred between harvesting and processing, fishermen and the government?
2) What institutions and mechanisms mediate the observed transfers?
3) How might the incentives of the main stakeholders contribute to observed behaviour?

The three channels of rent transfer were quantified for the period 2001-2014 using distinct methods. Transfers to fishermen were estimated by comparing actual remuneration to the opportunity cost of labour based on fish processing wages, adjusted for the risk of work-related accidents. Transfers to the processing sector were derived from the reported economic profits for the sector, adjusted for estimated inframarginal rent. Finally, transfers to and from the government were calculated based on quota fees paid to the government and the costs of managing the fishery. These transfers were used to adjust reported economic profits for harvesting, and estimate actual efficiency. The underlying mechanisms were investigated using secondary data sources covering legislation, union wage agreements and industry structure. The explanatory model was derived by interpreting the observed results in the context of reported behaviour in other rent seeking settings and presented as a hypothesis to stimulate further research.

The extent of rent transfers from harvesting to other stakeholders were found to be significant, consistently exceeding reported economic profits from 2008 onwards and peaking at 30% of reported harvesting revenue in 2012. The processing sector and fishermen were the main beneficiaries while the government share was relatively modest, but increased towards the end of the analysis period. Examination of the mechanisms determining these transfers revealed the central role of ex-vessel fish prices which influence the split of profits between harvesting and processing, affect crew remuneration which is based on the value of catch, and also quota fees which are based on reported harvesting profits. The high level of vertical integration means that most fish is valued at notional transfer prices set according to guidelines designed to balance the interests of vessel owners and fishermen. The subsequent introduction of a profit-based quota fee made the Icelandic tax payer an interested party whose interests may run contrary to those of vessel owners and fishermen. The explanatory model explains how this potential tension can

result in cooperation between harvesters and fishermen unions which would be consistent with the observed transfers.

### 1.6.3 Paper III

Byrne, C., Oostdijk, M., Agnarsson, S., & Davidsdottir, B.. The Transitional Gains Trap in grandfathered Individual Transferable Quota fisheries. Manuscript.

The ability to reverse changes in the environment and ecosystems has been emphasised as important to sustainable development (UN, 1987; 2015). However, the reversibility of social and economic impacts has received relatively little attention, presumably because these are considered to be under society's control. Nevertheless, several commentators have highlighted the need for flexible governance models which can adapt to improved scientific knowledge and a changing socio-political environment. In the context of fisheries management, it has been suggested that the decision to introduce ITQ´s via grandfathering may be difficult to reverse due to the Transitional Gains Trap ("TGT"). Paper III examines this assertion, proposing a potential quantitative measure of the trap which is illustrated in the case of the Icelandic ITQ system.

In this paper, the research questions were as follows:

1) What is a potential quantitative measure of TGT?
2) What is the estimated extent of TGT in the Icelandic harvesting sector, based on this measure?

The first question was addressed by developing a simple conceptual model of the incentives and mechanisms underlying the Transitional Gains Trap as described in Tullock´s seminal paper (1975). A quantitative measure, based on each harvester´s net cumulative investment, was then derived by making some simplifying assumptions regarding functional form and calculated for the most commercially important species. Each harvester´s quota holding at the beginning of each fishing year was combined with average quota prices to calculate the cost of buying and selling quota, with alternative proxies for resource rent based on reported economic profits and quota lease prices. Changes of ownership due to mergers were excluded on the basis that they involved pooling of interests rather than incremental investment and the cost of capital was assumed to be 6%.

The proposed measure varied greatly by species but was generally less than 60% by 2016, suggesting that the trap may be far from complete, although the outcomes were very sensitive to changes in the assumptions due to the cumulative nature of the measure. Lastly, it was shown that the proposed measure can decline over time as accumulated profits offset cumulative investment costs.

### 1.6.4 Paper IV

Byrne, C., Davíðsdóttir, B., & Agnarsson, S. (2021). Fuel intensity in Icelandic fisheries and opportunities to reduce emissions. *Marine Policy, 127*, 104448.

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Oil is the main fuel for industrialised fisheries and can account for a significant portion of vessel operating costs, particular in fisheries subject to overfishing or which target energy-intensive species. However, global pressure to reduce greenhouse gas emissions and the likelihood of higher oil prices due to depletion and geo-political instability mean that the industry may need to reduce its reliance on oil. Achieving this while maintaining or even increasing production will involve finding ways to reduce the fuel intensity of harvesting, at least until clean energy sources become technically and economically viable. Paper IV analyses the historic development of fuel intensity for Iceland´s key demersal and pelagic fleet segments and species. Factors known to contribute to variations in fuel intensity are then investigated in order to identify opportunities to reduce fuel use.

The research questions addressed in this paper were as follows:

1) how has fuel intensity evolved overall and for the main demersal and pelagic fleet segments and species?
2) how do the underlying components, Fuel Per Unit Effort and Catch Per Unit Effort, contribute to variation in intensity?

3) which operational modes account most for Effort?
4) what is the relationship between fuel intensity and stock abundance?

Fleet level intensity was derived from total annual catch and oil purchase statistics for the years 1982-2017 while segment and species-based intensities were calculated for the more limited period 2002-2017 during which segmental data regarding catch and fuel expenses were available. A hypothetical benchmark volume of fuel purchases, based on the most recent calculated species fuel intensities and historic catch by species, was also calculated in order to evaluate changes in overall fuel intensity for years prior to 2002. Decomposition of fuel intensity into the components identified in question (2) depended on the availability of additional data needed to calculate effort and was therefore limited to a sample of 19 demersal and pelagic vessels. The operational profiling involved splitting activity over the course of a fishing trip into four operational modes and identifying, for each mode, the average time, distance and therefore speed. This analysis was undertaken for two vessels over a calendar year using detailed GPS data with log book records of each haul and catch for each trip. Finally, the strength of the relationship between higher stock levels and lower fuel intensity was investigated using multivariate linear regression analysis.

Fuel intensity was highest for the demersal vessel segments and species but declined between 2002-2017 whereas pelagic intensities increased slightly. Comparison with the hypothetical benchmark suggested that fuel intensity levels were actually increasing between the early 1980´s and late 1990´s. Historic variation in fuel intensities was strongly correlated with stock levels although changes in gear use and fishing location may also have contributed to the increase in pelagic fuel intensities. Analysis of operational data indicated a lower average engine load for a sample of pelagic vessels compared to demersal vessels, suggesting engine load-balancing as an opportunity to improve engine efficiency. Overall, Icelandic fuel intensities are similar to those in Norway, and lower than those observed elsewhere at the regional and global level, implying that the industry is relatively well placed regarding competition from other fisheries. However, these results also imply that fuel use by the Icelandic harvesting sector is unlikely to drop significantly in the short to medium term without government intervention.

### 1.6.5 Paper V

Oostdijk, M., Byrne, C., Stefánsson, G., Santos, M. J., & Woods, P. J. (2020). Catch–quota matching allowances balance economic and ecological targets in

a fishery managed by individual transferable quota. *Proceedings of the National Academy of Sciences, 117*(40), 24771-24777.

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The aim of this paper was to examine Iceland´s solution to the challenge of discard bans in mixed fisheries subject to individual quota limits. The challenge is that vessels are required to land all fish caught and to have quota for all fish landed without being able to ensure that the mix of species caught matches its quota holding. As soon as quota in one species is exhausted, a compliant vessel will stop fishing before quota in other species are fully utilized if it is not able to obtain additional quota in the choke species, potentially leading to significant loss of profits. One solution to this problem is allowing harvesters limited flexibility to reallocate quota rights between periods or species although this approach, usually termed catch-quota balancing, has been criticised for increasing the risk of overfishing. Iceland´s ITQ system features a comprehensive balancing system and has exhibited high quota utilization without significant systematic overfishing. This paper studies the balancing behaviour of individual Iceland harvesters in order to evaluate the extent to which systematic behaviour emerges and is related to potential explanatory factors.

