Who Should Own the Past?

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Who Should Own the Past?*

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Abstract

We examine restitution of cultural goods. We show that host country ownership and location of the cultural good can be optimal when the host country invests in restoration and has indispensable technical skills. Full restitution becomes optimal when the host country completes restoration, while return in the form of loan to the source country can be optimal when the source country becomes indispensable due to its cultural significance. Valuation changes can trigger restitution, but do not pin down its optimal form. We apply our analysis to the restitution of Icelandic manuscripts and the proposed loan of Benin bronzes to Nigeria.

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1 Introduction

The return of cultural goods to their country of origin has always been a contentious issue. One needs to look no further than the cases of the Icelandic manuscripts and of the Parthenon marbles to get an idea of how controversial such restitutions are. The Icelandic manuscripts, the largest restitution of cultural goods to day, were returned to Iceland in their entirety in 1997, eighty years after the initial request. In the case of the Parthenon marbles, the initial request for their return was made more than a century ago and the issue has yet to be resolved.[1]

The issue of restitution of cultural goods is, in essence, a question of ownership. Who should own the cultural good, the country of origin or the host country? The debate over the ownership of such goods has been primarily based on legal, historical and moral arguments. Has the host country acquired the cultural good legally? Do colonial powers have a moral obligation to return cultural heritage back to their ex-colonies? Economic considerations are largely absent from this debate. We are addressing this open question by examining which ownership structure gives the best incentives to invest in the cultural goods. We model cultural goods as public goods and apply the property rights approach of Grossman and Hart (1986) and Hart and Moore (1990) and its application to public goods by Besley and Ghatak (2001) in determining the optimal ownership structure for the cultural good.

Full restitution is not the only form of return under discussion. When Emmanuel Macron opened his case for restitution of Africa's cultural heritage, he referred to *"temporary or definite restitution"*.[2] Temporary restitution is in fact a loan to the source country as the host country does not relinquish ownership.[3] This is the form of return currently agreed for the Benin Bronzes. European museums have agreed to lend some of their Benin Bronzes to the planned Edo Museum for West African Art

[1]For more details and for further examples see Greenfield (2007).

[2]Nayeri, Farah. 2018. "Museums in France Should Return African Treasures, Report Says." *New York Times*, November 21. https://www.nytimes.com/2018/11/21/arts/design/france-museums-africa-savoy-sarr-report.html. Accessed 2021-12-08.

[3]Macron later commissioned a report on African cultural heritage. The report recommends permanent restitution for "*any objects taken by force or presumed to be acquired through inequitable conditions*" (Sarr and Savoy, 2018, p. 61).

on a rotating basis. Definite restitution transfers also the ownership to the source country – as in the case of Icelandic manuscripts. In this paper we explore the difference in these forms of return for the incentives to invest in the cultural good.

There are two countries in our model, source country, I (Iceland), and host country, D (Denmark). Both countries invest in the cultural good project. Suppose that D invests in physical capital, such as restoration of the cultural good, while I invests in human capital, such as studying the history of the cultural good. Suppose also that D is indispensable due to its technical expertise, while I is moderately indispensable due to its local and cultural knowledge. We analyze how ownership and location of the cultural good affect investment incentives. We assume that I has a higher valuation for its cultural heritage and both countries prefer location in their own country. These assumptions imply that the valuation difference is maximal when the cultural good is located in I. This property plays an important role in our analysis. We also assume that location in I is first best as our focus is on national treasures. However, location in D may improve investment incentives.

We show that when D invests in the restoration of the cultural good and is indispensable due to technical expertise, I ownership and location give poor incentives for *both* countries – and the overall incentives can be improved by D ownership and location. However, when D completes the restoration stage or when I becomes indispensable due to its cultural significance, the return of the cultural good becomes optimal. In what follows, we examine the form of the return, i.e. whether full restitution or loan is optimal.

Suppose that I owns the cultural good. Then the default in Nash bargaining is that I continues the project on its own, in which case D's physical capital investment remains sunk in the cultural good improving both agents' default payoffs (public good benefits both parties even when no agreement in reached). Due to I's higher valuation for the cultural good, D's investment increases I's default payoff more than its own, weakening D's bargaining position and incentives. This negative bargaining effect is further exacerbated by location in I as then the valuation difference is maximal.[4]

[4]We assume for simplicity that location does not limit D's ability to invest in physical capital. D can restore the cultural good even when it is located in I. This could be achieved e.g. by visiting

Therefore, I ownership and location provide poor incentives for D. Even I has weak incentives under I ownership because its positive bargaining effect (positive due to its higher valuation for the cultural good) is eliminated by D's indispensability. I's investment does not improve the default payoffs when indispensable D leaves the project.

