Coasean economics and the evolution of marine property in Hawaii

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Abstract

The standard view that the absence of property rights is inefficient contradicts the Coasean proposition that the relative efficiency of different institutions depends on their ability to economize on transaction costs. Moreover, the comparative theory of open access and private property institutions fails to recognize the intermediate institution of common property, finesses dynamic optimization, and provides an incomplete account of governance. We provide a comparative statics framework for alternative modes of resource management, albeit one that allows for dynamic optimization, and show that open access can be efficient under conditions of low population pressure. We show that the intensification of production with population pressure in Hawaii co-evolved with specialization and increased governance, in accordance with the efficiency theory. Instead of market-based specialization, however, economic organization in pre-contact Hawaii was hierarchically determined via top-down management of the *ahupua'a*.

1. Introduction

Lack of academic convergence regarding the causes of changing property rights stems in part from the lack of a formal structure (see e.g., *Property Rights: Cooperation, Conflict, and Law*, edited by Terry L. Anderson and Fred S. McChesney). Drawing from the Hawaiian record, we hypothesize that property coevolves with governance, which increases with the intensification and specialization of production. The centerpiece of the theory is a simple comparative statics framework generalized from resource economics. We show how increasing scarcity of marine resources leads to more and broader governance and greater resource use restrictions, if enforcement mechanisms are also free to evolve. As Hawaii moved from small isolated villages to a unified kingdom and finally to U.S. territorial status and eventual statehood, old and new institutions, some of which were imposed, overlapped. The experience provides an intriguing opportunity to study the natural evolution of property rights as both resource pressures and relative prices change over time.

We will characterize the institutions of governance for Hawaii's fisheries from early settlement to contact with the Western world and explain the changes, to the extent possible, with the second-best theory of economic organization. Western contact brought increased pressure on fisheries resources. We will show how the intermediate institution of the *ahupua'a* economy – centralized decision-making and control in each, somewhat independent valley – evolved as an effective institution for common property management before Western contact but was ultimately not well suited to the extensive trading taking place within the Islands and with the visiting ships after contact.

1.1 The changing institutions of resource governance

In the canonical theory (North and Thomas, 1973, and Demsetz, 1967), private property is thought to generate unambiguously higher benefits than open access to resources such as grazing or hunting lands. Moreover, it was thought that once the efficiency benefits of the institutional change were greater than the enforcement costs, the institutional change would be effected (Demsetz, 1967; Anderson and Hill, 1975). Later, Ostrom (1990) and others showed that it was theoretically possible that common property (distinguished from open access by its well-defined rules of access and management) could achieve efficient allocation. She also reviewed substantial evidence suggesting that common property regimes were often effective at resource conservation. Taken together with Hardin's (1968) classic paper, these studies illustrate a generalized version of the Coase Theorem, to wit, *transaction and agency costs aside, decentralized, centralized, and intermediate institutions are all capable of achieving Pareto optimality, i.e. first-best efficiency.*

In the Coasean paradigm, however, first-best efficiency is only a point of departure for comparative institutional analysis. What is needed is a conceptual framework capable of generating propositions and explanations regarding which institution is second-best efficient under what circumstances.[1] The advocates of private property (Demsetz), public property (Hardin), and communitarianism (Ostrom) all implicitly agree that the relative efficacy of these institutions rests primarily on their ability to control the free-rider problem. Through the looking glass of Hawaiian history, we suggest that the theory of economic organization and institutional

[1] This use of second-best follows Dixit (1996). He subsumes rent-seeking, corruption, and other elements of political economy is his theory of the 3rd-best.

change must be developed beyond this narrow focus. In particular, the theory must explain the stylized fact that governance increases with specialization and the intensification of production. It must also be capable of explaining the non-monotonic relationship between these and the centralization of control, i.e. the *governmental Kuznets curve*.

2. Historical background

The co-evolution of governance and property with respect to marine resource scarcity can be clearly illustrated by considering two distinct periods in Hawaiian history, pre-Western contact and post-Western contact, each divided into sub-periods wherein property structures, governance, and scarcity pressures changed. The pre-contact period is divided into 4 eras: (1) Colonization, (2) Developmental, (3) Expansion, and (4) Proto-historic. The post-contact period is divided into 3 eras: (1) Unification, (2) Independent kingdom, and (3) U.S. territory/state.

2.1 Pre-contact overview

For some time after the Polynesians arrived in Hawaii (roughly 400 A.D.), an *´ohana* (community management) system evolved wherein the patriarchs of each extended family governed production, including the construction and harvesting from fishponds. This colonization period is characterized by extremely low populations, the introduction of new agricultural products (e.g., pigs, taro), and the slow subsequent transformation of the most fertile valleys, adjacent to superior fishing grounds, into populated communities. Marine resource pressures were low, and though the kapu system's origins must have traveled to Hawaii from earlier Polynesian settlements, implementation and enforcement were low (Kirch, 1996).

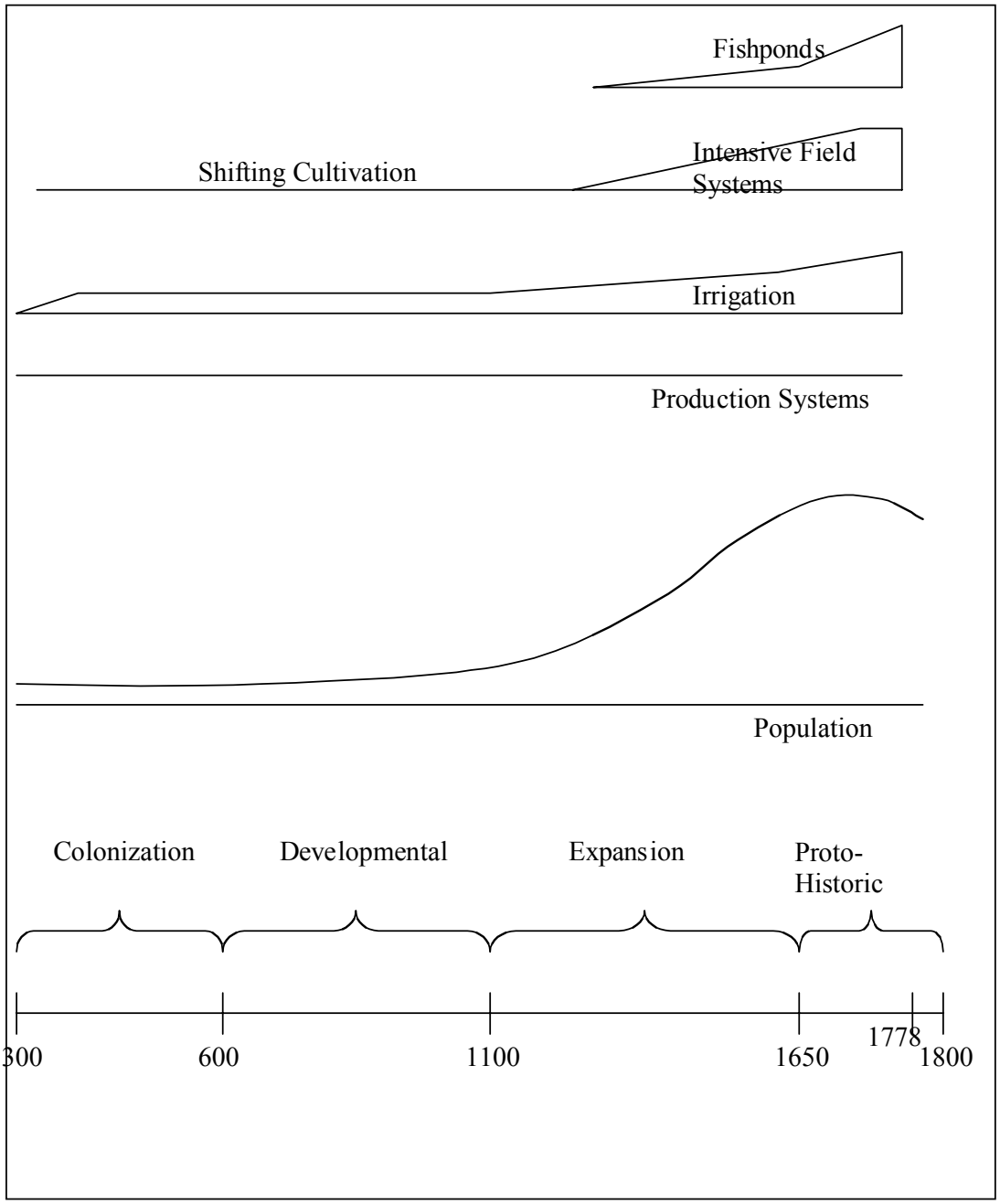

Figure 1: Timeline for Hawaiian resource use and development (Adapted from Kirch (1985), p. 300-1

As populations grew and became more permanent in the Developmental era, governance by family eventually extended to governance of the entire *ahupua´a* valley, under a single chief or *ali´i*. The chief allocated land and labor to their uses and began to take advantage of the top-down power to achieve economies of scale and increased production intensity through

specialization, building large-scale irrigation projects and fish ponds in particular. This system of control evolved into an extensive hierarchy during the Expansion era and eventually crystallized during the proto-historic period (1650-1785), at the height of the islands' population, exhibiting a much higher degree of social hierarchy, specialization, and governance structure than in other parts of Polynesia (Abbott, 1992; Handy and Handy, 1991).

Figure 1 summarizes available archeological and proto-historic evidence on the timing of Hawaiian cultural development. The acceleration of population growth, particularly from 1200-1650, was followed by the intensification of food production, including irrigation and fishpond development. The social hierarchy was also growing increasingly structured at this time. This accords with our hypothesis that population pressure induces institutional change, including increased governance, which facilitates more intensive modes of production.

