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THE VALUE OF SECURE PROPERTY RIGHTS: EVIDENCE FROM GLOBAL FISHERIES

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The Value of Secure Property Rights: Evidence from Global Fisheries*

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Abstract

Property rights are commonly touted as a solution to common pool resource problems. But in practice the security of these property rights varies substantially owing to differences in design. In fisheries, the design of individual transferable quotas (ITQs) varies widely; the consequences of these design differences on economic outcomes has not been studied. To test whether the security of these property rights affects asset values, we compile a unique dataset to examine the relationship between the exclusivity of property rights and the dividend price ratios for ITQs. We find evidence that stronger property rights lead to higher asset values and lower dividend price ratios in ITQ fisheries. This pecuniary effect of property rights security informs the current policy debate on the design of property rights institutions for managing natural resources.

1 Introduction

Property rights and institutions are believed to have a profound impact on investment and economic growth. Yet it is difficult to empirically disentangle the effects of institutions on economic outcomes. Case studies in a handful of settings suggest the critical role of institutions, often in the context of developing countries (see, e.g. Acemoglu and Johnson, 2005; Besley and Burgess, 2000, Alston et al., 1996; Alston and Mueller, 2010; Banerjee et al., 2002; Besley, 1995; Goldstein and Udry, 2008; Jacoby et al., 2002). Yet a key insight from early economic analysis, and the focus of our analysis, regards instituting property rights over previously unowned natural resources and how that might mitigate the ill consequences of the common pool. This paper contributes to this broader literature by examining the effect of stronger property rights on investment in common pool resources.

To overcome the problems pervasive in common pool resources (e.g. Gordon, 1954), rights-based management approaches are increasingly employed globally. Strong evidence of increased economic and ecological performance from rights-based approaches has emerged (Grafton et al., 2000; Costello et al., 2008), and the policy debate has shifted away from 'whether' these approaches are effective and toward questions of design. Many design elements are likely to affect the security of a property right. For example, so-called "sunset clauses" after which rights are

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revoked and redistributed will affect stewardship and value (Costello and Kaffine, 2008) and assignment of rights to only a portion of the resource stock may erode conservation and investment incentives (Deacon et al., 2010). Other fundamental design parameters include limits on ownership or transferability (Grafton et al., 2000), revocability, and geographic or temporal control over resource stocks. Despite their ubiquity and importance for design, the extent to which these limitations on property rights security affect behavior and economic value has not been carefully studied. The purpose of this paper is to empirically examine the effect of property rights security on asset values of a globally significant common pool resource.

In fisheries, where the common pool feature has lead to widespread collapse (e.g. Worm et al., 2006), there is a significant trend toward property rights-based approaches. Fisheries in developed countries have largely transitioned from open access to limited entry, where the number of vessels is restricted, and often an overall quota is set for all licensed fishermen. Under such management, resource rents may still be dissipated in the race to fish and overcapitalization (Homans and Wilen, 1997). In an attempt to allow the capture of resource rents, some fisheries have adopted catch shares or other rights-based management.

In this paper, we focus our analysis exclusively on Individual Transferable Quota (ITQ) fisheries. ITQs, a form of 'catch shares', are the most prevalent form of fishery property right in the industrialized world, where the holder of an ITQ owns an asset which confers the right to harvest a share of the total allowable catch in the present year and into the future. ITQs have been hailed by economists as a means to capture the rents in fisheries. But in practice, the design of ITQ systems varies significantly across fisheries; these design idiosyncracies affect property rights security in complex ways.

Under ITQ management, shares of the total allowable catch (TAC) are allocated to individuals (or firms or cooperatives), who then hold the right to harvest their share each year. Typically, the holder of an ITQ can exercise that harvest right, lease it to another fisherman, or sell it. This has been shown to help achieve allocative and technical efficiency (Grafton et al, 2000), which adds significant value in a fishery. In addition to eliminating the "race to fish," ITQ management has been shown to reverse the collapse of fisheries (Costello et al, 2008).

Since the introduction of the first ITQs in the mid-1980s in Iceland and New Zealand, ITQ fisheries have been established in many countries (prominently the United States, Canada, Peru, Chile, and Australia). The general structure of ITQ management has been adopted widely, but ITQs as property rights are viewed very differently by governments around the world. In New Zealand, ITQs are viewed as perpetual rights to fish. There, a quota is a legal asset whose owner can use as collateral in establishing credit with banks. On the other hand, in Canada and the United States ITQ ownership is considered a revocable privelege, and the future of ITQ property rights (at least in the long run) is uncertain.

There is also important variation in the security of property rights *within* countries. Beyond differences in design features, some stocks are prone to significant illegal harvest due to high enforcement costs, while highly migratory species are subject to harvest by neighboring jurisdictions or in international waters. Ownership of quota shares in these stocks is arguably less secure than stocks with good enforcement and/or species that stay within the waters of the managing jurisdiction.

This story is not unique to fisheries. The deleterious consequences of common pool management of resources such as timber, air, water, and biodiversity are increasingly realized. These declines have lead to the establishment of property rights over these resources. In so doing, governments inevitably wrestle with the dilemma of how much control to cede to private resource owners, where more control confers a stronger property right to its owner. Economic theory suggests that the strength of property rights should affect the value of the asset itself (in fisheries, this is the quota value) but should not affect the current lease value. The lease value simply reflects the current year's rents, whereas the sales price of a quota should in principle capitalize future expectations. Quota markets offer a good opportunity to study the effect of more secure property rights on asset values because the relationship between lease prices and sales prices of quota shares should be dictated by market fundamentals. Newell et al (2005) study ITQ markets in New Zealand and find that markets are sufficiently "thick" to operate well; the relationship between lease and sales prices approximately follows market interest rates, and asset values in fisheries that experienced significant rebuilding showed large gains. In a follow-up paper, Newell et al (2007) extend this analysis to a more formal model of asset pricing. They find that asset prices are higher when interest rates are lower, and asset values are lower for stocks with higher biological fluctuation. They also find that stocks that had large decreases in costs or high growth rates in output prices have higher quota asset prices. These papers contribute significantly to our understanding of quota markets and asset pricing in fisheries, though they do not address the issue of property rights security.