Research questions were as follows:

1) How similar is balancing behaviour across vessels for specific species/years?
2) Is observed similarity across the fleet correlated with potential fleet-wide drivers?
3) To what extent is balancing behaviour of individual vessels correlated with fleet-wide drivers and vessel-specific characteristics?

The questions were addressed by designing quantitative indicators associated with the variables of interest and undertaking panel data analysis. The first indicator quantified the extent to which balancing behaviour of

individual vessels tended to be in the same direction rather than canceling out. Additional indicators related to the potential for arbitrage due to mismatches between the relative cost of quota in different species via transformation as opposed to quota lease markets, harvesters´ ability to target particular species, and the extent to which a particular species appears to be acting as a choke. Additional dependent variables included TAC levels and the size of the harvesting vessel and owner.

A high level of behavioural similarity was observed. Transfers of quota between periods mainly involved deferral to the next year. Quota transformations were mainly negative for some species, reducing the relevant permitted catch, and positive for others. Positive transformations for a particular species were correlated with higher TAC level and transformation being a relatively cheap way of increasing quota compared to leasing, suggesting that harvesters were motivated by the opportunity to exploit arbitrage between the quota balancing mechanism and quota lease market. Vessel level analysis indicated that company size may also contribute to greater use of the transformation system, a result that may reflect the ability of larger companies with multiple vessels to analyse and act on such opportunities. Tightening of individual vessel limits for balancing in fishing year 2011/12 appeared to attenuate behaviour, suggesting that the limits were binding. The results imply that harvesters hedge the risk of running out of quota in particular species by maintaining a buffer of banked quota from year to year. Despite this, the extent of overfishing was limited. This was attributed to the constraining role of cod which is ubiquitous but for which quota cannot be increased by transformation.

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# 2 Paper I: Species-level quota concentration in the Icelandic harvesting sector

# 3 Paper II: Profit and rent in the Icelandic harvesting sector

# 4 Paper III: The Transitional Gains Trap in grandfathered Individual Transferable Quota fisheries

# 5 Paper IV: Fuel Intensity in Icelandic fisheries and opportunities to reduce emissions

# 6 Paper V: Catch–quota matching allowances balance economic and ecological targets in a fishery managed by individual transferable quota

# 7 Summary and discussion

## 7.1 Summary

The research in this thesis has examined the development and performance of Iceland´s ITQ system in terms of key challenges currently facing global marine capture fisheries across the three dimensions of sustainability; how to improve the economic benefits from fishing due to wasteful overfishing and overcapacity, how to ensure that the economic and broader benefits from fisheries are shared equitably by different social groups, and how to reduce the adverse impact of fishing on local ecosystems and the environment. A case study approach has been adopted and is considered appropriate given the unusual features of Iceland´s ITQ system. In particular, its age, profitability and national importance mean that certain issues, for example relating to conflict over the distribution of quota and the associated benefits, have had time to emerge and register at the national level. As access to natural resources becomes increasing limited and valuable, such issues seem likely to proliferate and attract the attention of more policy makers and scholars. If so, lessons derived from Iceland´s experience with ITQ´s may grow in relevance.

Paper 1 found that concentration in quota holdings has increased steadily as predicted by theory and consistent with other studies. Concentration varied widely across species, with pelagic species reaching levels associated with market power and regulatory limits, implying that the limits may be constraining further consolidation. Vessel-level concentration also increased but is generally not constrained by quota ceilings while competitive rivalry has declined and is particularly low for pelagic species. A key justification for permitting concentration is that this will allow economies of scale to be fully exploited, thus improving efficiency in harvesting. Meanwhile, the main arguments against quota concentration have revolved around the power over local stakeholders and the potential for new entry rather, than pricing power over customers in export markets. In light of these findings, it is suggested that current limits be reviewed with a comparison of the efficiency benefits of operating scale in harvesting (as distinct from processing) and the resultant power over stakeholders including potential entrants (as opposed to the traditional focus on customers and consumers).

Paper II estimated that economic rent from harvesting was higher than reported due to substantial transfers while the share received by the government due to a profit-based quota fee was far below the marginal rate on

which the fee is based. A speculative model was presented in which public pressure to tax profits perceived as a windfall benefit from grandfathered quota creates an incentive to shift harvesting profits into vertically integrated processing operations. This may be costly as it requires investment in processing and the support of fishermen unions and potentially leads to price distortions. An implication of the model is that the association of grandfathering with windfall profits may attenuate harvester incentives to improve efficiency.

Paper III presented a simple model of how ITQ systems can lead to a Transitional Gains Trap and then derived a quantitative measure of the trap based on the estimated potential loss of fishing companies as a result of purchasing quota which are subsequently revoked. Illustrative calculations for the Icelandic ITQ system suggested that the trap was only partial and fell in recent years, but also highlighted the sensitivity of results to price and yield parameters which were difficult to estimate due to the paucity of economic data. These results imply that there may be greater political scope to reform allocation of resource rent in ITQ fisheries than has been argued. The results also highlight the lack of transparency regarding the true economic value of quota.

Paper IV reported that fuel intensity levels in Iceland were generally the same or lower than those reported elsewhere, suggesting that scope to achieve much lower intensities may be limited. Fuel intensity levels fell in the demersal sector but increased slightly in the pelagic sector. Variation in fuel intensity is strongly correlated with stock abundance which has improved for demersal species, particularly for cod, but declined for pelagic species which are also fished in international waters and whose conservation is more dependent on international cooperation. Interestingly, total fleet fuel consumption in the early 1980´s was similar to that implied by the most recent species fuel intensities, indicating that, while Icelandic fuel intensity levels may be relatively low, they have also not have fallen much since the introduction of ITQ. Potential explanations are identified, including rebound effects in which improved fuel efficiency leads to increased fuel use, and races for catch history in anticipation of the grandfathering of ITQ for additional species including those caught outside Iceland´s EEZ as well as secondary demersal species. The results highlighted the contrasting ways in which effort is expended in demersal and pelagic fishing. The challenges of creating a policy instrument to reliably and cost-effectively reduce GHG emissions across diverse and heterogenous fleet segments were discussed and a novel approach outlined, involving the creation of tradable harvesting emissions quota parallel to traditional catch quota.

Paper V observed a high degree of behavioural similarity amongst vessels using catch-quota balancing mechanisms and found statistical evidence that this behaviour was linked to differences in the relative prices of quota implied by the species transformation mechanism compared to the lease market, consistent with studies highlighting the risk of consistent overfishing when quota transformation is permitted. Overfishing was nevertheless limited and this was attributed to tailoring of the system to the particular attributes of the Icelandic fishery. The results suggest that balancing mechanisms may be useful to ITQ systems introducing a discard ban, provided that they are adapted to the characteristics of the particular fishery.

## 7.2 Discussion of results

In this section, the results from the five papers will be discussed in terms of the traditional dimensions of sustainable development which provide the context for the overarching research objective of this thesis; the economy, society and the environment. Each dimension is first addressed separately and then the results are discussed in terms of linkages and resultant trade-offs across dimensions. Reference is also made where relevant to SDG 14.4 which focuses specifically on the contribution of fisheries management to sustainable development.

### 7.2.1 Economy

Economic activity is generally viewed as underpinning modern levels of prosperity but is constrained by the limited availability of factors of production, meaning that methods to produce more from less can lead to higher living standards. This is the essence of the ITQ approach to fisheries management; it aims to reduce the two main causes of inefficiency in global fisheries, biological and economic overfishing, which dissipate potential rent that has been estimated at up to 60-70% of harvesting revenue. Paper I found that while the reported performance of Iceland´s harvesting sector implied a large shortfall in efficiency, adjusting for rent transfers significantly reduced this gap, particularly in recent years. This reduction in overfishing is clearly in line with the aims of SDG 14.4 which calls for effective regulation of harvesting and has as its sole indicator the proportion of stocks fished at biologically sustainable levels.