Table 1 summarizes the estimated populations at the beginning and end of each period, as well as the progression of indicators of the economic, material and hierarchical structures of the society during the period in question. Throughout, we see evidence of increasing intensification of production both on land and at sea. Technology becomes standardized, evidence of intermediate goods produced by a rising class of specialized adz-makers and fishhook producers (Kirch, 1985, p. 184). As population increases, *konohiki* managers develop increasingly sophisticated irrigation[2] and communal fishing techniques, and fishponds are developed and evolve into true aquaculture[3], a unique Hawaiian development amongst Polynesian cultures, to increase productivity. Kinship networks give way to specialized skills in fishing and farming, managed by the *konohiki*. Without external trade, hierarchical stratification increases, as do efforts at resource extraction for the benefit of the *ali'i*. The commoners produce for the *konohiki*, who controlled the water supply, determined the land allocations for the commoners, determined fishing rights, and allocated ahupua'a resources for production, especially labor for communal projects. The *konohiki's* duty to the *ali'i* was to meet an expected production goal to be presented during the *makahiki* festival, at which time the ali'i divided the

[2] In particular, increased use of Type III irrigation systems, consisting of an irrigation canal running along the periphery of the field complex, allowing more sophisticated control of water distribution than was used in earlier Type II systems, where small groups of fields were watered by a single ditch that fed directly into the uppermost field.

[3] True aquaculture means that fish are bred and nourished in captivity; other Polynesian fishponds were holding pens fed by ocean tides.

tribute amongst his supporters in the chiefly class, including the *konohiki*. This mechanism supported an increasingly stratified society.

Table 1: Evolution of Specialization and Production

Time Period	Population	Social/Management Structure	Production and Specialization; Technological Change	Intensification of Production
Begin Colonization (300 AD)	Less than 100	Ohana network; ancestral; little social stratification	Wide variety of fishing implements and adzes; little specialization	Introduction of new plants, pigs, dogs, rats; transformation of landscape to support Polynesian culture
End Colonization/ Begin Development (600 AD)	1,000's	Ohana network; ancestral; little social stratification	Incipient form of Hawaiian 2-piece fishhook	Extensive growth dominant
End Development/ Begin Expansion (1100 AD)	c. 20,000 (inland population grows; specialization of farmers, fishers produces viable farming lifestyle)	Ohana network; social stratification increasingly evident (status goods growing)	Adzes fully standardized – specialized producers; new 1-piece fishhook introduced and becomes dominant; fishing gear increasingly standardized	Beginnings of irrigation and development of fishponds; increasing productivity yields in wet windward valleys
End Expansion/ Begin Proto-historic (1650 AD)	Several hundred thousand	Transition to territorial hierarchy (*ahupua'a* system) complete (*konohiki* class evident, alii genealogy distinct from commoners now tied to land not family)	Craft specialists develop in producing status goods (feathers, carvings) for increasingly stratified alii class.	Intensive dryland farming techniques developed; irrigation and fishpond development continues in established areas

End Proto-Historic/ Begin Monarchy (1800)	c. 200,000 (Population lowered by warfare, labor taxes)	*Ali'i* and *kahuna* (priest) classes increasingly stratified, increasing intensity of *kapu*; *konohiki* managers and specialized commoners for land and sea; *ali'i* increasingly favor rent-seeking	Introduction of western goods and technology increases efforts at crafts, shipbuilding, sandalwood harvest under *konohiki* management	Increasing fishpond investment; intensive harvesting of sandalwood resource
End Monarchy/ Begin Constitutional Monarchy (1840s)	c. 90,000 (Population dwindles with western diseases, labor taxes)	Private property initiated under Great Mahele; government and *konohiki* control marine property; public goods provision by state (e.g. education)	*Konohiki* managers become *konohiki* owners	Sandalwood depleted; fisheries suffering; fishpond development ends (1839 last pond)
End Constitutional Monarchy / Begin US Territory (c. 1900)	154,000 (Foreign migration)	Private ownership of land; increasing regulation of marine commons with size, gear restrictions; nearshore resources controlled by *konohiki*	*Konohiki* owners balance enforcement benefits and costs as registration required to continue marine rights	Coastal fishing dwindles and offshore fishing increases in importance
Present (c. 2000)	1.2 million	Regulated open access with subsidized fish populations	Public investment in cage farming technology	Leasing of marine rights for cage farming -- intensification of fish production

2.2 The *ahupua'a* system

The top-down management of the *ahupua´a* can be classified as common-property management, albeit more sophisticated than commonly described.[4] The *ahupua´a* provided everything "from *uka*, mountain, whence came wood, *kappa* for clothing, *olona*, for fish-line, ti-leaf for wrapping paper, *ie* for rattan lashing, wild birds for food, to the *kai*, sea, whence came *i´a*, fish, and all connected therewith" (Davis, 1974, p. 124). Both internal economies, e.g. in fishpond construction, and external economies were exploited. The strong hierarchical control also allowed enforcement of conservation measures that reduced the depletion of natural resources.

The community worked under a gift-exchange system known as *ko kula 'uka, ko kula kai*, where those upland traded with those on the sea. This allowed considerable expertise and specialization to develop as evidenced by the highly developed knowledge and skill amongst both fishermen and planters, and kept most economic transactions within the *ahupua´a*. The *ali´i* placed taxes on the *maka´ainana* (commoners) by requiring them to deliver commodities such as taro and to contribute labor, e.g. to the building of fishponds. Enforcement of the hierarchy rested in part on brutality and fear of the wrath not only of the chiefs but also of the gods. Both conditions enhance the benefits of common property rights as 2nd-best (Deininger, 2003, p. 31).

Top-down management also allows the exploitation of benefits across ecosystem boundaries, not just within them. Some of these benefits fit the standard theory, such as increased risk reduction. However the *ahupua´a* system also provided the external economies of specialization and trade, e.g. between taro cultivators living on the plains and fishermen living on the coast. (As discussed later, however, only external economies within the scope of the *ahupua'a* government could be readily exploited.)

The hierarchical system allowed exploitation of the external economies from specialization, given the existing avenues for trade, as well as internal economies in the production of particular goods. Furthermore, the centralized control at the *ahupua´a* level satisfied the four requirements for viable common property rights outlined by Deininger (2003):

(1) Unambiguous property lines prevailed as *ahupua´a* generally followed watershed lines,

[4] See e.g. the cases decribed in Ostrom, 1990.

(2) Investment in irrigation and fishpond infrastructure exploited economies of scale and ecosystem enhancement, improving directly the lives of the people,

(3) Community property alleviated risks of enemy incursion and reduced idiosyncratic risks, and

(4) Planters and fishermen retained portions of their effort, reaping individual benefits from their productivity.

Deininger also notes that common property is more likely to succeed where group members have equal entitlements, e.g. roughly the same quantity and quality of farmland. This makes the more fundamental condition that costs of membership are roughly proportional to benefits contractually simple to specify. The case of the *ahupua´a* system affords a generalization, i.e. proportional taxation can also be efficient and readily administered where wealth is unequally distributed, provided that separate rules are specified for each stratum and the members of each stratum have roughly equal entitlements.

First, the top-down management of the meant that work and reward were not distributed equally across society, only within each stratum. This facilitates a more general statement about the condition for successful common property management, namely that the allocation of costs conforms to the principle of benefit taxation, albeit within the prevailing system of vertical equity.

2.3 The *kapu* system: enforcement of rights

This fear of a god witnessing the breaking of a *kapu* must have reduced enforcement costs but not eliminated them. In 1824, C.S. Stewart noted in his published journal that he had seen a brackish fishpond "literally alive with the finest of mullet; the surface of the water is almost in a constant ripple from their motions; and hundreds can be taken at any time by a single cast of a small net." He attributes this to the success of the *kapu* and the fact that no one of rank had lived there lately (Dieudonne, 2002, p. 105). Alternatively, a 19th century Hawaiian historian wrote that pond caretakers could eat some fish species openly, "but others they would eat secretly" (Summers, 1964).

The earliest settlement sites (600-1100) were located in wet, windward areas with good fishing grounds. Populations may have been very small, perhaps 100 people in an extended

‘*ohana* (Kirch, 1996). It is clear from bone pile analyses that pig and dog populations were growing rapidly over the time period and increasingly supplementing the fish protein collected from the sea. During the Expansion Period (1100-1650) population estimates increase to several hundred thousand, with some estimates as high as 800,000 (Kirch, 1985; Kame´eleihiwa, 1992). With this growth, overfishing from open access was a bigger problem, and governance increased within the existing institutional framework. The chiefs limited access during certain seasons by placing a *kapu* (taboo) on fishing.[5] These *kapu* are generally associated with particular gods and variants of the system are known throughout Polynesia. The *kapu* were clearly conservation oriented; one of the most important *kapu* created alternating closed seasons for two species of primary import, *‘opelu* (Mackerel scad) and *aku* (skipjack tuna). Other *kapu* closed fisheries during spawning seasons in particular.