We show that it can be optimal for the cultural good to be owned by the lower valuation country D and to be located in the lower valuation country D. Transferring ownership to D curbs the negative bargaining effect – and improves D's incentives – because D's investment does not fully contribute to the default payoffs when I is moderately indispensable. Changing the location to country D further limits the negative bargaining effect because the valuation difference is minimal. However, since given investments are less valuable in country D, D's investment is increased only if the negative bargaining effect is sufficiently large, which indeed is the case since I is moderately indispensable.

Let us then turn our attention to I's incentives. Since I's investment is in human capital – which does not spill over to the project when I leaves – it does not affect the default payoffs under D ownership. Under I ownership I's investment does not affect the default payoffs either due to D's indispensability and, therefore, transferring ownership to D does not affect I's incentives. However, moving location to country D reduces the value of I's investment. Therefore, moving location to country D increases surplus if the benefit of D's higher investment outweighs the cost of lower value of I's investment.[5] In sum, it can be optimal for the cultural good to be owned by the lower valuation party D and to be located in the lower valuation country D.[6]

Suppose then that D completes the restoration stage and changes to investing

staff, which is in fact a common practise between the Arnamagnæan Institute at the University of Copenhagen and the Árni Magnússon Institute for Icelandic Studies in Iceland.

[5]Additionally, the value of given investments in country D cannot be too low compared to country I.

[6]Note that this argument does not justify the historic removal of cultural goods from their country of origin. Our model assumes that any changes in ownership and location are legal and compensated for. Furthermore, while the setup of our model – two countries participating in a joint cultural good project – is relevant for current times, it is not a good description of the era when the cultural goods were removed.

in human capital. Since there is no spillover from human capital, D's negative bargaining effect is fully eliminated by I ownership. As the negative bargaining effect is reduced to zero, it cannot be further reduced by location in D – and it becomes optimal to return the cultural good to country I. If completion of restoration makes D relatively dispensable, transferring ownership to I restores I's positive bargaining effect and improves I's incentives. Thus, full restitution of the cultural good maximizes both countries' incentives. We argue that the restitution of the Icelandic manuscripts is broadly consistent with these conditions. Denmark became relatively dispensable as Iceland developed expertise by cooperating with Denmark. Furthermore, restoration by Denmark was largely completed by the time the manuscripts were returned.

A change in I's role can result in a different form of restitution, loan to I. Suppose I becomes fully indispensable as in the current era it is important for the artefact to engage with its original cultural environment. Then it is D ownership that eliminates D's negative bargaining effect and location in D is no longer needed to mitigate it. Moving the cultural good to country I improves also I's incentives while ownership does not affect I's incentives if D continues to be indispensable. Therefore, returning the cultural good to country I as a loan provides the best incentives for both countries.

However, if D were to become relatively dispensable, then I ownership would restore I's positive bargaining effect and maximize I's incentives. Then full restitution may be optimal. We discuss the proposed loan of the Benin bronzes to Nigeria in the light of these results. If the European museums continue to be indispensable, e.g. due to their expertise in conservation and exhibition design, Nigeria's indispensability implies that loan is optimal in our model. However, if the European museums become relatively dispensable – e.g. due to plans to avoid Western 'glass box' exhibition style – full restitution may be optimal.

Furthermore, we show that changes in the valuations for the cultural good can trigger restitution. A rise in the national identity of the source country – increasing the value of source country location – or the diminished role of museums as ways to encounter other cultures – reducing the value of host country location – can lead to the return of the cultural good. However, valuation changes do not pin down the form of the return but it depends on the technological factors discussed above.

We also analyze how cost asymmetries between D and I affect restitution. A common argument against restitution is that the source countries have weaker resources to take care of their cultural treasures. However, recently source countries have made significant investments in technical and scholarly resources. We examine how the reduced asymmetries affect incentives and the optimality of restitution. We find that reduced cost asymmetries make either full restitution or loan to I more likely. However, the effect on D ownership and location is ambiguous. By reverse argument, I's weaker resources do not necessarily favour D ownership and location.

Finally, we analyze less common forms of restitution, such as returning the cultural good to the source country under joint ownership or transferring ownership to the source country but keeping the cultural good in the host country as a loan. We find that joint ownership is optimal in circumstances where it is the only way to mitigate the negative bargaining effect, while loan to the host country can be optimal for cultural goods that are not of a major significance to the source country.