The results indicate that efficiency of the Icelandic harvesting sector has improved considerably and compares favourably to the negligible overall profitability reported for global fisheries and also to other fisheries in the Nordic region (Nielsen et al., 2012, 2017; Greaker, 2017). In particular, the

author was not able to find evidence of any other country´s harvesting sector achieving economic efficiency in excess of 40%. The improved economic performance of Iceland´s fisheries has repeatedly been cited in the literature as evidence supporting the claimed benefits of introducing ITQ´s (Arnason, 2005; Gunnlaugsson & Saevaldsson, 2016; Knutsson et al., 2016; Gunnlaugsson & Agnarsson, 2019). However, while the results are directionally consistent with this, it should be emphasised that the evidence has often been anecdotal and that a systematic and comprehensive evaluation remains to be undertaken. Of particular interest are two areas for potential improvement; the speed of transition following introduction of ITQ´s and residual levels of rent dissipation. The speed of transition has been highlighted for example in SDG target 14.4 which refers specifically to restoration of fish stocks "in the shortest time feasible".

The relatively slow improvement in economic efficiency observed is surprising given that ITQ´s, particularly the grandfathered variety, are designed to incentivize trade which leads to the exit of excess or inefficient capacity. Quota trade did indeed occur and led to increased concentration, at both company and vessel level, as reported in papers I and III. However, it is not apparent that this immediately resulted in any reduction in harvesting capacity or numbers of fishermen. Fleet capacity, measured in terms of tonnage, did not begin to fall until around 2008 and total main engine power actually increased until 2001 and was still higher in 2019 than in 1990 (Statistics Iceland, 2021) (Eythorsson, 2000; Saevaldsson & Gunnlaugsson, 2015). Similarly, the number of people employed in fishing did not begin to fall until 2001. Interestingly, stock levels of the most commercially important species, cod, remained low during the 1990´s and did not recover to the levels observed in the late 1980's until 2012, as reported in papers IV and V. The opportunity for harvesting companies to exit at a profit appears to have been available from the beginning; the reported value of quota in fishing year 1991/2 was 13% higher than the total book cost of harvesting capital in 1990 (National Economics Institute, Statistics Iceland) and more than twice as much by 1997-8. Even with some write-down of vessel value, an exiting harvester might expect to enjoy substantial windfall profits. Why did the industry not rationalize and rebuild fish stocks more quickly?

Answering the above question is beyond the scope of the research in this thesis, but the results suggest some contributory factors. Firstly, the total capital value of quota rose rapidly during the 1990´s and 2000´s and this may have prompted quota holders to wait (Weninger & Just, 1997; Danielsson, 1997). Independent of rationalization and stock rebuilding, there were other reasons that harvesters might anticipate such a rise; increased confidence that

ITQ would not be revoked and the incorporation of additional species into the ITQ system, particularly stocks fished in international waters and brought under cooperative management following the UN agreement in 1995 (Stokke, 2001; Bjørndal, 2009). Harvesters anticipating the introduction of quota for blue whiting and Atlanto-scandian herring in 2002 (see paper III) would not only have an incentive to remain in the industry but also to increase effort in order to earn a greater allocation. The rate of adjustment may also have been slowed due to opposition from the fishermen unions described in paper II.

Although the gap between observed and potential efficiency can be partially explained by rent transfers, the remaining gap is still large, accounting for roughly half of estimated potential rent. Research into rent dissipation following the introduction of ITQ´s has largely focused on how they fall short of being property rights. For example, Kroetz & Sanchirico (2010) highlight efficiency losses due to restrictions, although these seem unlikely to be a significant factor in Iceland[6], while Costello & Deacon (2007) emphasise the imperfect delineation of ITQ´s due to the complex nature of fish stocks and Costello & Grainger (2018) show how uncertainty about the duration of ITQ can lead to harvester lobbying for higher TAC levels.

The research presented in this thesis suggest that alternative forms of rent dissipation triggered by the appearance of rent may also be important, as described in section 1.5. For example, the same incentives underlying rent seeking prior to the grandfathering of quota can subsequently motivate action to defend the status quo. Consistent with Tullock´s paradox, finding evidence of rent defending behaviour in Iceland is challenging. The most visible manifestation is the trade organisation, Fisheries Iceland, described in paper II. However, there are also reports that the fishing sector´s influence is more pervasive, involving financial support of political parties and individual politicians as well as media outlets (Chambers et al., 2017; Gylfason & Zoega, 2020; Eyjan, 2019; Juliusson, 2020; Juliusson & Ingvarsson, 2020; Vilhjalmsson, 2021). Arguably the least visible but most predictable and cost-effective form of rent defending is rent hiding[7]. Evidence consistent with this behaviour was described in paper II.

While obfuscated rent is, by definition, not dissipated its existence may be indicative of behaviour that does involve dissipation. In particular, opacity of

[6] The main restriction is that quota must be held by Icelandic entities. The restrictions regarding consolidation described in paper I do not appear to be hampering rationalisation at the vessel level for most species, with the exception of Greenland halibut.

[7] Tullock (1989) wrote that „public misunderstanding of the actual situation is almost a logical necessity for the average rent-seeking activity“.

profits has been associated with the risk of resource nationalism following the appearance of windfall profits (Durnev & Guriev, 2008; Ernst & Young, 2011; Andersen et al., 2013). While resource nationalism is commonly associated with extractive industries (Wilson, 2015; Koch & Perreault, 2019), some of the underlying causes may also apply to fishing sectors which are sufficiently large and profitable, or experience price booms (Salin et al., 2018). The results of paper II suggest that perceived windfall profits in fishing may lead to behaviour commonly associated with resource nationalism, in particular increased taxes and the prospect of revocation. However, some interesting contrasts are also identified. In particular, windfall profits in extractive industries are commonly associated with commodity price booms which are temporary and unpredictable whereas steadily increasing windfall profits in fisheries with grandfathered ITQ are a predictable and enduring consequence. Secondly, extractive industries usually produce commodities with well established prices whereas fish products are highly differentiated (for example, in terms of species, size, quality and degree of on-board processing), making it harder to establish whether transfer prices are arms-length.

Finally, the appearance of resource rent may lead to X-inefficiency by reducing the competitive pressure on harvesters. In particular, recipients of grandfathered quota that are either unable or unwilling to adopt efficient fishing practices can nevertheless continue operating at a profit provided that rent derived from their quota exceeds the costs of inefficiency. While the research in this thesis did not explicity investigate this channel of rent dissipation, some of the results are consistent with X-inefficiency, particularly the slow pace of rationalisation and declining measure of competitive rivalry described in paper I. While the potential for X-inefficiency in fisheries does not appear to have been studied explicitly, some of the underlying concepts have been discussed and appear to be relevant. For example, Nøstbakken (2012) analyses investment drivers for Norwegian purse seiners and argues that the resource rent earned by harvesters acquiring quota well below market value enables them to pursue objectives other than profit maximisation. Pinkerton & Edwards (2009) comment that „vessels fishing their own quota are so highly profitable that they are under little pressure to be technically efficient“.

The common thread in these alternative forms of dissipation is that they are more likely to arise when quota are grandfathered and lead to supernormal or windfall profits (Hilborn et al., 2005), particularly if the associated wealth is conspicuous at a national scale. In addition, the associated behaviours may not initially be apparent but are likely to increase over time as the expected efficiency benefits of ITQ´s gradually materialise.

### 7.2.2 Society

The social implications of introducing ITQ´s have been explored extensively in the literature. This thesis has focused on two issues which have received particular attention in Iceland; concentration of quota ownership and allocation of resource rent. Both issues involve conflict between quota holders and other stakeholders, broadly defined to include society at large.

Iceland´s ITQ system has been modified repeatedly in order to meet concerns about these two issues (Matthiasson, 2008; Kokorsch et al., 2015; Saevaldsson & Gunnlaugsson, 2015). Interestingly, these modifications occurred some years after the first introduction of ITQ, with legislation on quota holding limits being introduced in 1998 and quota fees in 2002, suggesting that tension regarding these issues may have increased over time. Since then, quota ceilings have been increased once while quota fees have changed more often, rising and falling with changes in government. These developments highlight the flexibility of the ITQ system. The need for adaptable institutions has been emphasised in the sustainable development literature (Folke et al., 2002; Bierman et al., 2017) and, in the context of fisheries, may smooth the transition to rights-based systems when the long-term implications for winners and losers may take time to emerge and therefore necessitate repeated adjustment (Costanza et al., 1999; Scharin et al., 2016). However, the results also highlight some challenges and two are discussed here; the potential for ratchet effects to reduce flexibility and the lack of a clear framework for setting policy goals.