2.4 Fishponds: a backstop resource

Credit for early construction of fishponds (mainly pre-13th century) is veiled in the mythology of pre-contact Hawaii and demonstrates the difficulties in ascertaining the native population’s relation to its resources in the early pre-contact period. Most early ponds are attributed to the *menehune*, or “little people,” who were said to have created great public works, particularly of irrigation (many still standing today), each in a single night’s work. The identity of these individuals is an interesting mystery related to resource use in pre-contact Hawaii. Some believe that the *menehune* were early arrivals to Hawaii (c. 400 AD) from the Marquesas Islands, and that they were conquered and made to work for the later, physically larger arrivals from elsewhere in Polynesia (c. 1100 AD)[6]. Whatever the truth, the man-hours actually required to construct these public works projects must have been considerable. Construction of one of the

[5] Fishponds may have been a response to this resource pressure not only as a source of increased production, but also as a social mechanism by which the *ali´i* could continue to consume fish during the *kapu* periods without “offending the gods.” Indeed, two main benefits arose from the ponds: (1) fish could be held and cultivated for easy access by the chiefs when desired, and (2) fish would be available to the chiefs during times of *kapu*, because the enclosure removed the area from the sea, which had the *kapu*, and placed it on land, from which the chiefs could still eat.

[6] This interpretation becomes more plausible in light of the fact that *menehune* is a permutation of *manahune*, or slave, in the Polynesian tongue from which Hawaiian is derived.

last new ponds on Molokai in the early 1800s took 10,000 men, and Summers (1964) estimates building of sizeable new ponds probably averaged a year.[7]

Strict limited access to the ponds must have been essential, and governance measures increased accordingly. Only 30% of *ahupua´a* had associated fishponds (ponds never crossed *ahupua´a* borders), and the ponds' total area of about 6650 acres would have produced somewhere between 1.75 million and 2 million pounds of fish per year – about 6 to 9 pounds per person per annum at the time of contact (Kikuchi, 1985; Hammon, 1975).[8] With little trading between *ahupua´a*, and the ability of the *ali´i* to reserve the catch for themselves, fishponds produced considerably greater sustenance for the higher levels of the social hierarchy with little direct benefit to the commoners. Indirect benefits stemmed both from reduced fishing pressure on the coastal fisheries and from the increased fish population overall. The hierarchical *ahupua´a* system allowed the capture of the economies of scale necessary to develop these fishponds while the complementary *kapu* system provided the mechanism by which efficient harvesting could be enforced. Inasmuch as the ali´i captured the rents, this exemplifies a case in which the *primary action group* (Davis and North), undertake the institutional innovation in question.

From records of oral genealogical history, we know that populations must have been driven to create ponds as soon as there was sufficient labor available to do so, if appropriate environmental conditions existed. There are at least 6 fishponds constructed on Oahu and Kauai before the 13th Century (Kikuchi, 1973). Also at this time communities begin to develop in the drier, leeward valleys, suggesting population expansion and resource pressures. The primary growth in fishponds is attributed to the 16th Century (Kikuchi, 1973), as is the growth in population. By the 18th Century, repairs to existing ponds may have been as important as new construction. The last ponds were constructed at the beginning of the 19th Century, as Western contact and the resulting population decreases changed the social structure and manpower of the islands. There were also more profitable opportunities for the *ali´i* developing in trade for other resources, particularly sandalwood.

2.5 Changes in land tenure, fishing rights, and Western contact

[7] As the ponds enhanced characteristics of the natural environment, there is no set size or dimensions for a fishpond. The ponds ranged from an acre in size up to 523 acres, and some walls were 1000s of feet long and several (up to 18) feet thick, while many were much smaller.

[8] Population in the islands has been conservatively estimated at 200,000-225,000 in 1778, at contact.

While rent extraction by the chiefs was expected and accepted as the way of life, the hierarchical control included a mechanism for transferring these rents every generation in order to maintain consolidated support for the *ali´i nui*, or head chief. This mechanism, the *mahele*, was a redistribution of rights that occurred with every change of top leadership. The new *ali'i nui* reallocated the lands amongst his supporters, who in turn reallocated land amongst their supporters. Commoners were free to move, and did so if the *konohiki* or *ali'i* mistreated them (Mitchell, 1992). The *mahele* enhanced the communal nature of the *ahupua´a* enterprise by lessening the import of developing capital that would not be transferable after a generation, and the *ali´i* and the landlords who managed the *ahupua´a*, the *konohiki*, acted more as stewards of the land than monopolists due in part to the fact they could lose their labor force to others if they did not appear fair.

King Kamehameha was a conservationist. Under his reign, three major fishpond projects were undertaken, and sandalwood trading with Westerners was carefully managed, for example. Being less adroit at governing the chiefs, however, Kamehameha's successor Liholiho lost control of resource conservation at Kamehameha's death. Already weakened by his stepmother and regent's (Queen Ka'ahumanu) transfer of loyalties, Liholiho was unable to consolidate his power through the traditional *mahele* mechanism and allowed existing chiefs to exploit sandalwood and other natural resources as payback for their fielty (LaCroix and Roumasset I).

Enforcement costs of the consolidated hierarchy increased under Liholiho. The introduction of new religious institutions (Christianity in particular) and the apparent impotence of the Hawaiian gods in protecting the population from Western diseases rendered the *kapu* system less effective and the system was officially abandoned in 1819. (Kame'eleihiwa, 1992, p 140ff).

As the *mahele* did not take place at the time of Liholiho's succession, the former chiefs became entrenched. A move toward higher productivity yields occurred (Khil, 1978). Of greater impact, however, following this relaxation of conservation and increase in rent-seeking by the lesser *ali'i*, the sandalwood resource was depleted by 1850, leaving not only a void in tradable goods, but also considerable environmental degradation to watersheds. Thus the greater scarcity of extractable resources increased the benefits of conservation just as the hierarchical institution designed to protect them failed due to the increased costs of governance.

The hierarchical system of *ahupua´a* control was relaxed and the commoners received greater protection of property. In 1839 a Declaration of Rights limited the ability of chiefs to extract property from commoners. This appears to have been necessary because the *ali´i* were finding increasing benefit from the exploitation of the commoners as producers of goods that could be traded for the newly influential foreign goods and the status and power they conveyed (Kame´eleihiwa, 1992, p 205).

Throughout the process of consolidation, the responsibilities of the commoners changed little; each was expected to perform his farming or fishing duties under the control of the *ahupua'a konohiki*. Two important trends evolved, however. First, the commoners developed specialized skills (e.g. in taro and dryland farming and various fishing techniques), enhancing resource productivity while tying them more closely to the *ahupua´a* (Handy and Handy, 1991, p. 310ff). Second, the *konohiki's* role of manager evolved with increased responsibilities and specialized knowledge (e.g. organizing hukilau, irrigation and other communal activities). When the position of *konohiki* first emerged (during the expansion period), he was primarily a tax collector providing service for a superior *ali'i* in return for status and a portion of the harvests. By the time of the Great *Mahele*, his role had been gradually transformed into a position that claimed ownership of the resources, and the associated ability to make decisions.

The *ahupua´a* extended into the sea, and property rights were also redefined and extended in coastal fisheries. Fishing rights remained tied to the management of the land, and remained in the hands of the *konohiki, ali´i* and the king, with intent of balancing stewardship for the people with private goals. While the fisheries were still common property, enforcement costs and benefits in coastal fisheries controlled directly by *konohiki* differed from those of the government controlled, open water fisheries, and the coastal, *konohiki*-managed fisheries. While government lands and their appurtenant fisheries quickly were opened to the public, the *konohiki* retained their rights to private use throughout the 19th century.

The *konohiki* (acting for the *ali´i*) could regulate fishing by monopoly reservation of a particular species and by seasonal restrictions. He could collect in rents 1/3 of the harvests of open access fishes, for the benefit of the *ahupua´a* (Khil, 1978, p 10). The rights belonged to the job of *konohiki*, not the man, and were not transferable, with the intent of maintaining incentives for stewardship. The king also had the ability to set restrictions on non-transient shoal fishes and

transient shoal fishes in the Main Hawaiian Islands. He was entitled to 2/3 of all harvests, for the benefit of the government (Khil, 1978, p. 11).

Throughout the 1840s, the Great Mahele and the changing constitutional rights slowly made more explicit the powers of the *konohiki* and the king and their portions of the take changed. In 1841, the king's take was reduced to 50%, and in 1845, the *konohiki* was given rights over the sea extending one mile from the beach at low water. The catch was to be shared evenly with the tenants. In 1848, Hawaiian property rights received their greatest institutional change under the Great Mahele. Under increasing pressure from the growing Caucasian population, the land was permanently divided amongst the king (state), the *ali´i* and *konohiki* (*ahupua´a*) and the commoners, paving the way for transferable rights to land and sea. It is at this time that the role of the *konohiki* seems to have changed from steward to owner[9].

From this period of history, we garner three potential trends in institutional evolution. First, each institutional framework has some flexibility in accommodating increased governance. Governance within an institutional system can respond to changes in resource pressures, albeit large changes in relative prices may occasion a transition to new institutions. Second, institutions do not simply switch instantaneously from one form to another, even when they are seemingly imposed. The example of the *konohiki's* slow transition from a minion of the ali'i, to an incentive-driven resource owner, shows the shift from manager to owner that accompanies a shift from a common property regime to a private property one.

Over time, the organizational triangle got higher with consolidation, i.e. there were increasing layers of hierarchy and a more structured system of governance (e.g. more control by the priesthood and more elaborate *kapu* restrictions). Within the levels of governance, e.g. konohiki, the "managers" held more independence. That is, the various players were not just passing down orders from the king; their own incentive systems were more developed. All fisheries didn't follow this pattern, however. Where the appurtenant fisheries became less

[9] Though the Great Mahele ostensibly divided land in equal shares between the royalty, the chiefs and the commoners through the agency of the *konohiki*, the actual process of attaining title to fee simple property was complex, and in particular, required a commutation fee that resulted in a large portion of the chiefs' lands being returned to the state in payment. The commoners' inability as a group to acquire much fee simple property stemmed from hurdles that included paying for land surveys and unfamiliarity with the system. Fewer than 8421 parcels, averaging 3 acres in size, were in the end awarded to commoners, accounting for 28,658 acres of land, or less than 1% of Hawaii's land area (Kame´eleihiwa, 1992, p. 294). The main beneficiaries of the Great Mahele appear to have been Westerners who could now obtain fee simple land.

valuable due to the development of other sources (e.g., fishponds), their organizations devolved towards open access, i.e. governance actually decreased.