In this paper we exploit differences in property rights across countries to determine the market implications of secure ownership of these assets. We then exploit variation in the exclusivity of the property right within New Zealand to determine the impact of more secure property rights on the dividend price ratio, a measure of the implied discount rate in asset markets. We find that property rights security has a significant effect on asset values in fisheries suggesting that property rights security may have a profound impact on economic behavior in (previously) common pool resources.

2 Background

ITQs allow the capture of resource rents by reducing the race to fish and allowing the price mechanism to move harvest rights to the most efficient fishermen. There is, however, considerable variation both across and within countries in the strength of the property rights underlying these assets.

Every country imposes idiosyncratic limitations on trades, duration, and use of ITQ shares, including (but not limited to) caps on ownership of shares, restrictions on ownership by foreign fleets, vessel capacity or gear restrictions, and sunset provisions. Rather than modeling structurally the independent and combined effects of these restrictions,[1] we will take a reduced form approach and leverage the fact that the ITQ asset price should capitalize this array of limitations and restrictions. By calculating the dividend price ratio in each fishery over time, we are able to test whether property rights security affects investment in these assets.

Experience with ITQ management varies widely, beginning with New Zealand as an early adopter in 1986. Species have been subsequently added to New Zealand's Quota Management System over the past two decades, and there are currently 98 species (or species groups) under quota management, with 690 separate management stocks.

North America has taken a more cautious approach toward ITQ adoption. Canada's Pacific Sablefish and Halibut ITQs were introduced in 1990, and the United States implemented its first ITQ program in the mid-Atlantic surf clam and ocean quahog fishery in the same year. Since the introduction of the first ITQs, several stocks have been added in the United States and Canada; the fisheries included in the analysis are listed in Table 1. While the general principle behind ITQs is the same in these countries, the governments have very different legal definitions of the quota share held by individuals; these imply palpable differences in property rights security.[2]

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[1] Arnason defines what he calls a "Q-Value", which is a measure of the quality (or strength) of property rights in fisheries. The Q-Value is a weighted index of assigned values for exclusivity, security, durability, and transferability, but in the current empirical setting the practical use of this index has limitations. Use of the Q-Value requires assigning values to each stick in the bundle for an individual country, and creating a weighted index of these scores to come up with an overall score for the property rights strength.

[2] Prominent papers examining the effects of property rights on resource use include Watts and LaFrance (1994) and Libecap (1981) who look at grazing permits; Rucker, Thurman and Sumner (1995) who examine agricultural quota transfers; and Johnson, Gisser, and Werner (1981) who focus on water rights transfers in the Western United

Table 1: US and Canadian ITQ Fisheries in the Analysis

Country	Species	Area	First Year Under ITQ	First Year With Data
USA	Halibut	Alaska	1995	1995
USA	Sablefish	Alaska	1995	1995
USA	Red Snapper	Gulf of Mexico	2007	2007
USA	Striped Bass	Virginia	1998	2008
Canada	Sablefish	B.C.	1990	1996
Canada	Halibut	B.C.	1990	1996
Canada	Groundfish (uncut)	B.C.	1997	1999
Canada	Arrowtooth Flounder	B.C.	1997	2006
Canada	Coastwide Hake	B.C.	1997	1997
Canada	Gulf Hake	B.C.	1997	1999

2.1 ITQs as Property Rights

In the United States, the resources in a marine fishery are deemed "common property," which is held in trust by the government for the community at large. Such resources cannot be transferred to or owned by individuals. The Magnuson-Stevens Act[3] holds that quota shares "shall be considered a permit;" "may be revoked, limited, or modified at any time;" "shall not confer any right of compensation to the holder...if it is revoked, limited, or modified;" "shall not create, or be construed to create, any right, title, or interest in or to any fish before the fish is harvested by the holder;" and "shall be considered a grant of permission to the holder of the quota share to engage in activities permitted by such...quota share."

As a result of this insecure property right, there is uncertainty about the future of the program, and holders of quota shares are generally unable to use their holdings as collateral at banks.[4] As anecdotal evidence, when asked why this is the case, a fisherman in the Red Snapper fishery in the Gulf of Mexico stated that "we don't really own anything. In the legal language, it's a privilege. There's always a danger that the government can change its fishery policy down the road, and then the quota would be worthless."[5] Another expressed his concern that the ITQ management would disappear after the five-year review.

A similar situation exists in Canada. Under Canadian law, ITQ shares are considered a revocable privilege, and a resistance to ITQs has led to other catch share systems (called Enterprise Allocations) in the Atlantic Provinces. Although fish are considered "Property of the Crown" in Canada, in 2008 the Supreme Court ruled that fishing quota

States.

[3] 16 U.S.C. 1801, 1996.

[4] This is not due to legal constraints, but rather the bank's willingness to accept a quota share as collateral. A recent exception in the United States is the ability of Alaskan fishermen to leverage against IFQ holdings with some Seattle-based banks.

[5] Personal communication with Keith "Buddy" Guindon, April 6, 2009.

are "property" for the purposes of the federal Banking and Insolvency Act[6]. ITQs are in place in several fisheries in British Columbia (see Table 1), but restrictions on trading were cited as a constraint on potential efficiency gains in the halibut fishery. That is, "substantial long-run gains in efficiency can be jeopardized by preexisting regulations and the bundling of the property right to the capital stock" (Grafton, Squires, and Fox, pg. 679).

In New Zealand, explicit property rights are established in the creation of ITQs, and over the past 25 years nearly all commercial fisheries have shifted to ITQ management. The right to a share of the catch is held in perpetuity, and when a program is discontinued, or where the allocation is changed by the regulator, fishers are entitled to financial compensation. Indeed, in the initial allocation of quota under the Quota Management System (QMS), allocations were in terms of tonnes, and the TAC was fixed. When fishery managers subsequently decided to lower the TAC, quota were bought back in an expensive scheme.[7] This buyback will be discussed further and leveraged in the empirical strategy in Section 5. A list of the ITQ fisheries studied in this paper is found in Table 2.