Ratchet effects are a form of path dependence in which change in one direction is easier than change in the other direction. The relevance to quota holding limits is clear; it is easier to raise limits than to lower them. A similar point was made by Botsford et al. in the context of overall harvesting effort (1997). As a consequence, there is a risk of creeping quota concentration which may be difficult to reverse, particularly since quota are not limited in duration. The current limits in Iceland were set almost twenty years ago and the subsequent steady increase in concentration described in paper I has meant that the 12% limit for total quota holdings (aggregated across species) has become a constraining factor, with a corporate transaction announced in 2019 resulting in a breach of the limit (Olafsdottir, 2019)[8]. It has also been pointed out that the current regulations combine holdings of related parties under majority control but do not take account of minority stakes which have resulted in at least one fishing company having beneficial ownership of quota in excess of the regulatory limit (Juliusson, 2020). Although limiting the

[8] This is permitted by law provided it is corrected within six months (Althingi).

influence of individual fishing companies was an original aim of the quota ceilings, and features prominently in current public discourse, the potential to actually reduce this influence is currently limited. The transitional gains trap described in paper III may also be viewed as a weak ratchet effect driven by cumulative trade, albeit ameliorated by the accumulation of excess profits. Such ratchet effects are of interest since they may reduce the flexibility of ITQ systems to adapt to prevailing public concerns. If these concerns do not abate, then the resultant tension will persist and may undermine the stability of the system.

The relevance of a clear framework linking policy instruments to stated goals is discussed in paper I in the context of quota concentration limits. It was noted that the legislation aimed to limit the power of quota holders over other sections of society on multiple dimensions while recognising the need for some increases in scale in order to improve efficiency. While the legislation sought to balance conflicting goals, it is far from clear if or how this has been achieved in practice. For example, it is not evident how the types of power to be circumscribed are assessed as acceptable or otherwise. Similarly, the nature of the scale efficiency argument for higher quota limits is not apparent. In particular, the increase in quota limits in 2002 does not appear to have been justified by the need to increase harvesting scale, at least at the vessel-level. A similar criticism can be made of the framework regarding the allocation of resource rent; the quantity which forms the base for the quota fee is restricted to reported harvesting profits and effectively insulates rent shared with other parts of the value chain, as shown in paper II. In the absence of objective criteria, other factors may dominate the policy-making process, potentially increasing the scope for on-going rent seeking. The risk of ratchet effects may also be exacerbated when policies are not grounded in objective criteria. A similar phenonemon, referred to as „shifting baselines“, has been described in the context of fish stock assessments based on anecdotal evidence (Pinnegar & Engelhard, 2008).

These issues do not appear to be inherent to the ITQ approach and should in principle be surmountable. For example, ratchet effects could be alleviated by limiting the duration of quota, with each new vintage allowing the government to periodically „reset“ policy regarding concentration. Similarly, sale of new issues by way of auction would provide a market-based measure of the associated value of quota for taxation purposes. An alternative approach

to transparency in resource rent taxation[9] would be to express the tax as a fraction of quota to be surrendered. For example, a resource tax rate of 33% and assumed quota yield of 6% would imply that 2% of quota be surrendered each year, thus alleviating the incentive to shift profits. While the adoption of such measures in Iceland would represent an unlikely seismic shift, the salient point is that the ITQ system could potentially accommodate alternative approaches.

### 7.2.3 Environment

The results of papers IV and V indicate that Iceland´s harvesting sector has performed relatively well compared to other fisheries in terms of the two challenges examined, greenhouse gas emissions and cost-effective balancing of catch with quota. The catch-quota balancing system has enabled quota in the mixed demersal fishery to be well utilised despite a long-standing discard ban. The potential for this system to lead to overfishing due to pervasive incentives was confirmed but the actual impact was attenuated by limits which have tightened over time and appear well-adapted to local circumstances, particularly the predominance of cod. Fuel intensity is relatively low, and the recent declines in the demersal sector can be seen as an indirect consequence of broader gains in efficiency due to reduced overfishing. Consistent with this, fuel intensity has increased slightly in the pelagic sector where stock levels have fallen, fishing has increased beyond the EEZ and races to fish have been more likely due to a less stable management regime (Bjørndal, 2009). These findings suggest mixed progress with respect to the sole indicator for SDG 14.4, that is management of fish stocks at biologically sustainable levels; with stocks whose conservation relies on international cooperation faring worse, even when the relevant countries manage their local fisheries responsibly. In contrast, the success of Iceland´s catch-quota balancing system indicates progress on SDG 14 with regard to ending illegal and unreported fishing since it reduces the cost of compliance for fishers by allowing them to more fully utilise their quota.

Perhaps the most striking result emerged from the benchmark analysis in paper IV which implied that overall intensity, adjusted for species mix, changed little between 1988-2017 despite fleet modernisation and stock levels

[9] There is no centralized exchange where trade is monitored. The market for permanent quota appears to be thin, particularly in pelagic species, and prices are not disclosed. The quota lease market is more active but reported trade may not be arms length (i.e. barter trade) and it has been suggested that lease prices may reflect the marginal contribution of quota and therefore overstate resource rent (Lindner et al., 1992; Asche et al., 2008).

for the main species being similar or higher by the end of the period. The apparent increase in fuel intensity until the mid-1990´s is consistent with results reported by Tyedmers (2001) and Runarsson (2001). This result implies that any technological improvements in energy efficiency were accompanied by more energy intensive fishing rather than lower fuel intensity („rebound effect“) (Jafarzadeh et al., 2016). The conclusion that significant reduction in emissions will likely require government intervention raises the question as to what kind of instruments might be appropriate, particularly since the approach promoted by the IMO targets a metric, emissions/tonne-km, that is not relevant to fishing. The possibility of extending ITQ´s to include emissions was introduced and seems well-suited to countries like Iceland where harvesting emissions are important to achievement of overall reduction targets. The catch-quota balancing system and potential to incorporate additional limits such as emissions illustrates the inherent flexibility of the ITQ approach to allow environmental and ecological constraints to be met cost-effectively using price signals (Abbott et al., 2015). In particular, the approach allows for overall limits while permitting a differentiated response by individual participants to ensure cost-effectiveness. While such an approach to emissions abatement can be criticised as theoretically sub-optimal in terms of cost-effectiveness, it may be superior in terms of enforcement by reducing the scope for this to be undermined by the weakest component (Barrett, 2010, 2016). For sectors which are of sufficient national importance, these considerations may outweigh the theoretical argument in favour of equimarginal abatement costs across sectors.

An interesting result emerging from papers IV and V is the dominance of individual species within particular fleet segments and seasons. This may contribute to the favourable outcomes described above by simplifying the task of matching catch to quota and reducing the associated fuel requirements. The staggered seasonality of the pelagic species described in paper IV is particularly striking and suggests that harvesting of each species may proceed almost independently. Consistent with this, quota transformation is not permitted between pelagic species and yet average quota utilisation rates (calculated as actual catch as a ratio of permitted catch) were between 93% and 97% over the period 2002-2018 depending on species. While harvest in the demersal sector is not seasonally staggered, there are nevertheless indications that the species mix for individual vessels and trips may still be heavily weighted towards particular species. For example, around half of demersal catch in 2014 was due to trips on which the main species caught accounted for at least two thirds of trip catch (Fig. 2). While this is to be expected given the dominant role of cod in the demersal fisheries, there is also

evidence that some less commercially important species may also be relatively targetable[10]. For instance, 48% of Atlantic wolffish catch in 2014 occurred when it was the main species caught, accounting for 69% of overall catch on the the relevant trips (Directorate of fisheries).