2.6 Dual systems of fisheries management: transitional institutions

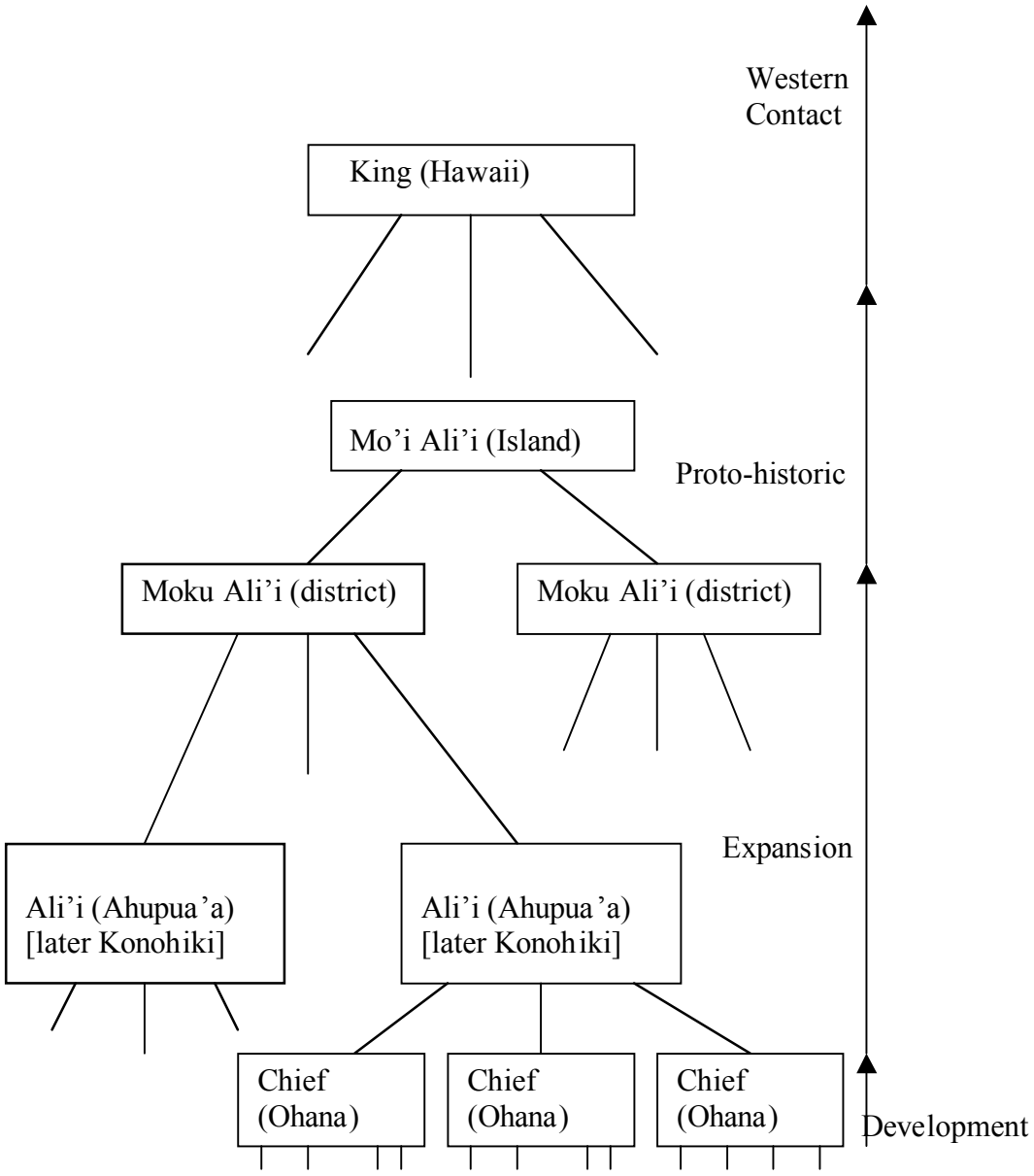

Figure 2: Hierarchy grows increasingly complex over time, but incorporates existing systems. The subsequent transition to decentralization relies on existing relationships (e.g. some functions of Ali'i assumed by Konohiki and later by resource owners)

Over Hawaiian history, social organization went from family to hierarchy to more complex and larger hierarchy (vertical and horizontal expansion) to private. Transitions were gradual, e.g. with some private property coexisting with hierarchies. Even the great Mahele, often historically billed as a quick transformation in 1848 from hierarchy to private property, took over a decade of governance expenses to settle, and was incomplete, i.e. it left much land and marine resources as forms of common property.

As mentioned, the monarch's fisheries moved towards open access[10] while many of the *konohiki*, where governance provided valuable returns, adopted stricter enforcement policies. In 1858, tenants regained some legal ground in piscary rights with a court ruling that stated the *konohiki* rights were subject to the tenant's rights, where tenants included all residents of the land (Khil, 1978).

The opening of state fisheries to the general public was explicitly an act to reduce enforcement costs on a low productivity resource. The new law, enacted in 1850, read in part:

> Whereas the fish belonging to the government are productive of little revenue; and whereas the piscary rights of the government managed by the fishing agents are a source of trouble and oppression to the people … all fish belonging to or especially set apart for the government shall belong to and be the common property of all the people equally … All fishing grounds pertaining to any government land, or otherwise belonging to the government, excepting only ponds, shall be, and are hereby, forever granted to the people for the free and equal use of all persons… (in Khil, p. 13)

This law increased pressure on the fisheries and resulted in the slow subsequent introduction of increased governance in the forms of gear restrictions, size restrictions, and seasonal restrictions. In 1850, use of fish poisons was made a misdemeanor offense. In 1872, use of explosives was restricted. This was presumably as much for the safety of the users as the preservation of the reef or fish, though in 1888 the possession of fish killed by dynamite was rendered enough evidence for prosecution. In 1888 size restrictions were introduced for mullet, except for live use in stocking fishponds. These restrictions were codified into the code of the Republic of Hawaii in 1893, while the *konohiki* retained their rights. (Khil, 1978).

[10] This is not to say that informal, non-governmental limitations of fishing rights did not exist.

2.7 Annexation and trade

Though the big picture of institutional change in Hawaii is one of increasing resource pressure accompanied by increasing governance and decentralization of control, at the level of individual resource assets, in particular coastal fisheries, we witness the richness of the model in explaining the connection between resource value and investment in governance. Coastal fisheries varied in economic value both within a given time period and across time, as a function of the resources' viability and the populations dependent on them. When costs of maintaining property rights increased for the *konohiki* fisheries at the end of the 19th century, responses varied according to economic benefits of the resource, with higher-valued fisheries commanding greater effort in the establishment of rights. Furthermore, as time decreased the value of all coastal fisheries due to increasing international trade and the greater availability of preferred substitutes, governance over all coastal fisheries decreased.

After annexation in 1898, and shortly thereafter the passage of the federal Organic Act in 1900, the *konohiki* fisheries came into conflict with federal law. The Organic act repealed all exclusive rights, but left a two-year window during which holders of exclusive rights could register and adjudicate their private claim. Any successful private claims could be condemned for public use, however, with allegedly proper compensation. Of the more than 400 private fisheries at annexation, only 107 registered claims were made within the mandated window. More than half were on Oahu, with its greater population, closer proximity to the courts, and growing reliance on markets, factors which lowered the transactions costs associated with enforcement and increased the net benefits of conservation activities.

The registered fisheries also held greater assessed market value on average. At least two attempts were made to value the *konohiki* fisheries, in part for use in condemnations[11]. The first, in 1939, described 349 *konohiki* fisheries, 101 of which were registered. Table 3 summarizes their findings by island. Kauai, Oahu and Molokai all generated greater than average value from the registered fisheries, while Maui actually received less. In this assessment, no account was made for the role of biological growth in the capital stock of the fisheries.

[11] The limited treasury of the new Territory was responsible for financing compensation for condemned fisheries, which limited their interest in doing so. The development of Pearl Harbor led to the first real cases for condemnation.

Table 3: Relative value of registered fishery *konohiki* monopolies

Island	*Number of fisheries*	*Estimated value ($)*	*Percent of fisheries registered*	*Percent of estimated value from registered fisheries*
Oahu	64	20,750	82.8	94.7
Hawaii	148	14,800	5.4	5.4
Maui	81	7,350	33.3	27.2
Molokai	28	3,100	10.7	19.4
Lanai	4	400	50.0	50.0
Kauai	24	9,900	33.3	83.8
Totals	**349**	**56,300**	**28.9**	**56.0**

Data from C.C. Crozier, Deputy Tax Commissioner (Mar 14, 1939)

In 1947, another assessment occurred in which an attempt was made to include biological growth and catch effort (Khil, 1978). These results tended to produce even lower valuations than the 1939 survey. Many of the fisheries were seen as lacking commercial uses and their appraised values reflected this. The most highly valued fishery, the 270-acre Kahana fishery on Maui, generated per-acre values of $37.04. This fishery was operated collectively on a profit sharing basis, where all catches were divided 50/50 between owners and fishermen. The lowest values were for less than twenty-five cents per acre.