3 Theoretical Background

Economic theory allows us to examine the value of secure property rights by using information inherent in the relationship between lease and sales prices of quota shares.[8] In a competitive market the lease price of an ITQ should be equal to the expected economic rents from the current year. The lease price is given by $p_{it} = E_t(r_{it} - c_{it})$, where r_{it} represents the revenues and c_{it} represents the economic costs in fishery i and year t; the expectation operator, E_t, simply reflects the fact that revenue and cost need not be known with certainty for this simple analysis to apply. The sales price of an ITQ asset will capitalize the expected discounted rent streams. If rights are secure and held in perpetuity, the current sales price is $\pi_{i0} = \sum_{\tau=0}^{\infty} \frac{E_0[r_{i\tau} - c_{i\tau}]}{(1+\delta)^\tau}$.

If the fishery is operating in steady state, expected costs and revenues are constant over time. Then the ratio of the current lease price to sales price of an ITQ can be written compactly as $\frac{p_{i0}}{\pi_{i0}} = \frac{\delta}{1+\delta}$. This ratio is commonly used in finance to test future expectations about earnings, to compare measures of asset value across geographically distinct markets, and to test for bubbles in asset markets (see, e.g., Campbell and Shiller, 1988 and Cochrane, 1991). In that literature, it is referred to as the *dividend price ratio*, to which we will conform here. Under the simple

[6] Saulnier v. Royal Bank of Canada 2008 SCC 58.
[7] For a detailed overview of the history of the Quota Management System, see Rees, 2005.
[8] A famous application of this type of reasoning is in Fogel and Engerman (1974), who examine slave price trends leading up to the end of the Civil War.

Table 2: New Zealand ITQ Fisheries in the Analysis

Common Name	QMS Code	First Year	Migratory Species	Illegal Harvests
Freshwater Eel	ANG	2000		
Barracouta	BAR	1986		
Blue Cod	BCO	1986		
Bigeye Tuna	BIG	2004	Yes	
Bluenose	BNS	1986		
Butterfish	BUT	2002		
Blue Shark	BWS	2004	Yes	
Alfonsino	BYX	1986		
Black Cardinalfish	CDL	1998		
Spiny Lobster	CRA	1990		Yes
Elephant Fish	ELE	1986		
Blue Mackerel	EMA	2002		
Flatfish	FLA	1986		
Frostfish	FRO	1998		
Garfish	GAR	2002		
Green-lipped Mussel	GLM	2004		
Grey Mullet	GMU	1986		Yes
Giant Spider Crab	GSC	2005		
Dark Ghost Shark	GSH	1998		
Pale Ghost Shark	GSP	1998		
Red Gurnard	GUR	1986		
Hake	HAK	1986		Yes
Hoki	HOK	1986		
Groper	HPB	1986		
John Dory	JDO	1986		
Jack Mackerels	JMA	1987		
Kahawai	KAH	2004		
Kingfish	KIN	2003		
Lookdown Dory	LDO	2004		
Leatherjacket	LEA	2003		
Freshwater Eel	LFE	2004		
Ling	LIN	1986		
Mako Shark	MAK	2004	Yes	
Blue Moki	MOK	1986		
Moonfish	MOO	2004	Yes	
Oreo	OEO	1986		
Orange Roughy	ORH	1986		
Dredge Oyster Nelson/Marlborough	OYS	1996		
Dredge Oyster Foveaux Strait	OYU	1997		Yes

Table continued on next page.

Table 2 Continued

Common Name	QMS Code	First Year	Migratory Species	Illegal Harvests
Paddle Crab	PAD	2002		
Parore	PAR	2004		
Paua	PAU	1987		Yes
Pilchard	PIL	2002		
Porae	POR	2004		
Porbeagle Shark	POS	2004	Yes	
Ray's Bream	RBM	2004	Yes	
Rubyfish	RBY	1998		
Red Cod	RCO	1986		
Ribaldo	RIB	1998		
Rough Skate	RSK	2003		
Red Snapper	RSN	2004		
Southern Blue Whiting	SBW	1999		
Scallops coromandel	SCA	1992		
School Shark	SCH	1986		
Freshwater Eel	SFE	2004		
Gemfish	SKI	1986		
Snapper	SNA	1986		Yes
Spiny Dogfish	SPD	2004		
Sea Perch	SPE	1998		
Rig	SPO	1986	Yes	
Arrow Squid	SQU	1987		
Smooth Skate	SSK	2003		
Stargazer	STA	1986		
Southern Bluefin Tuna	STN	2004	Yes	Yes
Kina	SUR	2003		
Silver Warehou	SWA	1986	Yes	
Swordfish	SWO	2004	Yes	
Tarakihi	TAR	1986		
Pacific Bluefin Tuna	TOR	2004	Yes	
Trevally	TRE	1986		
Trumpeter	TRU	1998		
Blue Warehou	WAR	1986	Yes	
White Warehou	WWA	1998	Yes	
Yellow-Eyed Mullet	YEM	1998		
Yellowfin Tuna	YFN	2004	Yes	

Species and species groups in the dataset for New Zealand. First Year denotes the first year under the Quota Management System. Highly Migratory is determined by the Ministry of Fisheries. Illegal harvests denotes species that the Plenary Reports discuss the problem of evidence of illegal harvests for that species.

model above, the dividend price ratio should be a function of only the discount rate, δ. In particular, fishery specific characteristics that affect revenues and/or costs conveniently cancel out of the dividend price ratio.[9] However, the calculus above implies an infinitely secure property right.