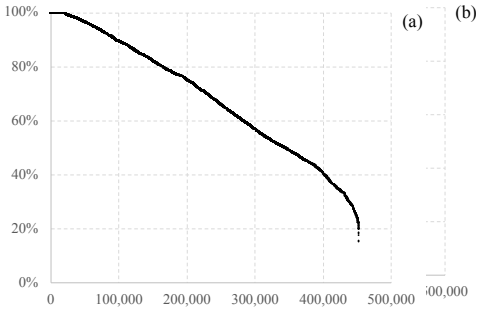


Figure 2. The above plots show the cumulative catch across selected trips in 2014 ordered by the fraction of trip catch due to the primary target species (defined as the species with the largest share of trip catch). The left panel (a) relates to trips for which the primary target species was demersal. The right panel (b) relates to trips for which the target species was pelagic. Source: Directorate of Fisheries, Author´s calculations.

In comparison, Mortensen et al. (2018) report much lower trip-level ratios for the primary target species, cod and saithe, in their study of a North Sea demersal trawler. Similarly, Gerritsen et al. (2012) report lower ratios for the primary target species in the Irish demersal otter trawl fleet. Unfortunately, studies of fine grained catch composition appear to be limited thus hampering a more comprehensive assessment as to whether or not Icelandic trip-level catches are relatively concentrated.

### 7.2.4 Linkages and trade-offs

A recurring theme of the research in this thesis has been the extent to which individual fishery management decisions link economic, environmental and social issues. In some cases, progress can be made simultaneously on multiple fronts; rebuilding stocks can improve economic efficiency and reduce emissions intensity (paper IV). More often, however, the linkages suggest

[10] Two caveats are in order. Firstly, ex post trip-level catch profiles may overstate a harvester´s ex ante ability to target particular species (Marchal, 2008). Equally, understatement is possible when the ability to target different species varies over a trip, for example according to fishing location, but is averaged out at the trip level.

tension between conflicting objectives. For example, the economic rationale for industry consolidation is in conflict with public desire to limit concentration of power (paper I). Similarly, the financial interests of quota owners and fishermen are in conflict with popular demand for a share of resource rent (paper II). Finally, catch limits and discard bans have ecological benefits but can reduce output in mixed fisheries (paper V).

Growing knowledge of and changing attitudes towards the above issues has led to continued modification of Iceland´s ITQ system that illustrates its flexibility. In particular, the trade-offs previously listed have been addressed with features such as a profit-based quota fee, catch-quota balancing mechanisms and quota ceilings which all feature tunable parameters. These features have generally become more comprehensive and the balances struck have been adjusted, repeatedly in the case of quota fees. While some aspects, such as the use of quota ceilings and banking, are common in ITQ systems, others appear to be unusual to Iceland, particularly the use of a profit-based quota fee and catch-quota balancing by means of species transformation.

The potential for Iceland´s ITQ system to further adapt in order to address outstanding tensions has also been emphasised, particularly in the context of emissions abatement and allocation of resource rent. However, the discussion of the ratchet effect with quota ceilings shows that flexibility has also been limited in some respects by current arrangements.

### 7.2.5 Broader implications for rights-based fishing and ocean governance

Several of the findings in this thesis have broad implications for ocean governance, either because they may affect the potential attractiveness of ITQ´s compared to alternative approaches or because they relate to specific features of ITQ´s which are found more generally and may lead to similar effects in other rights-based systems.

With respect to fisheries that have adopted or are contemplating alternative forms of rights-based management to ITQ´s, an important implication of the research in this study is that ITQ´s should not be viewed as an economic solution that necessarily prioritises efficiency above environmental or social concerns. While the theoretical and political rationale for adopting ITQ´s has been based on the imperative to reduce biological and economic overfishing, Iceland´s experience shows that the ITQ approach is flexible and can accommodate broader policy goals relating to the environment, ecosystem, social concerns and distributional justice (Asche et

al. 2018; Hoshino, 2020).[11] Conversely, the results of the current study beg the question as to whether the promise of efficiency under ITQ´s may be overstated – even adjusting for substantial transfers, Iceland still falls well short of estimated potential as discussed in paper II. If so, this may increase the economic attractiveness of alternative methods and also the importance of continuing to search for better policy instruments.

A finding in this thesis which is relevant to all forms of rights-based marine governance is the importance of how the resultant wealth is allocated. Iceland´s experience shows that uncompensated transfers of wealth by government that privilege a limited group of private actors can have long-term consequences that may not be foreseeable at the time of implementation (Matthiasson, 2008). Measures that may seem justifiable when an industry appears to be in the midst of a crisis (Runolfsson & Arnason, 2001) may be less palatable once the crisis has passed. In particular, the continued legitimacy of such government-mediated transfers can be called into question if they are later perceived as resulting in large, undeserved windfall profits for a small segment of society. Similar debates have taken place in other countries, including the Faroes and Norway, and have also involved other types of common pool resources (Standal & Asche, 2018; Jacobsen, 2019), including use of the ocean for aquaculture (Flaaten & Pham, 2019). Where rights eventually confer significant resource rent over a long period which can be capitalized upon transfer, then the perception of windfall profits and resultant political tension will be exacerbated but may be difficult to resolve without undermining the quality of property rights or social cohesion, both of which are undesirable outcomes for society as a whole (Hoff & Stiglitz, 2005).

While it is tempting to propose alternative methods of allocation such as auctions, there is currently insufficient empirical evidence to support this, at least within fisheries, suggesting that there may be a role for controlled policy experimentation (Raymond, 2016). Indeed one of the hallmarks of the Icelandic ITQ system has been its repeated adaptation to address emerging policy goals as discussed in papers I, II and V. In order to create room for such experimentation, a precautionary approach may be appropriate in which private rights are limited in duration (Bromley & Macinko, 2007) and also

[11] This is a common narrative but one could actually argue the opposite in the case of grandfathered fishing quota; that distributional concerns (particularly catering to the demands of incumbent vessel owners) may be prioritised over the potentially superior efficiency of alternative methods of allocation, such as auction. This observation is based on a theoretical counterfactual, the realism of which can be debated (see Paper II).

with respect to the protection they enjoy vis-à-vis the state as grantor (as opposed to other private actors) (Raymond, 2003). Such an approach would also increase the flexibility of policy makers to respond to new circumstances, for example relating to the impact of pollution and climate change on fish stocks (Scharin et al., 2016; Pinsky et al., 2018). While the precautionary principle is often framed in terms of environmental impact, the findings in this thesis demonstrate its broader relevance to social aspects (Som et al., 2009).

This thesis has highlighted the lack of financial transparency in the Icelandic ITQ system as a barrier to analysis of the harvesting sector´s performance and the value of quota. This result is surprising given the extent of quota trade and has been attributed to the high degree of vertical integration (paper II), the tendency for quota to be bundled with other assets and traded indirectly (see Paper III) and the secular decline in trade (see Paper I). Approaches to rights-based management which facilitate greater transparency will be helpful not only in informing the policy-making process but also increasing public confidence in its integrity (Gillies & Heuty, 2011; Walton et al. 2020; Guggisberg et al., 2021).

Other findings in this thesis which arise from one particular feature of ITQ´s are likely to have implications for governance systems with that same feature. For example, the quota transformation mechanism studied in paper V is intended to facilitate cost-effective compliance with quota limits in the mixed demersal fishery and may be relevant to managers of mixed fisheries subject to quota (or, indeed, other types of interrelated quota-managed natural resources). Similarly, concerns about high levels of concentration are likely to arise in any rights-based system with long-term transferable rights, even if regulatory limits are in place. Finally, the viability of carbon-neutral fishing is an existential question for almost all fisheries, given the sector´s current reliance on fossil fuels as described in Paper IV.