Table 4: Percent of catch by habitat type

Year	*Coastal (% of total)*	*Neritic-pelagic (% of total)*	*Slope and Seamount (% of total)*	*Pelagic (% of total)*	*Total Catch (Thousands of Pounds)*
1900	59.1	16.2	3.4	21.2	6157.8
1950 &1953 avg	4.8	3.4	4.0	87.8	17426.7
1985-6 avg	6.1	5.4	16.8	71.8	9868.0
2002-3 avg	1.3	2.5	5.8	90.4	23398.0

Sources: Shomura (1987) and State of Hawaii Department of Land and Natural Resources, Dept of Aquatic Resources (2004).[12]

This institution might have played a greater role in the development of long-term fisheries law if its commercial importance had not dwindled over the century or if enforcement had been simpler. Changing tastes, increased options for foods, and increasingly available open

[12] Reporting for the 2002-3 period includes a slightly different composition of species that under-reports coastal fishes compared to earlier years. However the important shift is clear: between 1900 and 1950, coastal fisheries dwindled in comparison to the expanding pelagic fisheries.

access fisheries all reduced the ability of this institution to function as a mechanism for 2nd best provision. Table 4 shows the relative change in coastal fisheries versus other Hawaiian fisheries over the century.

The simultaneous maintenance of private and open access fisheries in proximate space increased the cost of enforcement for the *konohiki*, and in many cases these higher enforcement costs outweighed the benefits. The commercial value of the in-shore fisheries they held became increasingly limited for much of the 20th Century. Pressures for multiple uses of the areas led to some condemnations, and today, virtually all of the fisheries are operated under complex government restrictions, but open to anyone who conforms to those regulations.

2.8 Stylized Facts

The evolution of economic organization, as illustrated by the simple case of Hawaii, can be characterized by the following trends. As private property expanded, so did government responsibility. Decision-making became first more centralized as the monarchy became established (1805) and then less so as it devolved, with a series of constitutions setting up legislative government beginning in 1840 and the privatization of lands under the Great Mahele at the end of that decade (Daws, 1974). The scope and breadth of central government control, however, increased; these constitutions established a cabinet, a civil service, and an independent judiciary by 1847. As the population of Hawaii expanded and resource pressures increased, the agents of this increasingly centralized control also intensified their governance efforts, imposing greater restrictions on the use of fisheries as well as developing and institutionally supporting stronger property rights for the coastal private fisheries.

Private decision-making within the new property rights system for fisheries continued to balance enforcement costs against benefits as well. *Konohiki* sought to incur the costs of fishery registration when the asset was more valuable, leaving less valuable assets to open access. Enforcement declined across all coastal fisheries as the resource value decreased over time.

The scope of the economy broadened and specialization opportunities expanded, bringing greater benefit from decentralized control after Kamehameha I's death. Kamehameha had worked to take skills from the Westerners and train his own people in newly important trades including shipbuilding and blacksmithing, to such a successful extent that at least one Western

carpenter refused to divulge his specialized knowledge for fear that there would be no role for Westerners in Hawaii (Daws, 1974, p. 49).

Governance efforts, however, did not abate; large investments were made in determining property rights and building the oversight mechanisms for enforcement needed after the abandonment of the *kapu* system. In the 1840s, a series of constitutions instituted a judicial system and placed control over public goods, particularly education, in the hands of a representative legislature (Daws, 1974, p. 107). Additionally, former managers within the hierarchy, like the *konohiki*, retained their management rights over resources like coastal fisheries, and the monarch maintained control of indivisible assets like fishponds.

Within every institutional framework from the first Polynesian arrivals to the present: the informal ohana network, localized chiefdoms, monarchy, territorial government, and state, governance efforts have increased in response to benefits of greater specialization, greater population pressures, and greater resource scarcity.

3. A capital-theoretic explanation

The objective of this section is to provide a framework for comparing the performance of institutions that govern resource use over time and to show how population pressure or changes in the net benefits of resource use can induce a change in the optimal institution. This requires first assessing the relative advantages and disadvantages of the organizational forms in question: central planning, decentralized decision-making, and centralized decision-making at the community level and then determining how population or other resource pressure affects the pros and cons of each institution.

A natural starting point for understanding the advantages and disadvantages of private property versus other institutions is provided by Anderson and Hill (1975): balance the first-best benefits of switching from open access to private property against the costs of enforcement, which are in turn equated with the cost of fencing.[13] Allen (2003) has suggested that this theory could be extended such that the second-best benefits of various management institutions can be weighed against the enforcement costs of those institutions, designating that institution with the

[13] North and Thomas (1970) and Davis and North (1971) only recognize the political cost of changing the institution, not the enforcement, administration, and other organizational costs of the institution in question. Demsetz (1967) implicitly considers enforcement costs, but how they are to be balanced against benefits is unclear, especially since neither benefits nor costs are not well-defined (see, e.g. Anderson and Hill, 1975).

highest net benefits as the optimal one. Even this extended theory is incomplete. It implicitly assumes that the enforcement costs of a particular institution are clearly defined. This in turn suppresses the problem of determining, for a particular organizational form, how much and what form of governance is optimal. For the case of common property management, for example, the community must determine the rights and responsibilities of members, and choose an incentive structure as well as its technology of enforcement. Until this governance structure is specified, neither the benefits nor costs can be determined.

The three commonly proposed solutions to the open access problem are private property, common property, and public property. Comparing these institutions according to the extended Demsetz theory involves comparing known enforcement costs with the benefits that a particular institution delivers by reducing free-riding. This non-categorical theory has not successfully delivered useful categorical theories, however.[14] Rather, analysts are left with asserting that changes, such as the invention of barbed wire, increased the relative net benefits of a particular institution, thereby explaining its adoption. In other words, the benefits and costs of institutional change are not well-defined. This and other examples led Samuelson and Baumol to remark that the New Institutional Economics is not operational. In the present context, we seek a theory of why governance costs, both within and across institutional forms, increase with population pressure, specialization, and economic modernization.

Another conceptual weakness of property rights theory is its lack of capital theoretic foundations. As an asset's value increases, it is natural to expect that investments in protecting or enhancing its value will increase over time. Anderson and Hill (1990) have provided a dynamic theory of a one-time investment in enforcement costs, e.g. building a fence, but have not considered the possibility of increasing governance-capital over time. In what follows, we exploit resource economics to provide this theory.

For the case of renewable and non-renewable resources, the first-best condition for optimal resource use may be written as:

[14] See e.g. Vivian Walsh's entry in *The New Palgrave Dictionary of Economics* for an illuminating discussion of categorical vs. non-categorical theories.

$$\dot{P} + \frac{d}{ds}[\rho F(s)] = r(P - c) \text{or}$$
$$P - c = \frac{\dot{P}}{r} + \frac{\rho F'(s)}{r} - \frac{c' F(s)}{r} \qquad (1.1)$$

where P-c is the resource royalty, defined as the resource price minus its extraction cost; $F(s)$ is the growth of the resource as a function of its own stock, $F(s) = 0$ for non-renewables; and r is the real interest rate. Since the right-hand side of (1.1) is the marginal user cost, (1.1) states that optimal resource extraction is achieved when the marginal benefit (royalty) of resource use equals the marginal user cost.[15]

For simplicity, we do not illustrate the possible dynamic paths that optimal resource use takes over time here (see e.g. Clark, 1990, for visual representation). Rather we describe the static first and second-best outcomes at different points in time to emphasize the shift in resources to compensate for the move to the second-best outcome. Panel A of Figure 1 illustrates first-best optimal resource extraction X^*, in contrast to open access extraction which occurs where the marginal benefit, P-c, falls to zero (X_{OA}), for a single time period. Panel B reflects these curves' mirror images to show clearly the marginal benefits (MBC) and marginal costs (MCC) of conservation of the resource in the form of reduced extraction, so that first-best optimal conservation is $X_{OA} - X^*$, where the marginal benefit of conservation equals its marginal cost.

[15] See e.g. Pearce and Turner (1990).

