Coasean economics and the evolution of marine property in Hawaii

Brooks Kaiser (Gettysburg College) and James Roumasset (University of Hawaii Manoa)

Abstract

The standard view that the absence of property rights is inefficient contradicts the Coasean proposition that efficiency depends on how institutions compare regarding 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*. When Western institutions were exogenously imposed, however, intellectual failure resulted in inefficient regulations and subsidies. The example of fishing regulations illustrates Coase's council against blackboard economics.

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 (Demsetz, 1967) or political costs of change (Davis and North) that private property tended to evolve. This view was latter challenged by a number of authors (e.g.; Libecap, 1989; Anderson and Hill, 1990, Roumasset and LaCroix, 1988; who showed that rent-seeking can render the advent of private property either too late or too soon.

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. As already mentioned, however, there is no presumption that institutional change is entirely driven by efficiency. The possibility remains that institutional change deviates from second-best efficiency due to political economy considerations.[1]

We will characterize the institutions of governance for Hawaii's fisheries from early settlement to contact with the Western 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.

Changes in fisheries management after Western contact and then annexation by the U.S. were increasingly regulated by government agencies. These regulations illustrate how blackboard economics, in particular Pigouvian economics, fails to allow for voluntary agreements that internalize the external effects associated with competitive resource harvesting. The regulations also failed to take account of important non-convexities and interlinkages between *ahupua´a* resources.

2. Conceptual Framework

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 can induce a

[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 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 pressure affects the pros and cons of each institution.

A natural starting point for understanding the advantages and disadvantages of privatization is provided by Anderson and Hill (1975): balance the 1st-best benefits of switching from open access to private property against the 2nd-best costs of enforcement, which is in turn equated with the cost of fencing.[2] In order to explain the evolution resource governance, the theory needs to be clarified and extended to incorporate the capital theoretic aspects of resource management.[3] In addition, enforcement costs, administration costs, and other organizational costs need to be clearly conceptualized and incorporated into the theoretical framework.

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

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

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.

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

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[2] 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 enforcement costs is unclear (see, e.g. Anderson and Hill, 1975).

[3] Anderson and Hill (1990) provide a dynamic theory albeit only of the timing of a one-time, discreet investment decision.

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.