## 7.3 Contribution to academic and practical knowledge

### 7.3.1 Academic

This thesis augments academic knowledge in a number of areas. Concentration of quota under ITQ´s is of interest to researchers since it can signal the desirable elimination of excess capacity but also undesirable accrual of power to individual quota holders and higher barriers to entry. Paper I analyses two aspects of concentration not previously examined; vessel-level quota holdings and industry competitive rivalry. Vessel quota holdings give a fresh perspective on harvesting economies of scale, particularly when fishing companies are vertically integrated and concentration may be driven by

pursuit of downstream economies of scale. Consistent with this, the maximum amount of quota held by individual Icelandic companies was found to be close to the regulatory limit for several species while the corresponding values for individual vessels were well below the limits. This result implies that the limits are generally not preventing exploitation of scale economies driven by vessel size and raises the question as to whether the combined benefits of downstream scale and vertical integration are sufficient to justify raising quota ceilings. The question of competitive rivalry has been raised in relation to ITQ´s due to the natural barriers to entry that arise from limited availability and can be compounded by grandfathering (Pinkerton & Edwards, 2009). Paper I contains a novel application of the Hymer-Pashigian Instability index of competitive rivalry to an ITQ system and shows that the index has declined across species and is lowest in the highly concentrated pelagic sector.

Paper II draws attention to the significant gap between reported and estimated potential economic efficiency in Iceland´s harvesting sector. The paper partially bridges this gap by identifying substantial transfers to vertically integrated processing operations and fishermen, and tracing the development of supporting mechanisms and institutions. An explanatory hypothesis is proposed which draws on established concepts in the broader literature on rent-generating sectors but represents an approach to analysis of ITQ fisheries which is novel in two respects. Firstly, the quality of rights to grandfathered ITQ´s are claimed to vary inversely with perceived windfall profits. These profits, and therefore deterioration of rights quality, are likely to increase over time reflecting the rate of fleet rationalization and stock rebuilding which are partly endogenous to the industry. This perspective is a clear departure from the standard treatment of ITQ rights quality which emphasises design features and does not provide for any link between the security of the resultant rights and industry performance (Arnason, 2005). Secondly, rent hiding is emphasised as an industry response to the above threat, in contrast with the over-extract / under-invest alternatives which are argued here to be less relevant due to the discipline of externally imposed of TAC limits[12] and secondary market for fishing vessels (Stokke, 2001; Quillerou & Guyader, 2012). Rent hiding becomes relatively more attractive and is facilitated by the difficulty of establishing arm's length prices between harvesting and downstream operations. While the concept of hiding value in order to protect

[12] This discipline may be attenuated by industry lobbying but is unlikely to be completely absent. To the extent that industry is able to influence TAC levels, this ability would make industry profitaiblity more endogenous.

it can be found in multiple strands of the literature, it does not appear to have been explored in the context of grandfathered fishing quota.

Trade in grandfathered quota systems has been claimed to cause a transitional gains trap which ultimately prevents policy makers from later reallocating fishing rights or the associated benefits. However, the claim is usually made in passing and there do not appear to be any studies in which it is examined from a theoretical or empirical perspective, in a fisheries setting or more generally. Paper III is a preliminary, limited step towards filling this gap in the literature. A simple conceptual model is used to derive a potential trade-based measure which is then applied to the Icelandic ITQ system. Finally, it is shown that holding a combination of grandfathered and purchased quota can lead to a decline in the proposed measure, contrary to the standard interpretation of the transitional gains trap.

Growing interest in the economic and environmental consequences of fuel use in harvesting has resulted in an extensive literature which includes several fuel intensity studies in the Nordic region. Paper IV adds to this literature by studying the development of fuel intensity in the Icelandic marine capture fishery which is an important comparator. The paper also presents a simple technique for indirectly comparing current to historic performance using a virtual benchmark, which may be useful when data limitations prevent direct comparison. Finally, a novel policy instrument is outlined for limiting greenhouse gas emissions in ITQ fisheries using individual emissions quota. While the instrument is proposed in the context of fisheries, it may be of interest to policy makers wishing to limit throughput of jointly consumed resources in a particular sector.

Catch-quota balancing mechanisms aim to alleviate the effects of choke species on mixed ITQ fisheries by allowing harvesters to adjust quota allowances to actual catch within limits. Interest in these mechanisms is growing with proliferation of ITQ systems and discard bans. The species transformation mechanism has been criticised due to the risk of arbitrage and overfishing but is used in the Icelandic ITQ system in which quota are well utilized without significant overfishing. Whereas previous research has examined the use of transformations at the aggregate fleet level, Paper V analyzes the behaviour of individual vessels and investigates correlation with potential explanatory variables. Finally, the paper introduces a simple measure of behavioural similarity which may be useful in studies which distinguish between systematic and random behaviour.[13]

[13] The author could not find reference to an index of this kind in the literature.

### 7.3.2 Practical

The research in this thesis makes a number of contributions to practice, primarily relating to fishery management policy. Paper I concludes with the need for a fundamental review of Iceland´s current quota cap legislation. In particular, it is argued that the standard framework for analyzing the effects of concentration should be applied with caution. Firstly, the benefits of permitting increased concentration should distinguish between harvesting and processing; if they relate primarily to processing then this may weaken the argument for higher limits in harvesting. While previous research has analysed sources of efficiency gains in the processing sector (Agnarsson, 2006), the author is not aware of any study analyzing the harvesting sector. Secondly, greater clarity is needed regarding the relevance of the limits to the concerns they are intended to address, that is the ability of large quota holders to influence local stakeholders and institutions, including would-be new entrants. Paper I argues that the measures and benchmarks normally associated with market power may be of limited use and that new approaches may be needed.

Practical recommendations are offered in paper V in order to mitigate two risks of the Icelandic catch-quota balancing system. First, the limit on how much quota a vessel can transform into each species is currently based on total demersal catch (1.5% of total demersal catch evaluated in cod equivalents). This limit can be a multiple of catch for lesser species and should instead be scaled relative to quota in each species, in line with all the limits for banking and negative transformations. Second, the rate at which quota can be transformed between species should be better aligned with market values in order to reduce arbitrage potential. This could be achieved by using more recent data and focusing on profitability rather than sales prices (which are the bases for cod equivalent values).

In addition, a number of the findings discussed in section 7.3.1 may have practical value to the extent that they inform and enhance the policy making process. For example, Paper III shows that the Transitional Gains Trap should not be accepted at face value as an argument against reallocation of rent associated with quota in mature ITQ systems, potentially increasing the breadth of options considered by policy makers.

## 7.4 Limitations

In this section, the limitations of the research in this thesis are discussed with respect to the reliance on a single case, the Icelandic ITQ system, and the availability of data.

### 7.4.1 Case study approach

The research in this thesis focuses on the performance of Iceland´s ITQ system rather than a sample of ITQ systems. In addition, elements of the fuel intensity analysis in paper IV are based on small samples which may not be representative of the overall system. The potential for local factors to limit the general relevance of the results means that reported values should be treated as benchmark observations for comparison to other studies. Similarly, postulated relationships between variables should be viewed as hypotheses for further investigation.

In view of these limitations, it is appropriate to consider the extent to which characteristics of Iceland´s ITQ system might be expected from other examples. Two distinguishing features previously discussed are highlighted here, the integral role of the fishing industry in the local economy and the degree of species concentration. The size and profitability of the Icelandic fishing industry make it unusually prominent in domestic affairs, as pointed out in section 1.3. This prominence is integral to the explanatory model hypothesized in paper II since it stimulates public pressure to charge harvesters a commensurate fee for privileged access to nationally owned marine resources. However, it may also indirectly influence other results presented in this thesis. For example, the implied incentive to hide rent might be expected to increase vertical integration which would strengthen the link between concentration in quota and the processing sector. Meanwhile, the species mix of catch for Icelandic individual vessels and trips may be more concentrated than in other countries, as outlined in section 7.2.3. If such concentration is predictable, it could reduce the need for harvesters to avoid cod and make it easier to fully utilise quota, as discussed in papers IV and V.