Suppose instead that participants in the market for quota share in fishery i place some non-zero annual probability, θ, on the revocation of rights (e.g. the government discontinues the ITQ program or shuts down the fishery). In that case, the lease value remains unchanged, but the sales value (at time 0) is now given by

$$\pi_{i0}^{uncertain} = p_{i0} + \sum_{\tau=1}^{\infty}(1-\theta)^{\tau}\frac{E_0[r_{i\tau} - c_{i\tau}]}{(1+\delta)^{\tau}}. \tag{1}$$

Again, if the fishery is in steady state it is straightforward to show that the dividend price ratio is given by:

$$\tilde{R} = \frac{1+\delta-(1-\theta)}{1+\delta}. \tag{2}$$

All else equal, less security about ownership in an ITQ program leads to a predictable effect on the dividend price ratio, $\tilde{R}$. Perhaps of more practical significance, we can solve Equation (2) for the annual revocation probability, θ:

$$\theta = \tilde{R}(1+\delta) - \delta. \tag{3}$$

For example, suppose the dividend price ratio is $\tilde{R} = 0.15$ (a typical value from the ensuing empirical analysis), and that the relevant discount rate is $\delta = 0.05$. These values imply an implied annual revocation probability of about 11%. Instead, if $\tilde{R} = 0.10$, the annual revocation probability is about 6%. We can use Equation (3) to tease apart the implied strength of property rights in two different fisheries with the same δ. The difference between annual revocation probabilities in fisheries i and j are given by:

$$\theta_i - \theta_j = (1+\delta)(\tilde{R}_i - \tilde{R}_j), \tag{4}$$

which provides a convenient means to compare property rights strength across fisheries.

In cases where ownership of an ITQ is considered a privilege and is not guaranteed in perpetuity, the sales price would be lower, while the lease price would remain unchanged. Similarly, if exclusivity of the right to a share of the TAC is attenuated by fishery-specific characteristics, $\tilde{R}$ would be high. All else equal, $\tilde{R}$ should be lower where property rights are secure.

[9] A result that will become useful in our empirical specification.

The goal of this paper is to test the hypothesis that strong property rights lead to a lower dividend price ratio in the context of renewable resources. Using sales and lease prices from countries with varying strengths of property rights, we first test for differences in the dividend price ratio across countries. In that analysis we attempt to control for other differences across countries and fisheries and we leverage the insight that the dividend price ratio differences out fishery specific variables that might affect asset values. We then focus on differences in dividend price ratios within countries, examining how fishermen implicitly perceive the future value of quota holdings. Because ITQ programs are generally subject to federal laws that define catch shares, it is difficult to obtain within-country heterogeneity in property rights security.[10] For within-country evidence, we exploit variation in the exclusivity of the property right across fisheries resulting from enforcement of the property right (illegal harvesting) and neighboring jurisdictions that arise due to biological characteristics (migratory species). Furthermore, we exploit a policy shock to look for evidence that discounting behavior changed in quota markets following a high-profile buyback.

4 Data Description

We have compiled a unique panel dataset spanning hundreds of ITQ fisheries in three countries. The primary variables of interest involve ITQ share sales and lease prices. Because data on individual transactions are generally not available, we use annual average prices for sales and leases of quota shares in three countries: Canada, the United States, and New Zealand. Variables that can affect the price of quota shares include the total allowable catch (TAC), ex-vessel prices, the market interest rate, and biological characteristics of the species. A detailed description of the data sources is available from the authors.

Data from New Zealand are the most comprehensive and come from FishServe, the New Zealand Seafood Industry Council, and the Ministry of Fisheries. For each species under quota management and for each management area, we have average annual prices for sales and leases, average greenweight tonnage prices,[11] the total allowable commercial catch, and biological data from the Ministry of Fisheries and FishBase.[12]

[10] There is some variation within the United States in how catch shares have been implemented by regional management councils, but due to data limitations, we focus our attention on New Zealand.

[11] In New Zealand, ex-vessel prices are not available for the entire time period. Following Newell et al (2005), we calculate greenweight tonnage prices using export price data for each year, and conversion factors from Clement and Associates.

[12] In consultation with FishServe, a small number of observations are omitted from the analysis because they are believed to contain significant errors. Including these observations does not qualitatively change our results.

Canadian quota prices are from management reports, Department of Fisheries and Oceans consulting reports from Nelson Bros., and Individual Fishing Quota reports from Munro & Associates. Canadian fisheries included in the analysis are British Columbian halibut, sablefish coastwide hake, gulf hake, arrowtooth flounder, and "uncut" groundfish, all of which operate under an ITQ.

Finally, United States data come from the National Marine Fisheries Service (NMFS) and regional management councils. Fisheries under ITQ management included in the analysis are the Alaskan Halibut and Sablefish, the Gulf of Mexico Red Snapper, and the Virginia Striped Bass fishery.[13]

As an introduction to the data, consider a simple graph of the median $\tilde{R}$ across time for New Zealand, Canada, and the United States (Figure 1). While this simple graph fails to control for other factors (e.g. the interest rate, fishery characteristics), it suggests there might be a systematic difference across countries. The median $\tilde{R}$ in New Zealand always falls below that of the United States, and typically falls below that of Canada. Furthermore Canada's median $\tilde{R}$ is typically below that of the United States. This graphical evidence is consistent with our theory and descriptive accounts that property rights are most secure in New Zealand, somewhat less secure in Canada, and substantially less secure in the United States. The spike in 2007 for the United States includes only the first year of ITQs in the Red Snapper fishery. In 2008, both the Red Snapper and Virginia Striped Bass are included. These ratios tend to be significantly larger than US halibut and sablefish, which are included in earlier years in the figure.[14] In New Zealand, there is a downward trend from the first year of the Quota Management System (QMS) until present. The median ratio in the first year of the program was about 15%, whereas that rate in 2008 was near 8%. As is clear from Equation 2, the interest rate appears to play a key role in determining this ratio.

It is useful to further motivate our approach with an anecdote. Consider two similar fisheries in the United States and New Zealand: the Gulf of Mexico Red Snapper fishery, and the New Zealand Snapper (SNA) fishery. The Snapper fishery in New Zealand was first put under quota management in 1986, and the median $\tilde{R}$ for that species group for the first three years of the program (a period of extremely high interest rates) was about 17%, and over the entire series the median $\tilde{R}$ is about 8.8%. On the other hand, the Red Snapper fishery in the Gulf of Mexico had a mean $\tilde{R}$ of about 27% during the first two years of the ITQ program. Though biologically similar, the implicit revocation probability in the Red Snapper fishery is much higher, anecdotally supporting our hypothesis

[13] At this time, data from the Alaskan Crab fishery are not available. Furthermore, we are unaware of any data on quota prices in the Atlantic Surf Clam / Ocean Quahog fishery.