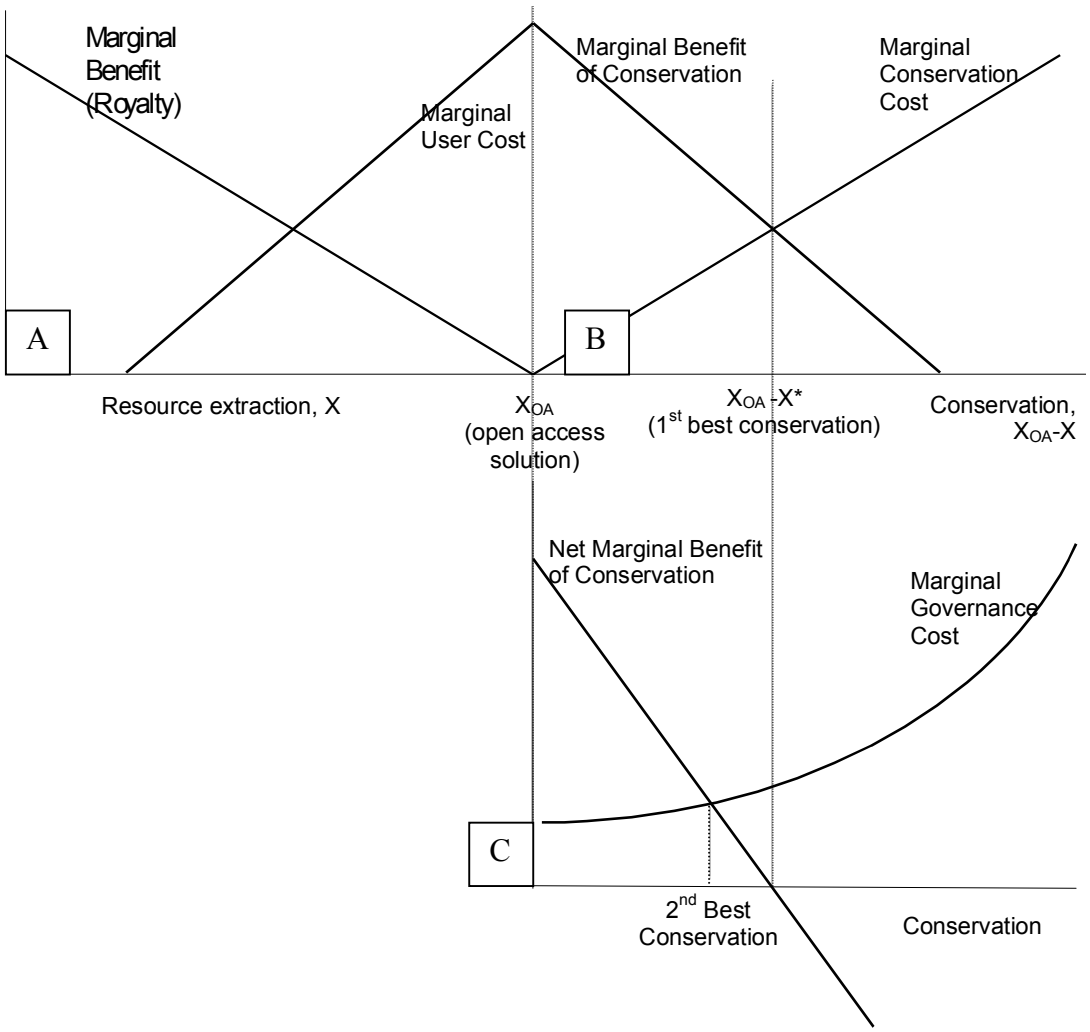

Figure 2: A second-best theory of resource management (common-property or otherwise)

Now recognizing enforcement and other organization costs, we can see that second-best optimal enforcement is generally less than that of the first-best solution. First, define governance costs as the actual resources used up in the enforcement and organizational effort plus the shirking costs that remain.[16] Panel C shows the net marginal benefits of conservation (NMBC) and introduces the governance costs (MGC), which are assumed to increase with the level of conservation. The net marginal benefit of conservation (MBC-MCC) is the marginal benefit of controlling resource use. The optimum governance of resource extraction occurs where this

[16] For the special case where the organization is a firm, governance costs are agency costs (Jensen and Meckling, 1976; Roumasset, 1995).

marginal benefit equals the marginal cost of governance whether it be through socialism, capitalism, or communitarianism.

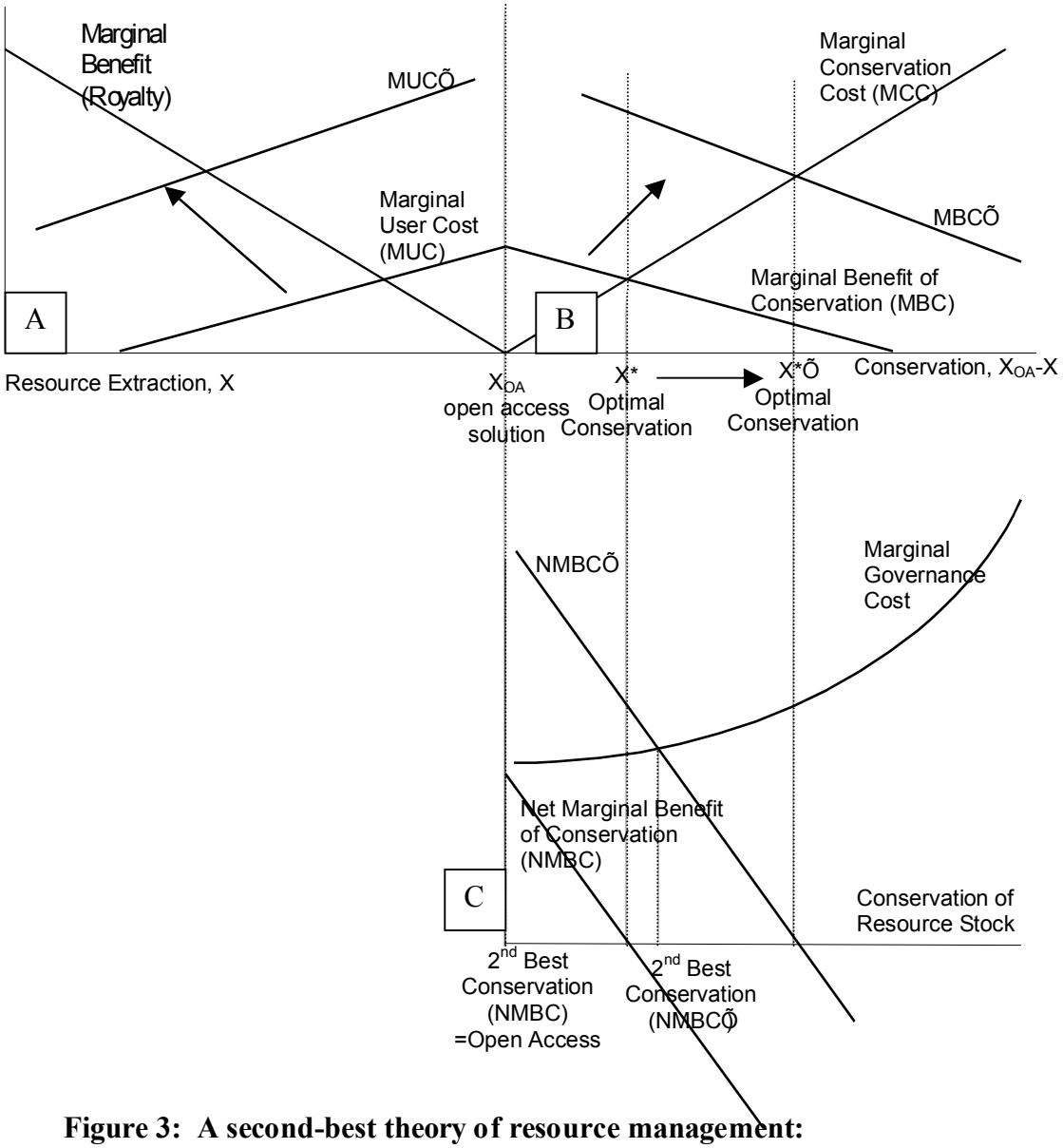

Figure 3: A second-best theory of resource management: comparative statics

This structure can be used to explain the co-evolution of governance and fisheries management. As the curves shift to reflect population pressures and resource availability, the second-best optimal solution may change. Figure 3 corresponds to the Hawaiian situation as population pressures increased resource pressures over time. The tightening of the *kapu* system followed as the population grew and increased the marginal user cost of conservation. Not shown explicitly here, but evident from the graph, is that when population is low and resources

abundant, little or no governance costs are warranted. Indeed if resource use is sufficiently low, open access may be 1st-best optimal, i.e. curves of figure 2 intersect in the negative quadrant. This corresponds to the early stages of Colonialization and Development, when governance was informal and managed through an ohana (family) network.

With even greater population pressure, intensification and resource depletion, however, potential gains from trade across districts increase (LaCroix and Roumasset, 1984) and the dictatorial hierarchies controlling each ahupua´a economy are not well suited to exploit those opportunities. If such potential gains are large enough to warrant the increased governance costs of further centralization of control (albeit not necessarily of decision-making), the second-best theory predicts that such institutional change will take place. At the time of Western contact, Hawaii was headed for just this sort of unification of control.

Another advantage of hierarchical government, however, lies in its ability to exploit internal economies of scale, e.g. in fishpond construction, external economies from the division of labor, and resource interlinkages, e.g. between watershed conservation and the maintenance of stream flows during drier months. We witness these economies of scale exploited to develop fishponds for resource enhancement and conservation as resource pressures increased in the Expansion and Proto-historic periods.

Figure 4 translates figure 3, which is specified in terms of the marginal benefits and costs, into an agency cost framework, i.e. in terms of governance costs and the total costs of benefits foregone (see e.g. Jensen and Meckling 1976). In addition to agency costs, however, we include other departures from the first-best solution in the definition of total transaction costs (e.g., North and Wallis, 1986; Allen, 2003). In particular, these include failures to capture economies of specialization.