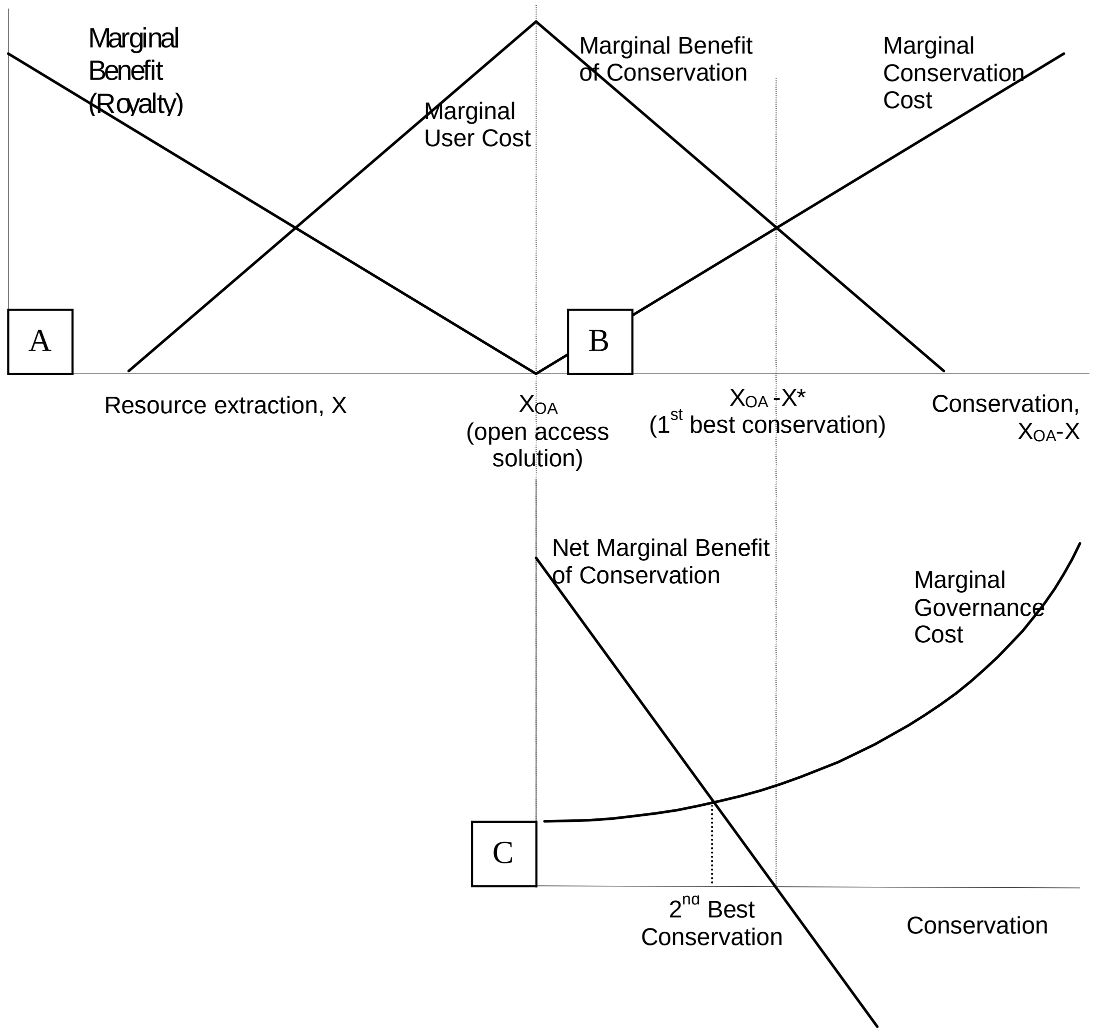

Figure 1: A Second-Best Theory of Resource Management (Common-property or Otherwise)

Now recognizing enforcement and other organization costs, we can see that second-best optimal enforcement is 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.[4] 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 marginal benefit equals the marginal cost of governance whether it be through socialism, capitalism, or communitarianism.

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. 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 1 intersect in the negative quadrant.