[14] Data for Alaskan Halibut and Sablefish ITQs leases are not available past 2006.

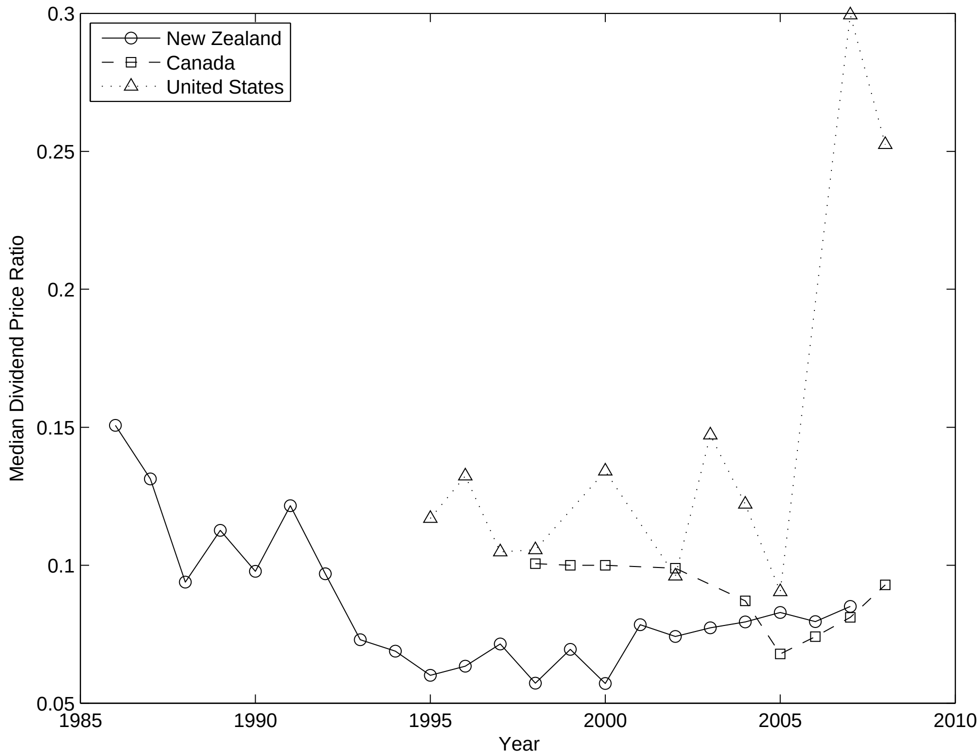

Figure 1: Median dividend price ratios for New Zealand, Canada, and United States.

that weaker property rights raise the dividend price ratio. Of course, a host of factors could affect $\tilde{R}$, which we consider in the following section.

In Figure 2 for each New Zealand species under ITQ management we show a scatter plot of the sales and lease prices of quota since 2002.[15] The graph is arranged as follows. Each dot represents the median lease and median sales value (in 2008 NZ dollars) for a particular New Zealand species under ITQ management between 2002 and 2008. Species above and to the left have higher dividend price ratios, $\tilde{R}$. We distinguish between stocks with high illegal take (upward triangle), highly migratory stocks (downward triangle), and other stocks (open circle). The mean $\tilde{R}$ for the latter category is about 8%, and is graphed by the lower line. The mean $\tilde{R}$ for the former categories is about 12% and is graphed by the upper line. While this simple graphical illustration fails to account for other factors which affect sales and lease prices of fisheries quota, it is suggestive of the intra-country effects of property rights strength. Species with high illegal catches and/or are highly migratory have less exlusive property rights, and they tend to have higher ratios. The importance of exclusivity of property rights will be discussed further in

[15] Newell, Sanchirico and Kerr (2005) provide similar plots in their study, but focus on market functionality and liquidity, not the value of stronger property rights.

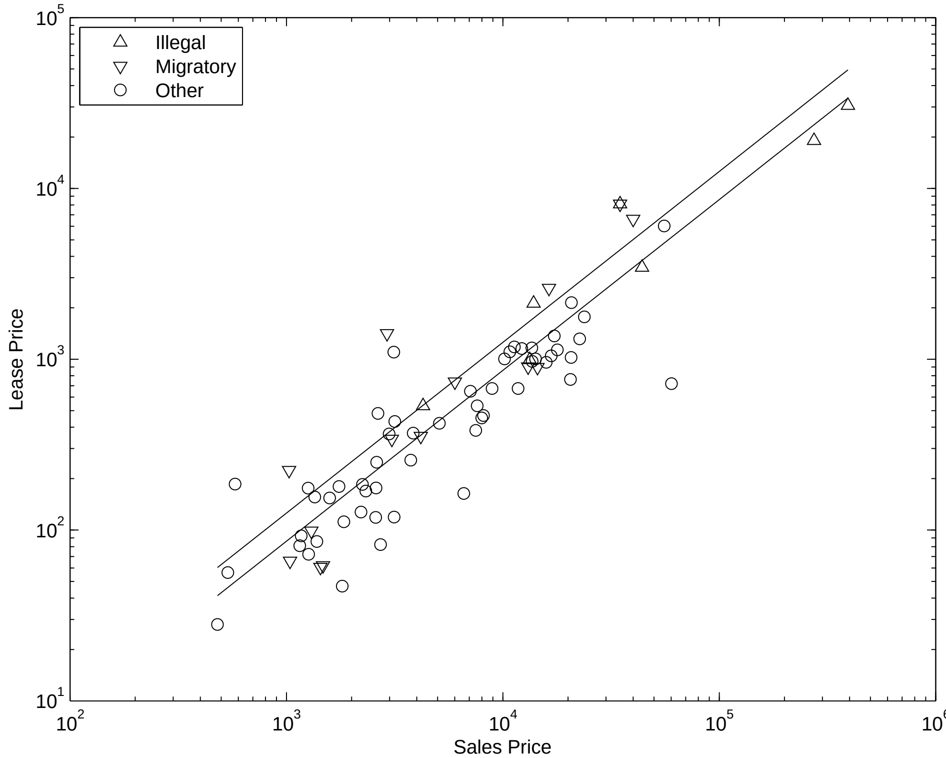

Figure 2: ITQ Lease and Sales Prices for New Zealand Fisheries.

the next section.