Despite the above limitations, the case study approach is considered justified from a number of perspectives. Firstly, it is unavoidable when the topic of interest is specific to Iceland, for example the catch-quota balancing system and development of profit-based quota fees. Secondly, it permits in-depth analysis that might not be feasible for a larger sample due to limited availability of data and research resources. Thirdly, but related to the second point, case studies can be a useful method to generate novel hypotheses. This may be particularly worthwhile if the hypotheses facilitate early identification of issues that may be expected to emerge in other systems and where the precautionary principle dictates that it is important to anticipate the consequences of decisions that are difficult to reverse.

### 7.4.2 Availability of data

The research in this thesis was hampered by a number of data limitations. The most common issue concerned the lack of data from the 1980´s and 1990´s. As a consequence, the analyses in papers II, IV and V are largely restricted to periods commencing around 2000-2001 and do not capture the initial development of the ITQ system. While the quota ownership data employed in papers I and III extended further back to 1991, its utilization necessitated a significant amount of manual data input. In addition, several important quantities were not available for part or all of the analysis period and therefore had to be estimated, including wage levels for full-time fishermen (paper II), quota prices (paper III) and fuel prices (paper IV).

The greatest data challenges related to the fuel intensity analysis in paper IV. In particular, fleet-wide data was only available aggregated for the overall fleet (volume of fuel purchased) or by fleet segment (fuel expenses and catch volumes) rather than being available by vessel. As a result, the estimation of segment fuel intensities assumed that fuel use in each segment was in proportion to expense (an assumption which was sensitized). In addition, the species intensities were based on mass allocation across segments rather than individual vessels. The lack of vessel-level data for a large representative sample meant that the reported results for the fleet did not capture variation within each segment and could not be placed within confidence intervals. Where individual vessel data could be obtained, the samples were small which made reporting of confidence intervals problematic.

A final issue related to the reliability of data obtained. For example, the statistics on fleet performance obtained from Statistics Iceland are based on a survey. While sample coverage has been high, particularly in recent years, no information is available regarding the potential for bias. The statistics derived from the survey have sometimes formed the basis for calculation of the quota fee and it is possible that the incentive to reduce the fee might introduce some bias[14]. Secondly, quota lease prices are used repeatedly throughout the thesis

[14] Three sources of bias suggest themselves; (1) companies which do not respond to the survey may have above average profitability; (2) vertically integrated harvesters may have flexibility to select the method of overhead allocation between harvesting and other operations; and (3) harvesters may have in incentive to inflate the insurance value of fishing vessels which would increase the imputed cost of capital and reduce reported economic profit. While such behaviour might lead to higher insurance costs (historically 1-2% of insurance value) the decrease in economic profit would be much greater (12% of insurance value). Perversely, at marginal fee rates above 15-20% such behaviour could be rational from the perspective of the harvesters as a group. It should

(in papers II, III and V) but it is not clear to what extent they are arm's length. For example, around a third of quota leased between 2001-2019 was "zero-priced" suggesting that the relevant transfers were either between vessels owned by the same company, related parties or as a result of barter trade.

## 7.5 Further research

This thesis identifies avenues for further research relating to the allocation of natural resource rights, rent hiding and zero-carbon fishing.

### 7.5.1 Links between initial allocation of rights to renewable natural resources and dissipation of rent

This thesis was motivated in part by the surprising gap between existing and estimated potential efficiency of Iceland´s harvesting sector. The results provide tentative evidence that the initial grandfathering of ITQ´s in Iceland has influenced industry development in ways that may detract from efficiency in the following decades. The clearest evidence relates to the on-going conflict between the industry and broader society over who should enjoy the wealth associated with the creation of the ITQ system. This conflict has led to rent seeking and defending behaviour which is at the very least distortionary and may also be costly, for example if it causes excessive vertical integration or attenuates the incentive to increase profits. At the time of writing, the issue still appears to be far from resolved, with reform of the quota system and introduction of market-based fees featuring in the policy platform of at least two political parties (www.vidreisn.is, www.piratar.is). Circumstantial evidence and the broader literature suggest further potential sources of inefficiency related to grandfathering including reduced competition, greater barriers to entry and increased power over the market and other stakeholders (Bromley & Macinko, 2007; Pinkerton & Edwards, 2009; Nøstbakken, 2012).

The scale and profitability of Iceland´s ITQ-managed fishery relative to the overall economy make it unusual and potentially limit the broader relevance of any research findings, at least at present. However, the sustainable development agenda seems likely to change this as tighter restrictions on the use of natural resources lead to limited use rights which must somehow be allocated. These rights are likely to be valuable, given the essential nature of many resources and ecosystem services, and the fact that current levels of economic activity are exceeding the planet´s natural carrying

be noted that economic profits reported by Statistics Iceland are no longer used to calculate quota fees following a change in the law in 2018 (Althingi, 2018).

capacity (Costanza et al., 1997, 2014; Steffen et al. 2015; Lin et al., 2018). The value of renewable energy resources, in particular, may be expected to increase as use of fossil fuels declines due to depletion and climate change, and supply of other exhaustible resources becomes increasingly dependent on recycling. This is important because many renewable resources have common pool characteristics which mean that some form of governance is necessary if they are to be conserved and economically productive. Researchers have emphasised that a range of approaches are available and have cautioned against viewing any one approach as a panacea (Ostrom, 2008; Stavins, 2011). Regardless of approach, the question is inevitably raised about how the associated gains should be allocated.

The above observations imply that research to evaluate alternative allocation methods could be of great value in the context of sustainable development. In particular, the scope to limit quota duration and increase use of market-based mechanisms, such as auctions or Harberger taxes (Posner & Weyl, 2017) when issuing new quota seem worth further exploration. Such approaches have the appeal that they might resolve some of the issues raised in this thesis relating to industry competitiveness and distribution of resource rent. However, they may also entail other issues, for example relating to compensation for losses due to the introduction of ITQ (Trebilcock, 2014) and potential inefficiencies due to channelling rent through the public sector.

Establishing the relative merits of different methods of allocation is problematic given the dominance of the grandfathering approach in fishing and other sectors[15]. Some commentators have claimed that grandfathering is the only feasible way to allocate quota, at least in fisheries, due to the practical necessity of support from incumbent harvesters and acceptance of their need for compensation when faced with the prospect of lower profits or leaving the industry (Hannesson, 2014; Grainger & Costello, 2016). However, with the benefit of hindsight and given the stakes involved, it seems prudent to critically examine the validity of these arguments. Firstly, there is the matter of proportionality (Weninger & Just, 1997) - rough calculations show that the value of quota granted far exceeds the capital value of fishing vessels which themselves may far exceed the cost of retiring vessels from the fishery (given

[15] Grandfathered quota have been introduced for various sources of air pollution (Schmalansee, 2015). UNFCC agreements to reduce GHG emissions can be viewed as loosely based on grandfathering since country´s targets are defined relative to historic emissions (Kuyper et al., 2018). Grandfathered pollution quota may be expected to perform differently from fishing quota to the extent that the long-term aim is usually to reduce or eliminate pollution (a "bad") whereas fishing quota generally aim to increase long-term harvests (a "good").

the slow decline in capacity and secondary market for fishing vessels). Secondly, there is a question of equity given the lack of compensation to other stake holders who may also have capital invested in the industry, whether physical, human or social that is arguably at greater risk of being stranded than a fishing vessel which can be resold abroad (Matulich et al., 1996; Macinko, 2014). More broadly, it is reasonable to ask when compensation is justified (Trebilcock, 2014; Barichello et al., 2009) and how much weight should be accorded to the support of incumbent vessel owners compared to that of other stakeholders, including fishermen, processing companies, local communities and the ordinary voter and tax payer (Hersoug, 2018).

While the above research agenda is, to some extent, anticipating problems that have yet to materialize, it is nevertheless considered by the author to be worthwhile, both from a precautionary perspective (due to the risk of lock-in to inferior allocation methods) and in order to reduce the risk that a lack of broadly acceptable allocation methods undermines efforts to reach agreement on limiting the use of natural resources, resulting in further environmental degradation.