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

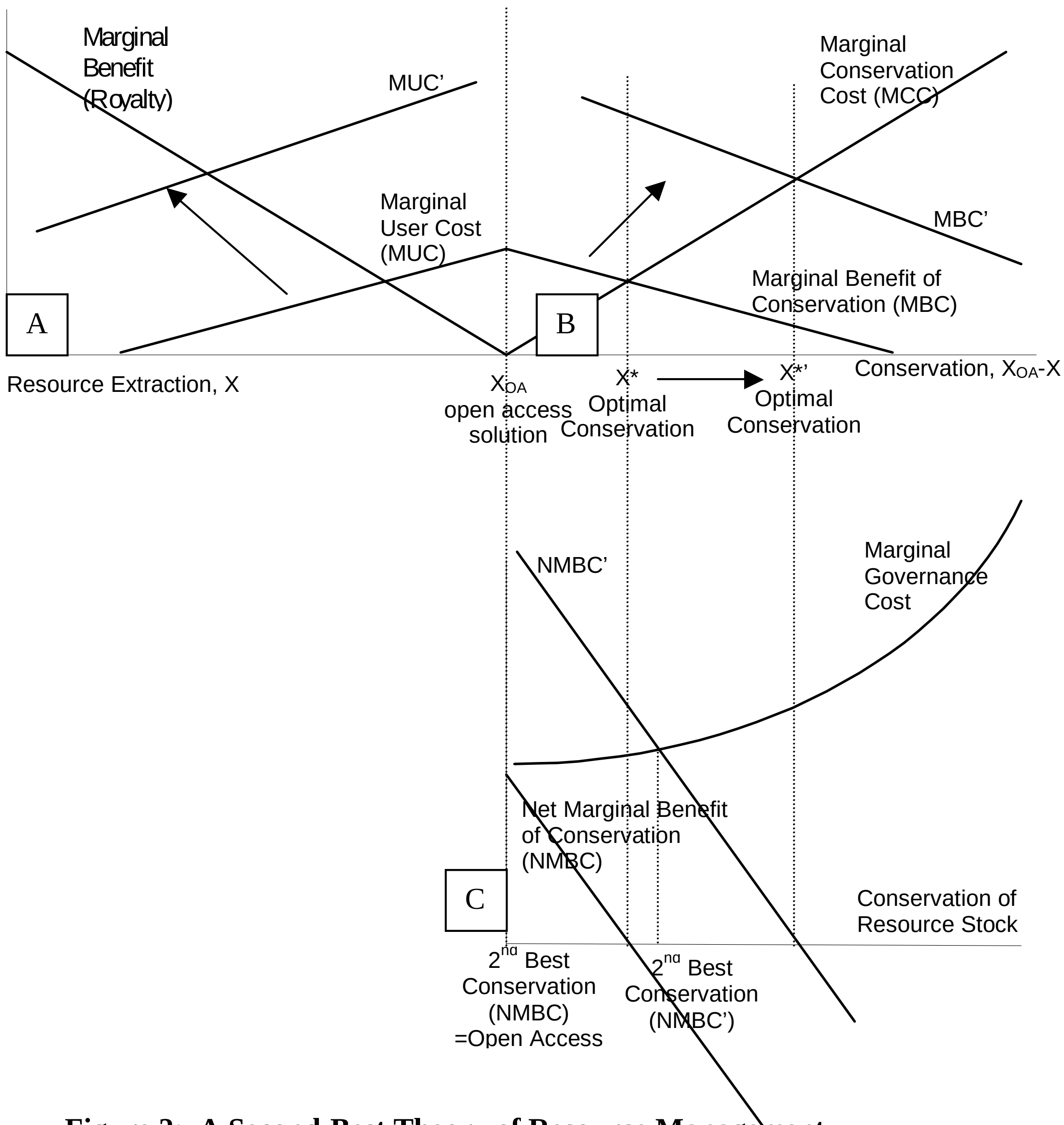

Figure 2: A Second-Best Theory of Resource Management Comparative Statics

Figure 2 illustrates the case of a shift in marginal user cost corresponding to a growing population over time. With a low population, resource depletion and marginal user cost may be sufficiently low such that net marginal benefits are less than or equal to marginal governance costs, even at zero conservation, i.e. open access is second-best optimal. As the pressures on the fishery increase and MUC shifts to MUC’, net marginal benefits of conservation increase and optimal governance increases.

We show in section 3 that population pressure did indeed lead to increasing fisheries governance via the *ahupua´a* command economy and the *kapu* system of regulation. 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. 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 find that the second-best theory 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.