5 Empirical Results

5.1 Cross-Country Evidence

As described above, there is substantial variation in the property rights underlying ITQs across countries. It may be possible to qualitatively describe each property right characteristic for each fishery, but comparing these property rights characteristics across fisheries and countries is difficult. Here we take a more agnostic approach, estimating reduced-form equations to test for systematic differences in property rights across countries. We augment our data set and attempt to carefully control for relevant fishery- and country-specific characteristics. Once again, we make use of the observation that by dividing lease price by sales price, the dividend price ratio washes away many fishery and country specific factors that affect the value of the fishery.

The dependent variable throughout this section is the dividend price ratio of ITQs, $\tilde{R}$.[16] We exploit the panel-

[16] This variable was constructed using average annual sales and lease prices, which may introduce some measure-

structure of the data and estimate country fixed-effects, which we use to test the null hypothesis that there is no systematic difference in dividend price ratios across countries. We estimate several equations, including controls for market conditions, biological characteristics, fixed effects for species groups, and year fixed effects to control for time-varying unobservables.

The most basic specification regresses $\tilde{R}$ on country fixed effects, species group fixed effects,[17] and the market interest rate (in this case that country's 5-year Treasury rate in that year). The results are in column (1) of Table 3. The results suggest that, on average, $\tilde{R}$ in the United States is about 5.7 percentage points larger than in New Zealand. $\tilde{R}$ in Canada is also significantly larger than in New Zealand, and the difference between the United States and Canada is significant. In the second specification (column 2), we add year fixed effects to control for unobserved contemporaneous shocks.[18] In this case, the ratio in the United States is about eight points higher than in New Zealand.

Clearly there are other factors that could influence the sales price of quota shares that are not included in the stylized model presented above. Expectations about the future harvest and ex-vessel prices would dictate future profitability, and hence quota sales prices. We attempt to control for these expectations by including trends for harvest and ex-vessel prices. Specifically, we control for the percentage change of this year's harvest from last year (in that fishery), and the percentage change of this year's average ex-vessel price from last year.

Although species group fixed effects are included in every specification, we alo add biological characteristics of each fishery, which could influence the horizon over which stocks rebuild. We control for years to maturity, length at maturity, and the maximum age of a species. Inclusion of these variables does not affect the main results, perhaps unsurprisingly because there is little variation in these variables within ISSCAAP species groups. Finally, the dynamics of a ratio within a fishery over time suggest that the ratio of lease to sales prices decrease with the tenure of an ITQ program. For each fishery, we include the number of years since the first year of ITQ management. We also include a quadratic term to account for nonlinear relationships, and each of these variables is interacted with country fixed effects to allow this effect to vary across countries. In column (3), conditional on the control

ment error into our dependent variable. Because our data are on an annual basis, we cannot take into account intra-year fluctuations in lease or sales prices. Furthermore, because we are not constructing the ratio from individual transactions, we cannot observe whether any outliers (which may not represent arms-length transactions, for example) are included. To the extent that any measurement error is random (and uncorrelated with the independent variables), our estimates will be unbiased.

[17] We use ISSCAAP species group classifications to hold constant species-specific effects; there are 18 groups in the baseline specification.

[18] The results are robust to the inclusion of a quadratic function of interest rates.

variables, the ratio in the United States is about 11 points larger than in New Zealand. In Canada, the point estimate indicates that the dividend price ratio is nearly seven points larger than in New Zealand.

As discussed above, New Zealand's Quota Management System includes many species not managed by ITQs in the United States or Canada. In column (4), we restrict the sample to include only New Zealand species with "comparable" counterparts in the United States or Canada. Specifically, we restrict the sample to include only species in ISSCAAP groups 25, 31, 32, 33 or 34. These results are shown in column (4) of Table 3. In this case, the point estimate implies that the dividend price ratio in the United States is thirteen points higher than in New Zealand.

Our cross-country results suggest that the dividend price ratio of ITQs is significantly higher in the United States and Canada, where property rights governing ITQs are relatively weak. Rather than picking up the desired effect of property rights security, these results could be reflecting a higher risk of collapse in US and Canadian fisheries. While we have no empirical or anecdotal evidence that this is the case, we can test for it in our analysis. In columns (5) and (6) we include a dummy variable for stock collapse; our results are robust to the inclusion of this variable, as well as alternative definitions of collapse or measures for the health of the stock.[19] In column (6), our preferred specification, the dividend price ratio in Canada is about seven points higher than in New Zealand, and that ratio in the United States is nearly 14 points higher than in New Zealand.

The cross-country regression results suggest that ITQ fisheries in the United States have a significantly higher $\tilde{R}$. The ratio in the United States is higher than in Canada, which, in turn, is higher than New Zealand, though the results for Canada are not robust across specifications. Because we are controlling for fishery-specific characteristics and market factors, we argue that property rights strength explain the difference in dividend price ratios across these countries.[20] In the next section we examine within-country evidence.

[19] Specifically, we include an indicator variable equaling one if the stock is below ten percent of historical harvest levels, a common measure of fishery "collapse" developed by ecologists (Worm et al. 2006).

[20] Our results are robust to a variety of additional controls, including fishery collapse, revenue volatility, and quadratic functions of the control variables. Our results are also insensitive to inclusion of fixed effects for year or ISSCAAP category. Furthermore, when estimating these regressions excluding the Red Snapper and Virginia Striped Bass fisheries (both of which have very high dividend price ratios), the difference between the United States and New Zealand remains significant.