### 7.5.2 Rent-hiding response to public pressure to tax rent

Paper II proposed a hypothetical model for further investigation in which the risk of greater taxation or even revocation of grandfathered quota due to public perception of windfall gains by the industry is alleviated by shifting harvesting profits to downstream operations in vertically integrated companies. This line of inquiry does not appear to have been explored in the context of fisheries. This is surprising given the increasing emphasis on transparency in the contexts of natural resource governance, taxation and sustainable development[16] - allocation of the wealth derived from the creation of limited fishing rights is arguably at the nexus of such concerns (Williams, 2011; Mejía Acosta, 2013; Lips & Valderrma, 2020; Petersson, 2020). In addition, as is argued in paper II, ITQ fisheries have certain features that seem likely to make rent-hiding particularly relevant; less scope to over-extract or under-invest and greater opacity regarding the local market price of fish products (particularly in the pelagic sector). If estimates of the potential rent from efficiently managed fisheries referred to in paper II (typically 60-70% of harvesting revenue) are accurate and grandfathered individual quota systems continue to

[16] There have been several initiatives in these areas in recent years including the Extractive Industries Transparency Initiative (EITI), the Fisheries Transparency Initiative (FiTI), and the OECD Global Transparency Forum and Base Erosion and Profit Shifting (BEPS) initiative.

proliferate, then the incentive to obfuscate harvesting profitability seems likely to become more widespread.

The above topic could be investigated from a number of perspectives. The most obvious line of inquiry would be to test the hypothesis on other ITQ systems, in fishing or more generally. However, in order to do this, the hypothesis would first need to be reduced to a predictive model in which the key variables can be quantified. Ideally such a model would also explain why transfer pricing has not been more aggressive given the potential tax saving[17]. To this end, further investigation of the Icelandic ITQ system might be of benefit. A potential first step would be to estimate the effect of vertical integration on profitability and ex vessel prices for individual harvesters. A second approach would be to compare Icelandic ex vessel prices with those in other countries and explore the reasons for any observed differences[18]. A third approach would be to survey the opinions of local stakeholders; this might be helpful for identifying potential constraints on transfer pricing.

### 7.5.3 Carbon-neutral fishing

Sustainability in fishing has traditionally been framed in terms of fish stocks rather than the fleets powered by fossil fuels which harvest them. However, growing concern about climate change and the resultant pressure on governments to reduce and eventually eliminate net greenhouse gas emissions mean that sustainability in fishing will increasingly depend on the industry´s ability to limit its use of fossil fuels and switch to clean energy sources (Sterling & Goldsworthy, 2006; Lin, 2013; Parker et al., 2018). What these trends mean in practice at the local level is currently unclear. In particular, what role can different fisheries play in achieving overall abatement targets, how quickly and at what cost? What are the implications for competitiveness with alternative food sources and what forms of policy intervention, if any, are appropriate?

These questions suggest a number of lines of inquiry on different time scales. Firstly, it would be useful to develop models which forecast the

[17] Reported economic rent from processing has generally been close to, but not exceeded that from harvesting. In theory, ex vessel prices could be reduced and crew shares increased so that the processing sector earns greater profits while the harvesting sector only breaks even.

[18] For example, it has been reported that Icelandic pelagic fish prices are far below those reported in Norway but Fisheries Iceland have claimed that the fish are not comparable. This topic has received significant attention in the local press, particularly during negotiation of wage agreements between fishermen unions and the Fisheries Iceland (see paper II).

emissions from fisheries under different scenarios. Such models would be useful to establish the long-term viability of fisheries under low or zero-carbon regimes, the implied transition pathways and need for policy intervention. Of particular concern is the prospect that some fisheries may be so inherently energy intensive that they will not survive, even if the products attract a significant premium to alternative food sources. One limitation of this approach is that it depends on long-term assumptions, for example relating to the supply and cost of alternative energy sources, which may be difficult to estimate. A more limited, but potentially more robust, approach would be to compare a fishery powered by biofuels from agriculture with the alternative of producing food from agriculture directly. Biofuels are of particular interest since they are more compatible with established vessel propulsion technology than alternatives such as electricity or hydrogen from renewable sources.

Complimenting the above research into the appropriate abatement targets for fisheries is the need to develop instruments that support achievement of these targets and meet broader policy goals such as cost-effectiveness (Sterner & Coria, 2003). Paper IV outlined a potential instrument involving individual emissions quota for fishing vessels, scaled according to their fishing quota and total allowable emissions. The idea of multi-dimensional quota seems worthy of further investigation and comparison to alternative instruments. In particular, it should be clarified how such a system would work in practice given the variation in pelagic catch, and how much it would cost compared to the potential benefits. Perhaps most importantly, the costs and benefits of a sector-based approach should be evaluated, including the extent to which diminished flexibility to equalize abatement costs across sectors is offset by the reduced risk of leakage (Barrett, 2010). In this respect, it should be emphasised that second best concerns could potentially be ameliorated by allowing trade in emission quota across ring-fenced sectors.

Lastly, the contrasting trends in fuel intensity for demersal species and pelagic species in Iceland suggests a further line of inquiry. In particular, comparing the performance of different national fleets jointly exploiting straddling pelagic stocks may offer a new strategy to elucidate the influence of country-specific factors such as the fleet and fishery management system since factors relating to the stock (such as abundance and quality of international cooperation) would be the same for all fleets.

## 7.6 Conclusion

The global fishing industry has repeatedly been described as being at crossroads; with the potential to contribute significantly to sustainable

development but also facing a raft of challenges. This thesis investigated how some of the main challenges have been addressed in Iceland´s ITQ system.

The results indicate a qualified success, particularly in terms of the economic and environmental challenges, consistent with the expected benefits of ITQ´s. For example, correcting for rent transfers revealed substantial gains in efficiency following consolidation of quota and rebuilding of key demersal fish stocks, particularly cod. However, a large portion of potential rent may still be dissipated and exogenous factors, such as the growing abundance of new pelagic species, may have contributed to improved performance. Similarly, fossil fuel intensities were found to correlate strongly with higher stock levels and compare favourably to other fisheries but room for further improvement may be limited without government intervention. The quota balancing mechanisms were found to function well but this result appears to reflect tailoring to particular characteristics of the fishery. In terms of social impact, the results indicate tensions that could increase over time as quota become more valuable and concentrate in fewer hands.

An important finding in this thesis is that Iceland´s ITQ system has exhibited versatility and flexibility to adapt to emerging issues and changing priorities. For example, the quota balancing mechanism has been repeatedly refined and fine-tuned, partly to reduce the risk of arbitrage-driven overfishing. Concerns about concentration led to the introduction of limits which were subsequently increased, while public pressure for a greater share of the wealth derived from quota resulted in a profit-based tax applied at a rate that has risen and fallen with changes in government. The scope for flexibility in other areas has been emphasised, particularly regarding the potential for extension to emissions quota and alternative methods of allocation.

The ITQ approach has been criticised widely as an economist's solution that attributes less importance to social and environmental outcomes. The results of this thesis suggest that while this may have been the case in Iceland, at least initially, this outcome did not reflect inherent limitations of the ITQ approach and is more likely due to political constraints. Looking to the future, the two issues that are now arguably most pressing, reduction in greenhouse gas emissions and greater consensus on wealth distribution, both appear amenable to government intervention within an ITQ framework provided that a policy goal can be agreed.

It has been pointed out that the acuteness of some of the challenges faced by Iceland´s fishing sector, particularly political conflict over wealth distribution, are accentuated by the unusual prominence of the industry. This caveat may limit the relevance of some of the findings in this thesis to other

fisheries which generally occupy a much smaller role in their national economies. However, in the broader context of sustainable development, it seems plausible that the need to create limited use rights for a wide range of natural resources and ecosystem services will involve the creation of rent and wealth which make the method of allocation, between and within countries, a matter of great importance to many people around the world. It has been argued in this thesis that exploration and evaluation of alternative methods of allocating rights to resources in this broader context is therefore a worthwhile area for further research and policy development.

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