3. Historical background

3.1 Pre-Contact Overview

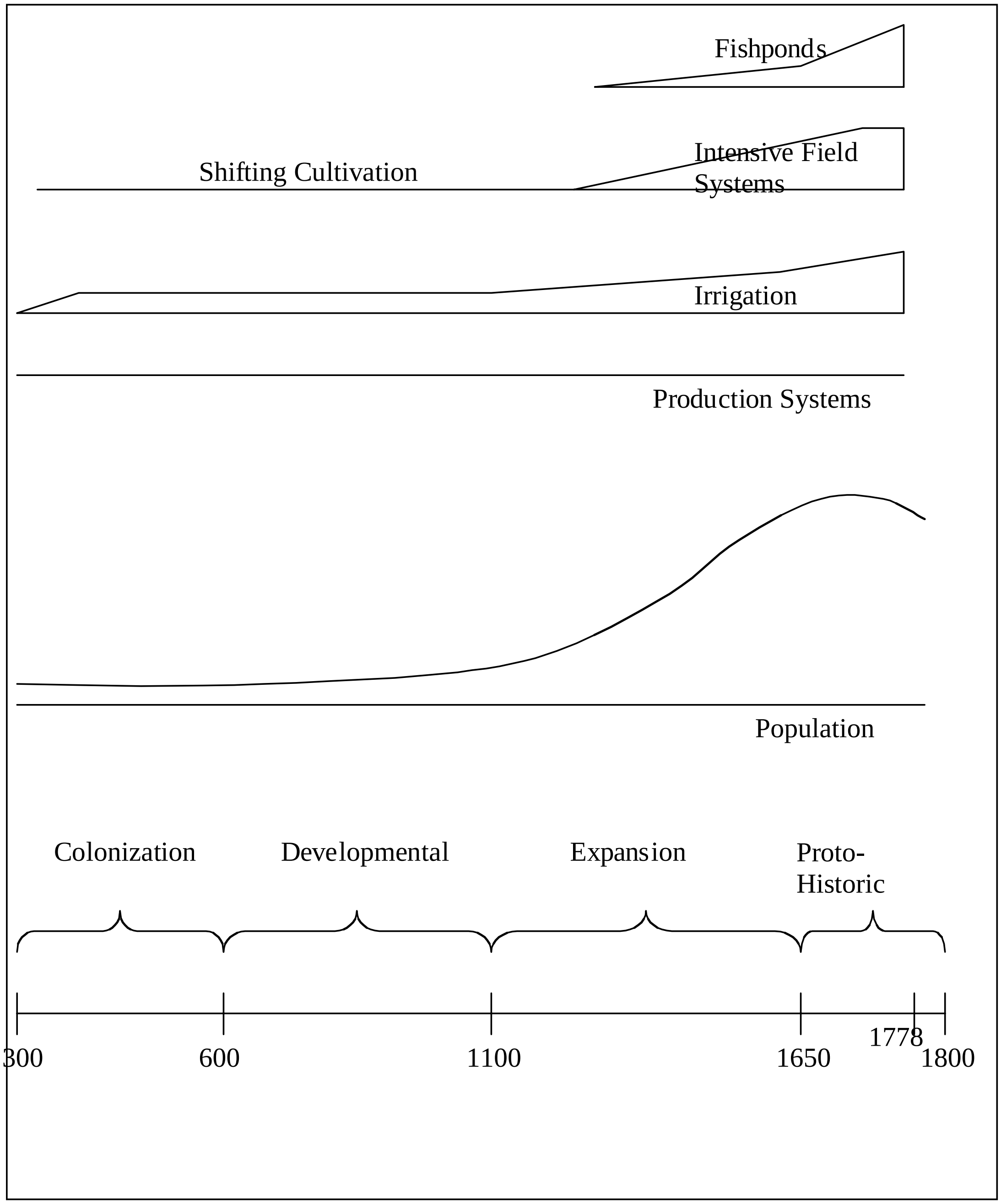

Figure 3: Timeline for Hawaiian Resource Use and Development (Adapted from Kirch (1985), p. 300-1

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. 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). Governance by family eventually extended to governance of the entire *ahupua´a* valley, under a single chief or *ali´i*. This system crystallized during the proto-historic period (1650-1785), at the height of the islands' population, and exhibited a much higher degree of social hierarchy than in other parts of Polynesia (Abbott, 1992).

Figure 3 summarizes the best information available 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.

3.2 The *ahupua´a* system: common property

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). The community worked under a gift-exchange system known as *ko kula ʻuka, ko kula kai*, where those upland traded with those on the sea. This allowed considerable expertise and specialization to develop and shows in the highly developed knowledge and skill amongst both fishermen and planters, and kept most economic transactions within the *ahupua´a*.

Centralized control at the *ahupua´a* level satisfies the requirements for viable common property rights (Deininger, 2003):

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

(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.

In addition, 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 Hawaiian case is suggestive of two qualifications to this theory, and their inclusion expands our understanding of the evolution of property rights in the face of non-convexities and external economies. First, the top-down management of the *ahupua´a* 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.

The other important distinction is that top-down management 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.

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. The strong hierarchical control established considerable ability to reduce resource pressures and enforce conservation measures. 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).