Table 3: Cross-Country Regression Results

	(1)	(2)	(3)	(4)	(5)	(6)
United States	0.0572***	0.08119***	0.1097***	0.1344***	0.1092**	0.1354***
	(0.0124)	(0.0189)	(0.0405)	(0.0426)	(0.0407)	(0.0429)
Canada	0.0150**	0.0217	0.0684***	0.0701***	0.0677***	0.0699***
	(0.0071)	(0.0153)	(0.0186)	(0.0174)	(0.019)	(0.0175)
5 Year Treasury Rate	0.5521***	1.3513*	0.8550	0.6120	0.8484	0.6257
	(0.0872)	(0.7798)	(1.1099)	(1.0829)	(1.1132)	(1.0858)
Pct Change in Harvest			0.0047	0.0010	0.0048	0.0011
			(0.0046)	(0.0045)	(0.0047)	(0.0046)
Pct Change in Ex-Vessel Prices			-0.0040	-0.0031	-0.0042	-0.0031
			(0.0107)	(0.0103)	(0.0107)	(0.0103)
Time to Maturity			0.0005	0.0023**	0.00050	0.0024**
			(0.0008)	(0.0010)	(0.0008)	(0.0010)
Length at Maturity			0.0000	0.0002*	0.0000	0.0002*
			(0.0001)	(0.0001)	(0.0001)	(0.0001)
Maximum Age			0.0000	-0.0005*	0.0000	-0.0005*
			(0.0002)	(0.0003)	(0.0002)	(0.0003)
Collapsed					0.0164	0.0216*
					(0.0393)	(0.0123)
Year Fixed Effects	No	Yes	Yes	Yes	Yes	Yes
ISSCAAP Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	2,097	2,097	1,059	670	1,059	670

The dependent variable is the ratio of the average lease price to the average sales price of quota in a management area. Each specification also includes, for each country, the number of years (and years squared) since an individual fishery has been managed by ITQs. Collapsed equals 1 if that fishery has current harvest levels less than ten percent of the historical maximum in our dataset. Standard errors (in parentheses) are clustered on country-year, and ***, ** and * denote significance at the 1, 5 and 10 percent levels, respectively.

5.2 Within-Country Specifications

5.2.1 Migratory Species and Exclusivity

For within-country evidence, we examine more closely the data from New Zealand. While property rights characteristics such as disposition, use, and possession do not vary significantly across fisheries within New Zealand, there is substantial variation in exclusivity. This variation is not policy-induced, but rather is a function of the characteristics of the species. While some species do not move significantly across space, several highly migratory species move in and out of New Zealand waters, where they are subject to fishing pressure outside the control of the Quota Management System.

New Zealand waters contain tunas and other large pelagic species that migrate long distances seasonally, often outside of the country's Exclusive Economic Zone, into unmanaged international waters or into the waters of other jurisdictions. These species are characterized as "highly migratory."[21] Because highly migratory species are subject to fishing pressure that is unregulated by New Zealand's quota management system, the exclusivity of the ITQ right is arguably weaker than for species that stay within New Zealand's waters. This property right insecurity is driven by poor (or no) management in neighboring waters.

Our empirical approach formalizes the casual observation from Figure 2 that highly migratory species tend to have higher $\tilde{R}$. Table 4 provides within-country estimates for New Zealand. In these specifications we are able to control for a host of factors, including 5-year Treasury yields, trends for catch and greenweight prices,[22] time to maturity, length at maturity, maximum age, fishery type (inshore, offshore, or shellfish)[23] and whether or not the Ministry characterizes a species as recreationally or customarily "significant." In addition, we control for stock-specific revenue volatility, which captures both inter-annual fluctuations in total harvest and product prices. In column (2) we include year fixed effects instead of the interest rate. Depending on the control variables included, $\tilde{R}$ is between 0.8 and 1.1 percentage points higher for highly migratory species, supporting our hypothesis of the effects of property rights strength on the dividend price ratio.

[21] In Table 2, the fourth column indicates whether each species is classified as highly migratory.

[22] New Zealand's fish production constitutes less than one percent of worldwide production, and exports (in terms of value) make up about two percent of overall international trade in fish products. Some stocks, however, are large on a worldwide basis. In these fisheries the ex-vessel price is arguably endogenous. While we do not have a plausible instrument for ex-vessel prices, in alternative specifications (available from the authors) we exclude these fisheries. All of our results are robust to the exclusion of these fisheries from the analysis.

[23] In this specification we do not include ISSCAAP category fixed effects because they are highly collinear with the indicator for Highly Migratory Species. When included, though, the species group fixed effects that include highly migratory species are jointly significant.

5.2.2 Illegal Harvest and Insecure Property Rights

Evidence of illegal harvests in some stocks would suggest a weaker property right due to lack of enforcement. For each commercial species in the Quota Management System in New Zealand, the 2008 Plenary Report from the Ministry of Fisheries discusses any known evidence of illegal harvests. Of the 75 species with sufficient data for the analysis here, there are six instances where significant illegal takes are believed to occur. If fishermen are also aware that some fish are illegally harvested from these stocks, it is plausible that they would place a lower value on the future value of quota holdings. In Table 4, we also include an indicator variable equal to one if that species has been prone to illegal harvesting. The point estimates suggest that these stocks have dividend price ratios that are around three percentage points larger than for similar stocks.

5.2.3 Quota Buybacks and the Treaty of Waitangi

Finally, several policy changes in New Zealand between 1989 and 1992 may plausibly have impacted beliefs about ITQ security within New Zealand. In 1986, the initial allocations in the QMS system were in terms of tonnes, rather than as a percentage of the annual total allowable catch. When it became clear that the initial allocation was too high for many stocks, the Ministry of Fisheries proceeded to redefine the right as a percentage of the total allowable catch.[24] After much debate, the government honored the property rights by issuing a buyback of quota where the initial allocation was too high. As quotas were relatively new in New Zealand (and around the world), this action by the government likely served as a signal that it would treat quotas as legal assets. The buybacks began in 1989 and were finalized in the next two years.