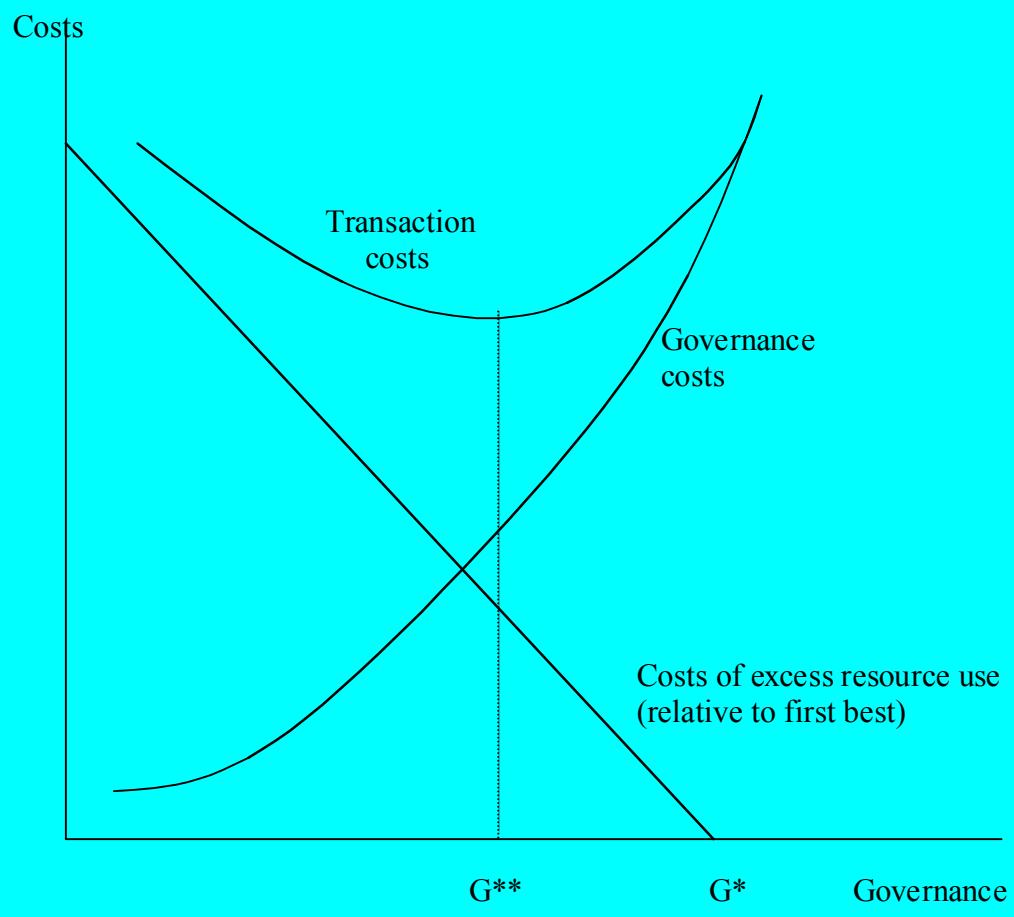

Figure 4: Transaction cost approach to second-best conservation

These transaction costs will shift dynamically, e.g. in response to population pressure and the changes costs and benefits of specialization. Figure 5 illustrates a shift in transaction costs within an institutional framework.

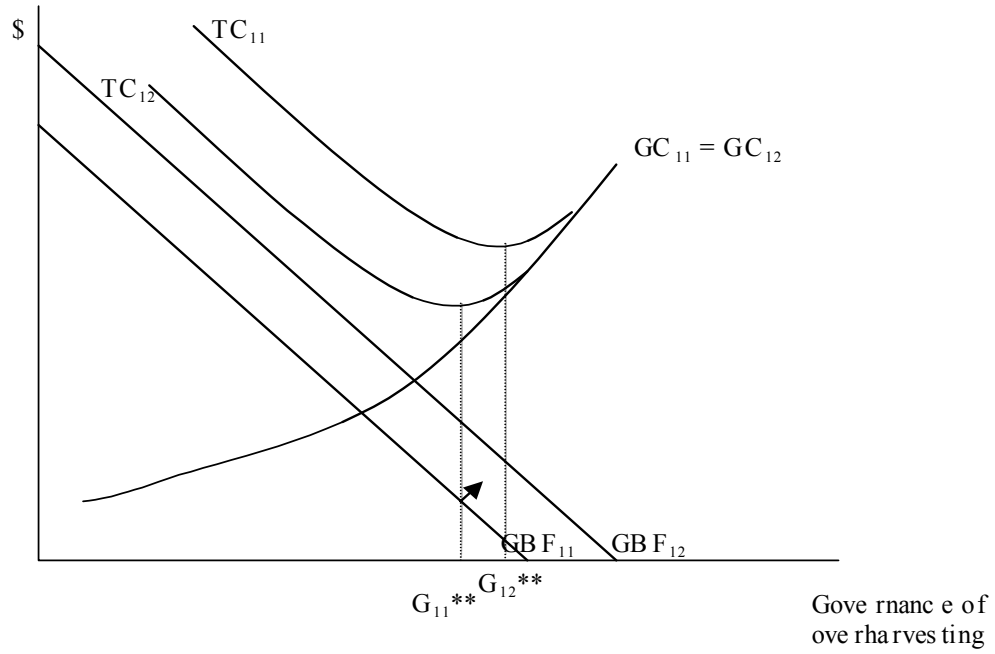

Figure 5: Transaction cost dynamics within an institution.
The g raph show s a sh ift in tran sac tions co sts (TC_{it}) and 2nd-bes t optima l gove rnance (G_{it}) as bene fits fo regone as a fun ction of gove rnanc e (GBF_{it}) inc rease und er any given institution.

The graph describes a shift that stems from increased benefits from resource conservation due to increased population pressures and increasing external economies from enhanced trading opportunities. Increased benefits yield increased governance and tightening of control. We expect that the dynamics will differ across institutional frameworks. In the private property case, for example, additional benefits from specialization and external trade may be captured and governance may increase more rapidly than under hierarchy once fixed costs of developing the institutional framework are incurred. This addresses in part the understanding that increased property rights will require greater third party support for the institutional framework itself through increased governance and investment in the framework itself.

In Figure 6, we examine the choice of institutional framework given the minimization of transaction costs within each framework. Over time, transaction costs are increasing for all institutional structures, however they do so at varying rates. Here, we illustrate the case for Hawaii, where in time period 1, transaction costs are minimized by choosing G_1**, where hierarchy is the optimal institutional choice. By time period 2, the benefits of hierarchy have

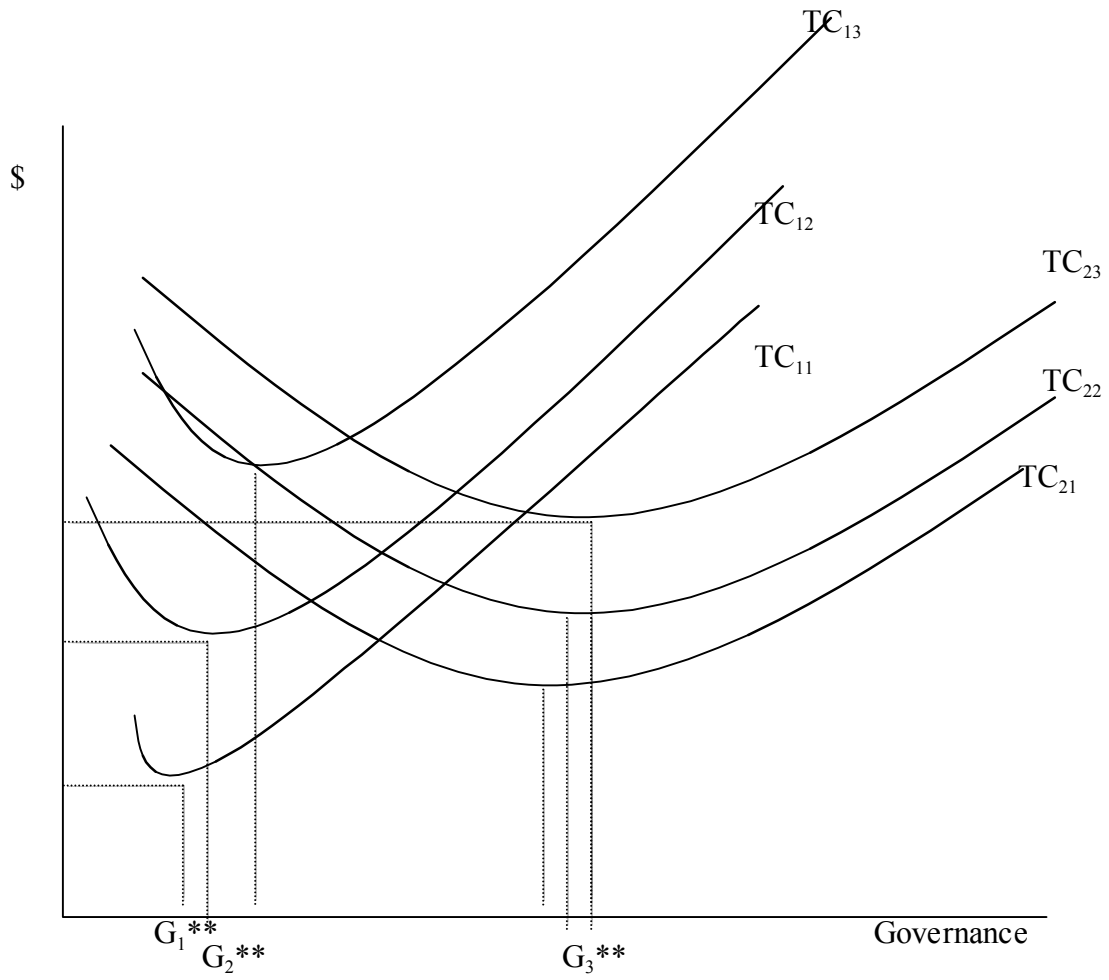

Figure 6: Comparative institutional transaction cost analysis.
Transactions costs differ in magnitude and respond differently to increasing levels of governance. Here, TC_{1t} approximate costs of hierarchical control where benefits from internal trade quickly lower costs while the difficulties in achieving external trade economies increase costs dramatically with governance. TC_{2t} curves approximate private property, where institutional fixed costs raise and flatten agency costs but the ability to achieve external economies lower the net costs of higher governance.

been reduced as population pressures increase the benefits of governance and the well-known burdens of central planning begin to show themselves. Still, this may be preferred to making the switch to private property, with similar costs that would recommend a higher level of governance. Finally, the burdens of managing hierarchy combined with the loss of ability to

achieve specialization from external economies increase transactions costs above the minimum transactions costs achievable by switching to private property.