3.2 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. The chiefs limited access during certain seasons by placing a *kapu* (taboo) on fishing. These *kapu* are generally associated with particular gods and variants of the system are known throughout Polynesia.

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. 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.

Strict limited access to the ponds would have been essential. 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).[5] 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’l captured the

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

rents, this exemplifies a case in which the *primary action group* (Davis and North), undertake the institutional innovation in question.

3.3 Fishponds: resource enhancement

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 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]

Three kinds of fishponds were constructed, freshwater, saltwater, and brackish. All required communal effort in development, and the *ali´i* controlled access with an increasingly strict dictatorial hierarchy of priests and landlords.

Freshwater ponds were stocked by the natural flow of streams. This required sufficient watershed conservation however such that the streams would not dry up during rainless weeks or months to the extent that the fish would die. Fish were also raised in freshwater ponds whose primary purpose was growing taro. These fish were cultivated for primary use by the commoner growing the taro, while dedicated-use fishponds were restricted to use by the chiefs. Freshwater fishponds seem mainly a complementary by-product in the production of taro, which required significant infrastructural investment and cooperation in irrigation (Handy et al, 1991, p. 281).

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[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.

[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.

Brackish ponds were constructed as part of natural wetlands that were fed both by streams and connected to the ocean. Brackish ponds created environmental conditions that most benefited the growth of mullet, a particular favorite of the *ali´i*. Brackish ponds have been shown to not only function as storage for mullet but also increase their growth (Summers, 1964).

Saltwater ponds enclose a natural curvature of the shore or extend out in an arc along a straight piece of shore. In saltwater (and brackish) ponds, *makaha* (gates) were placed in outlets to the ocean to allow fish to swim in but not out. Though fishponds appear throughout Oceania, the *makaha* appears to be a uniquely Hawaiian innovation (Apple et al., 1975). The reef structures on most Polynesian islands are considerably more developed in structure than Hawaii, forming barriers and lagoons, due to their much longer geological time scale and greater diversity of reef-building creatures. It is possible that, just as the new arrivals in Hawaii transformed the landscape with plants and agricultural techniques, they worked to transform the reef to resemble the productive reef flats and lagoons of their former homes. The construction of fishponds and their interconnectivity with other resource systems illustrate the internal and external economies that could be achieved by centralizing management at the *ahupua´a* level.

From records of oral genealogical history, we know that populations must have been driven to create ponds as soon as they could. 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. The real 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.

3.4 Changes in land tenure, fishing rights, and Western Contact

While rent extraction by the chiefs was expected and accepted as the way of life, the hierarchical control included a mechanism for dissipating 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 *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.

After Western contact and unification of the Islands under King Kamehameha, pressure on Hawaiian resources increased, especially under his relatively weak successor, King Liholiho (LaCroix and Roumasset). Under King Kamehameha, centralized resource management was not obviously inefficient. Under his reign, 3 major fishpond projects were undertaken, and sandalwood trading with Westerners was carefully managed, for example. However, in the transfer of power to Liholiho, rent-seeking increased and resources were widely exploited for direct gain to the chiefs.

Under Liholiho, the *kapu* system was officially abandoned in 1819. The *mahele* did not take place at the time of Liholiho's succession, and local chiefs began to become entrenched. A move toward higher productivity yields occurred (Khil, 1978). Of greater impact, however, following this relaxation of conservation and increase in rent-seeking, the sandalwood resource was depleted by 1850, leaving not only a void in tradable goods, but also considerable environmental degradation to watersheds.

Throughout the 19th century, the dominance of Caucasians increased. As Hawaii adopted Western political ideology, 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). Since the *ahupua´a* extended into the sea, coastal fisheries were included in this redefining of rights. 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.

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 state (Khil, 1978, p. 11).

Over the next ten years, the powers of the *konohiki* and the king were slowly made more explicit 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 as it extended 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[8].

3.5 Dual systems of fisheries management: transitional institutions

While state lands and their appurtenant fisheries quickly were opened to the public, the *konohiki* retained their rights to private use. 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:

> 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:
>
> Therefore,

[8] 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.