Around the same time, there was a debate about how the Maori people, native New Zealanders, were being treated under the QMS system. The Maori people had traditionally relied on the ocean's resources, and there was a concern that the quota system did not take into account the significance of the fisheries to them. Since the inception of the QMS program, there was much controversy and dispute surrounding the treatment of native people under the fisheries management regime. In 1992 there were concessions citing the Treaty of Waitangi of 1840, in which the Maori people were allocated 20% of the TAC for some key stocks. This policy decision formalized the government's position and removed substantial uncertainty about the future of property rights in New Zealand fisheries. We argue that this further strengthened security and would thus be expected to decrease the dividend price ratio. In column (3) of Table 4, we estimate a regression with the same controls as in column (1), but also including an

[24] This approach has since been adopted by nearly all countries.

Table 4: Within-Country Evidence: New Zealand Regressions

	(1)	(2)	(3)
Highly Migratory Species	0.0081*	0.0111**	0.0079*
	(0.0049)	(0.0047)	(0.0047)
Extensive Illegal Harvest	0.0300***	0.0293***	0.0310***
	(0.0073)	(0.0072)	(0.0075)
Revenue Volatility	0.0097	0.0159*	0.0104
	(0.0087)	(0.0090)	(0.0085)
Highly Significant Spp.	-0.0074	-0.0106**	-0.0089*
	(0.0048)	(0.0046)	(0.0047)
5 Year Treasury Rate	0.3851***		-0.0545
	(0.0993)		(0.1679)
Pct Change in Harvest	-0.0015	0.0010	-0.0006
	(0.0046)	(0.0044)	(0.0046)
Pct Change in Ex-Vessel Price	0.0014	-0.0068	0.0037
	(0.0091)	(0.0096)	(0.0091)
Age at Maturity	0.0013*	0.0013**	0.0013*
	(0.0007)	(0.0006)	(0.0007)
Length at Maturity	-0.0001	-0.0001**	-0.0001*
	(0.0001)	(0.0001)	(0.0001)
Maximum Age	-0.0002	-0.0002	-0.0002
	(0.0002)	(0.0001)	(0.0001)
Post-1992			-0.0408***
			(0.0111)
Year Fixed Effects	No	Yes	No

The dependent variable is the ratio of the average lease price to the average sales price of quota in a management area. There are 992 observations in each regression. Heteroskedastic-robust standard errors are in parentheses, and ***, ** and * denote significance at the 1, 5 and 10 percent levels, respectively. Each specification also includes "type" fixed effects, corresponding to offshore, inshore and shellfish (freshwater excluded), as well as the time trends for number of years (and years squared) since an individual fishery has been managed by ITQs. Revenue volatility is calculated as the standard deviation in real total revenue for that fishery over all years in our dataset.

indicator variable that equals one for all years including 1992 and thereafter. The point estimate suggests that post-reforms there was a four percentage point decrease in the average dividend price ratio, controlling for interest rates and fishery-specific characteristics.

5.2.4 Summary

The results within New Zealand provide further empirical evidence that the security of property rights affects quota asset values. Fisheries within New Zealand are governed by federal legislation, so we look to other sources of variation to test whether the security of property rights affects dividend price ratios of quota shares. While other factors are clearly important, such as market interest rates and the volatility of revenues for that fishery, factors that strengthen or attenuate the security of property rights affect quota asset values. We find strong evidence of a pecuniary effect of property rights strength, which suggests that the design of these institutions plays a critical role.

6 Conclusion

This paper provides the first empirical evidence that stronger property rights lead to higher asset values and lower dividend price ratios ($\tilde{R}$) in ITQ fisheries. Our cross-country evidence is based on descriptive accounts of ITQs as property rights in New Zealand, Canada and the United States. In our cross-country regressions, the point estimates suggest that $\tilde{R}$ for quota in the United States is nearly twice as large as in New Zealand. The average $\tilde{R}$ for quota in Canada is larger than in New Zealand in some specifications, but these results are not as robust. Our estimates are consistent with the general view that ITQs as property rights are more secure in New Zealand than in North American fisheries.

We then exploit important differences in the exclusivity of property rights within New Zealand to test whether stronger rights lead to lower dividend price ratios. Where the exclusivity of the catch share is limited by migratory species or illegal harvesting, $\tilde{R}$ is significantly higher than other similar fisheries, even when controlling for biological and other fishery-specific characteristics. This lends insight into the importance of strong property rights, but also suggests that coordination across jurisdictions and better enforcement of these property rights might lead to lower implicit discount rates and greater quota asset values.

Several caveats should be mentioned. First, across countries, we cannot quantify the effects of component characteristics of property rights on asset values. Instead, we rely on country fixed-effects and dummy variables to capture differences in property rights security across fisheries. However, our focus on fisheries and the use of the dividend price ratio allows us to isolate the effect of country-specific institutions on investment in common pool resources. Second, our cross-country results could be consistent with systematic differences in the probability of fishery collapse across countries. To attempt to rule out this possibility, we control for trends in harvest and ex-vessel prices in our main specifications and we control for whether an individual fishery was "collapsed" in any given year. Our results are robust to the inclusion of controls for the state of the fish stock as well as market conditions and trends, but, as in any cross-country regression, other unobserved heterogeneity may still be influencing our results. Third, our cross-country results could be consistent with credit constraints and non-collateralizable assets. The dividend price ratio could be higher in the United States because of credit constraints and the inability to secure a loan for ITQ shares. This would simply be a mechanism through which insecure property rights affect asset prices. Finally, our results suggest that there is a pecuniary effect of property rights security, and if this result is present elsewhere (such as capital investment) the security of property rights are critical to fisheries management.

On the other hand, if the only impact of property rights security is through quota asset values then the impact on social welfare is unclear, though the security of property rights would clearly affect the distribution of wealth.

Rights-based management in fisheries can lead to significant economic gains by eliminating the race to fish and providing private incentives to steward the resource. Our results suggest that stronger property rights lead to greater quota asset values. A closely related question concerns how property rights strength will affect different dimensions of investment in common pool resources (e.g. physical capital, environmental recovery, etc.). Indeed, these changes in investment may be partially responsible for the changes in asset values we observe. One implication may be that weak property rights decrease the incentive for good stewardship of the resource by increasing the average implicit discount rate in fisheries. While we can only speculate on the underlying mechanisms, we hope that this research will help motivate future work on the effects of property rights security on the management, biological status, and sustainability of the resource itself.

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