We hypothesize that had Hawaii maintained independence as a kingdom longer after western contact rather than becoming part of the United States in the late 1890s, this centralization of control and decisions would have been unstable and failed to last (Glaeser & Shleifer, 2003). Of the many Pacific Island kingdoms that developed via similar hierarchical processes to Hawaii, only Tonga remains a feudal monarchy today, and it is increasingly unstable, as population pressures that challenge longstanding mandates of land tenure (each male at age 16 is to receive 8.25 acres [U.S. Department of State Background Note, Tonga, 2003]) make it difficult to resist calls for democratic reform and devolution of power.

Figure 7 illustrates the efficient evolution of centralized control. At first, centralization of control and decisions increase together, to reduce idiosyncratic risks through mutual insurance and diversification, and exploit economies of scale in production, e.g. in communal net fishing (hukilau).

Hawaii during pre-contact followed this pattern from the ohana network through to monarchy. Just after contact, King Kamehameha I unified the islands under his control, bringing all the islands under one rule for the first time. Almost immediately, however, pressures in the unwieldiness of this top-down management reduced the effectiveness of this unified control at conserving resources and exploiting economies of scale. As the monarchy continued through the 19th century, the *ali'i* under the kings acquired increasing power and one of the chief potential benefits of unified control, stewardship of the resources, was traded for political support as governance costs were unsupportable. Newly introduced goods from the West transformed the relative prices of resources, as particularly sandalwood increased in value. The last investment in fishponds occurred in 1839.

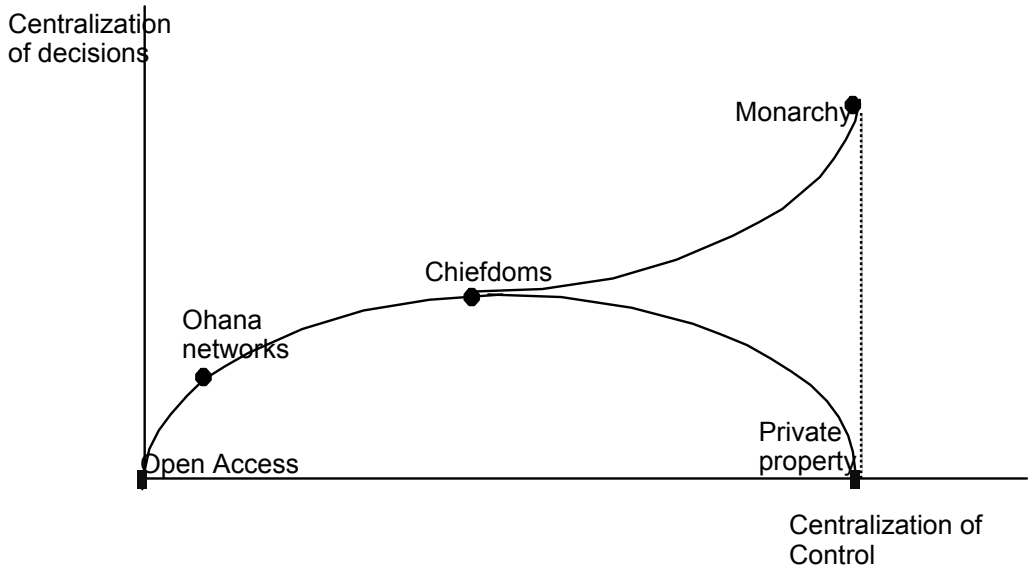

Figure 7: The Governmental Kuznets Curve

We find that the second-best theory, which suggests that institutions will change when the net benefits to doing so are positive, is inadequate for explaining institutional change after Western contact. While Kamehameha I was able to maintain conservation, rent-seeking prevailed in subsequent administrations such that conservation declined.

An additional inefficiency force increasingly apparent with Western rule was intellectual failure, including the failure be vigilant towards unintended consequences. More recent government policy follows Pigouvian logic quite well, despite Coase's warnings about "blackboard economics" (Coase, 1994, ch. 1). We provide a two-instrument Pigouvian policy for correcting dynamic open access inefficiencies that corresponds to the actual policies adopted. In addition to a Pigouvian tax (or equivalent quantity restriction) to move the non-cooperative solution to the optimum, a simultaneous subsidy of fingerling production and release can be derived. We describe this at greater length below. This blackboard analysis fails to consider voluntary solutions, however, and the subsidies undermined the development of private property through ocean-cage fish farming.

5. Summary and conclusions

As Hawaii's population increased, production systems were intensified. Social organization became increasingly complex, accommodating increasing division of labor. The increased vertical and horizontal specialization was facilitated by new incentive and governance structures summarized by the *governmental Kuznets curve*. Specifically, we witness a natural progression from a small, ohana network of reciprocal exchange, managed by a clan chief, to an increasingly stratified hierarchy and resulting in a monarchy in 1805. With Western contact, relative resource values diverge greatly from the past, and a new path toward decentralization of decision-making begins while centralization of control is transferred from one institutional framework to another but continues to intensify, despite the decline of population. With respect to marine property, this increasingly centralized control is evidenced in the increasing adoption of open-access fishing restrictions. At the same time the government foregoes its previous rights to shares of the catch, which are dwindling in economic importance.

Inasmuch as Western institutions were exogenously imposed, cannot be sure that hierarchical control would have eventually withered away and been replaced by market institutions. Considerable specialization and exchange was possible within the hierarchical system. The development of the position of *konohiki* as a specialized land manager and then its transformation into resource owner exemplifies the interdependence of specialized skills and productivity, which intensifies along with institutional change.

Our explanations of these stylized facts provide an extension of the theory of property rights. Chief among these are the dynamic foundations needed for a complete theory of second-best resource management. We have also sketched a categorical theory explaining why, as the benefits of resource management increase with population pressure or other causes of specialization, governance costs increase both within and across institutions. A methodological point of possible interest is that second-best analysis cannot proceed without first-best analysis. Indeed this is implicit in Coasean analysis. It is precisely the proposition that, absent transaction costs, different institutions are capable of the same first-best solution, which allows us to use the first-best solution as a benchmark against which the transaction costs of alternative institutions can be compared.[17]

[17] For this to be generally true, we must use transaction costs in its broadest sense, i.e. that transaction costs are the costs of running the economic system and are the equivalent of friction in physical systems (Williamson, 1985).

More specifically, with respect to alternative solutions to the open access problem, we have shown the following. First, it is not necessarily a problem; open access can be the first-best solution. This is the case in early Hawaiian history, when resource pressures were low, and though the *kapu* institution was available as it was brought with the first settlers, its use was expectedly minimal. Second, even if open access is first-best inefficient, it is not necessarily the case that open access is inferior to at least one of the three proposed alternatives; it can be second-best efficient. Indeed, we have suggested that there is a second-best transition, as the optimal degree of specialization increases, from open access to common property management to private property, which helps to explain the *governmental Kuznets curve*.

The second-best theory of induced institutional change predicts an increase in conservation effort as population pressure and modernization deplete natural resources. Unlike previous theoretical frameworks, the suggested theory allows for changing resource extraction (or changing investment) over time. We witness this increase in conservation effort in Hawaii along with institutional development that benefits from the ability of hierarchy to capture economies of scale in land and resource management, and then seeks to benefit from the change in relative benefits by decentralizing decision-making into the hands of the *konohiki* rather than the king. The increase in governance and the institutional change from open access to the intermediate *ahupua'a* system and later to a centralized system accord with second-best theory. Religion and brutal hierarchical control were used effectively to enforce limited access at relatively low cost.

While the co-evolution of intensification, specialization, and consolidation are consistent with second-best theory, subsequent developments require third-best analysis. For example, while centralized governance was initially effective at resource conservation (under King Kamehameha I), the inherent opportunities for rent-seeking were exploited by King Kamehameha II (Liholiho) and subsequent rulers. The intervention of Western culture and politics created an additional third-best force at odds with efficient institutional change. Western influence stressed the hierarchical system in at least two ways. First, it provided opportunities for specialization and trade beyond *ahupua'a* boundaries that were not readily captured under *ahupua'a* governance. Second, Western contact increased the benefits of extracting labor taxes from the commoners in order to import status goods.

The history of recent government regulation is a perfect illustration of what Coase calls *blackboard economics*. The Pigouvian solution for the open access problem would be tax fishing (or impose quantitative restrictions) and to simultaneously subsidize fish nurseries. That is roughly what happened. What the blackboarders failed to realize was that there was private contracting alternative – ocean cage farming. The nursery subsidies led to "dumping" fish at artificially low prices, which drove some of the early fish farmers out of business.

The co-incidental use of both "private" *konohiki* fisheries and increasingly regulated, open access fisheries in the 19th and 20th centuries illustrates the role of non-convexities and externalities in the institutional governance of resource use. Indeed, advances in aquaculture technology, such as cages, could have developed quite naturally out of the *konohiki* system described above. They may have been delayed in Hawaii due to required changes in federal law granting leases and uncertainty about the existence of appropriate markets for fingerlings. By abstracting from non-convexities, the standard theory suggests that increased pressure on resources due to economic growth automatically contributes to the evolution from open access towards private or centralized control.

To the extent that inter-district trade is facilitated by centralized control and decentralized decisions, two questions arise that may be suitable for further research. First, can the decentralization of decision-making evolve from the top-down system of medieval Europe or pre-contact Hawaii without violence or external force? Second, where decision-making is centralized as well as control, e.g. as in socialism, is it prudent to transition directly to decentralized exchange at the national level or is devolving central control to a sub-national level a useful intermediate step?

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