> Be it enacted by the house of nobles and representatives of the Hawaiian Islands in legislative council assembled: Section 1. That thirty days from and after the publication of this act … all fish belonging to or especially set apart for the government shall belong to and be the common property of all the people equally…
>
> Section 2: 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)

With this open access came increased pressure on the fisheries and the slow subsequent introduction 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).

3.6 Annexation and federal law move Hawaii toward Pigouvian solutions

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 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.

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[9]. The first, in 1939, described 349 konohiki fisheries, 101 of which were registered. Table 1 summarizes their findings by island.

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)

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.

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 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.

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

[9] 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.

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

Table 2: Percent of Catch by Habitat Type

	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).[10]

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 actual or de-facto open access, with complex government restrictions.

The pressures of this growing open access required increasing intervention at the beginning of the 20th century. The 1888 mullet size restrictions were in place but unenforced, and observers in the islands noted that mullet fisheries in Honolulu were rapidly declining (Cobb, 1902). The fine mesh nets widely in use were removing large portions of juveniles from important coastal species including *akule*, *ulua* (Crevalle), and goatfishes. In 1905, net sizes were regulated. In 1911, seasonal restrictions were placed on mullet. (Khil, 1978). These controls all required enforcement investment by the state. By mid-century, the decline in

[10] 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.

commercial coastal species was cause for public debate. On the one hand, the problem was identified as open access itself:

> Owners of fishing rights [*konohiki*] who are far-sighted – and many of them there are – do not allow their fisherman to keep inshore fish that have not reached the spawning age…
>
> Nearly everyone who has lived in the Islands for three or more decades has noticed the rapid decline of the inshore fish food supply. (Honolulu Advertiser, Apr 13, 1954).

Others felt that enforcement was the problem, and that continued open access with greater enforcement was a better use of resources: "[Given] the proper law and manpower, there is no reason why the Territorial Fish and Game Division should not enforce stronger conservation measures." (Honolulu Star-Bulletin, Jul 24, 1945).

This latter argument seems to have won. As federal fisheries law has developed, various quota systems have been imposed, eventually allowing transferability. In the 1980's and '90's, government fishing restrictions of quotas, seasons, and type of equipment, were supplemented by breeding programs whereby selected fishing grounds were restocked by juvenile fish bred in captivity.[11] All of these regulations were oriented to mitigating overfishing. The connectivity of different systems was left unaccounted for, and the benefit of a single manager of the mountain-to-sea *ahupua´a* unit was foregone.

4. Introduction of a second policy instrument: fingerling distribution

In the 1990's and in the early years of the 21st century, private entrepreneurs obtained leases to raise certain fish species, principally *kahala* and *moi*, in ocean cages. Some entrepreneurs expected a secondary market in fingerlings to help defray the investment costs. Simultaneously, the Oceanic Institute, a non-profit research organization with state and federal funding, began releasing fingerlings or providing them at no or low cost to fish farmers. Some of the owners have claimed that the subsidized breeding programs have rendered their businesses

[11] Both the Department of Land and Natural Resources, Division of Aquatic Resources, and the National Marine Fisheries undertake these programs.

unprofitable and filed suit against the agencies whom they hold responsible. We describe this situation in Figure 4[12].

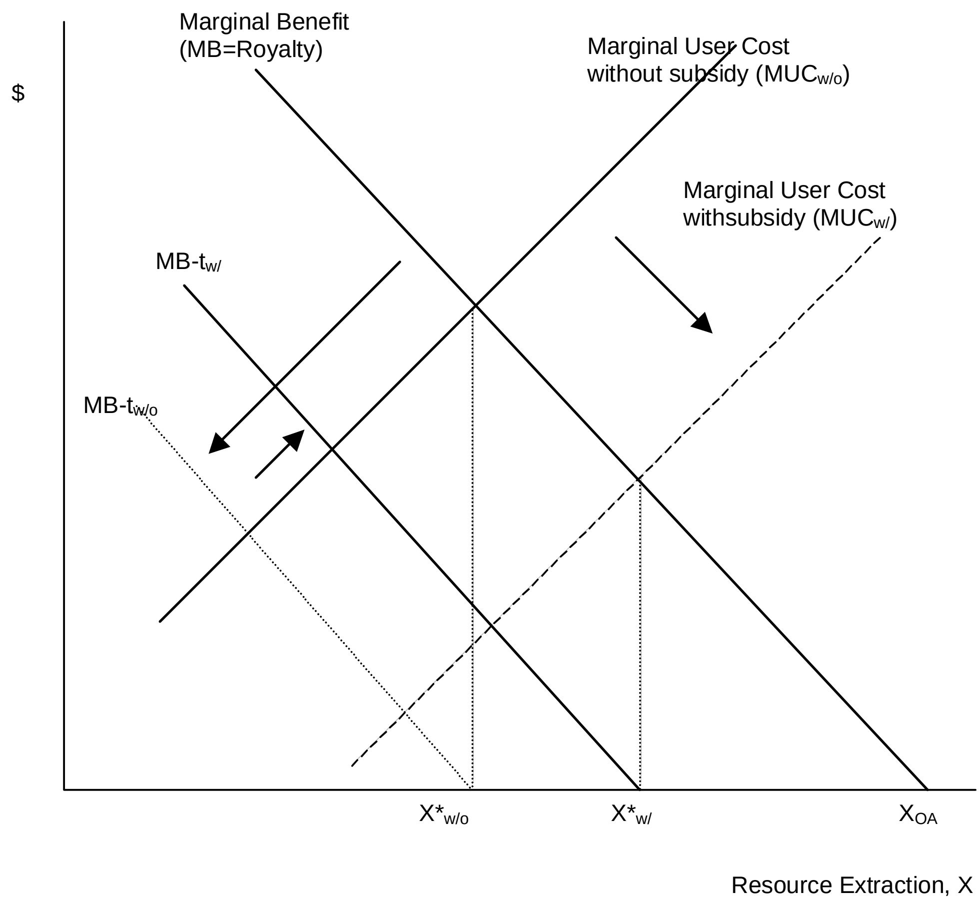

Figure 4: Simultaneous Solution of Pigouvian Tax and Fingerling Subsidy

Here, we see that a Pigouvian Tax or equivalent quota system alone can decrease the marginal benefits to MB-$t_{w/o}$ and return the equilibrium to the optimum ($X^*_{w/o}$) from the open access outcome, but that a higher extraction rate ($X^*_{w/}$) and lower tax ($t_{w/}$) can be sustained with a simultaneous subsidy in the form of fingerling releases that increase the resource population and reduce marginal user cost from $MUC_{w/o}$ to $MUC_{w/}$. While this two-instrument policy is a creative solution to the dynamic open access problem, it ignores the role that institutions could

[12] For a two-instrument Pigouvian intervention for paper tax and recycling subsidy, see Spofford (1971).

play in creating similar outcomes with reduced intervention. The equilibrium parallels the development of the *kapu* system and fishponds as a method for controlling and supplementing fishery stocks. This analogy is so direct that the Pigouvian solution Hawaii has implemented has even resulted in restoration of fishponds on Molokai and training of individuals in fishpond management.

4. Summary and Conclusions

The second-best theory of induced institutional change predicts an increase in conservation effort as population pressure depletes natural resources. Unlike previous theoretical frameworks, the suggested theory allows for changing resource extraction (or changing investment) over time. Within this framework we show that open access can be both first and second-best optimal. 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 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 under subsequent rulers. The intervention of Western culture and politics created an additional (third-best) force at odds with efficient institutional change. 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 public 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.

Institutional change in pre-contact Hawaii also illustrates the co-evolution of intensification and specialization in an increasingly layered hierarchy. Inasmuch as Western institutions were exogenously imposed, we do not know whether the hierarchical control would have eventually withered away and been replaced by market institutions. But considerable specialization and exchange was possible within the hierarchical system. 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? 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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