Our paper builds on Besley and Ghatak's (2001) analysis of ownership of public goods. They show that ownership should be allocated to the party who values the public good the most, regardless of technological factors. Their analysis has been extended in various ways. Halonen-Akatwijuka (2012) allows the agents to be indispensable and shows that the nature of human capital and technology are also important determinants of the optimal ownership structure. Halonen-Akatwijuka and Pafilis (2014) introduce location choice and find that it can be optimal to separate location from ownership. Our model is closely related to both extensions.[7] In this paper we show that ownership by the lower valuation party and location in the lower valuation country can be optimal and can arise in natural circumstances. We furthermore examine the triggers of changes in ownership and location. The literature has also analyzed ownership of impure public goods (Francesconi and Muthoo,

[7]Location of public goods has also been analyzed using the Hotelling model. However, this literature does not consider ownership. See e.g. Cremer et al. (1985) and Chau and Huysentruyt (2006).

2011), applied generalized Nash bargaining solution (Schmitz, 2013) and examined asymmetric information (Schmitz, 2021).

To the best of our knowledge, our paper provides the first economic analysis of restitution of cultural goods. Kremer and Wilkening (2015) examine the effect of export bans on the trade of antiquities focusing on the opposite problem - how to keep antiquities in the home country. They argue that complementing export bans with long-term leases, where the value of the object is determined in the competitive market, can provide incentives to maintain and reveal antiquities. Our paper also contributes to the economics literature on cultural goods that has examined auctions (see Ashenfelter and Graddy, 2003, and Ashenfelter and Graddy, 2006, for a survey), trade of illicit artefacts (Fisman and Wei, 2009), museums (see Frey and Meier, 2006, and Fernández-Blanco and Prieto-Rodríguez, 2020, for a review) and heritage (e.g. Rizzo and Throsby, 2006; Benhamou, 2020).

2 The model

We model cultural goods as public goods. There are two agents, source country 1 and host country 2, making investments, y_1 and y_2, in the cultural good. Investments can be in physical capital, such as restoration of the cultural good, or in human capital, such as studying the history of the cultural good. The investments are specific to the cultural good, observable to both agents but not verifiable to third parties. The investments are measured by their costs, $c(y_i) = y_i$.

The benefit from the cultural good project depends on investments and is given by $v(12, a\,|y_1, y_2)$ when agents 1 and 2 participate in the project, where a is the cultural good. We assume that the benefit function is symmetric in investments, $v(12, a\,|y_1, y_2) = v(12, a\,|y_2, y_1)$, increasing and concave and satisfies the Inada end point conditions.[8] We denote $v^i(12, a\,|y_1, y_2) = \partial v(12, a\,|y_1, y_2)\,/\partial y_i$ and assume $\partial^2 v(12, a\,|y_1, y_2))/\partial y_i \partial y_j = 0$ for $i \neq j$. To simplify notation, we drop the reference to investments, unless necessary for clarity, and write $v(12, a)$ and $v^i(12, a)$.

[8]In Section 5.1 we examine asymmetric investments in terms of costs.

The agents value the project differently. Their valuation depends also on the location of the cultural good. The value of the cultural good to agent i is $\Theta_i v(12, a)$ if it is located in country 1 and $\theta_i v(12, a)$ if located in country 2. We assume that each agent prefers location in their own country, $\Theta_1 > \theta_1$ and $\Theta_2 < \theta_2$, and that agent 1, the source country, has higher valuation for its cultural heritage, $\Theta_1 > \Theta_2$ and $\theta_1 > \theta_2$. These assumptions imply the following ranking.[9]

Assumption 1. $\Theta_1 > \theta_1 > \theta_2 > \Theta_2$.

Assumption 1 implies that location in country 2, the host country, reduces the valuation difference, $\theta_1 - \theta_2 < \Theta_1 - \Theta_2$. This feature will play an important role in our analysis.

We also assume that for given investments location in the source country is optimal.

Assumption 2. $\Theta_1 + \Theta_2 > \theta_1 + \theta_2$.

Assumption 2 holds when Θ_1 is sufficiently large. This is a reasonable assumption for national treasures, the focus of this paper. However, location in the host country may improve incentives to invest in the cultural good.

The first best investments in the cultural good located in country 1 are given by

$$(\Theta_1 + \Theta_2)\, v^i(12, a) = 1 \;\; i = 1, 2. \tag{1}$$

We furthermore analyze the ownership of the cultural good. The cultural good can be owned by agent 1, agent 2 or be jointly owned, denoted by J. We denote by $o : \ell$ a structure where $o \in \{1, 2, J\}$ is the owner and $\ell \in \{1, 2\}$ is the location. We are particularly interested in the case where 2:2 is the starting point – i.e., where the cultural good is both owned by and located in the host country – and the return of the cultural good to the source country becomes optimal. The form of the return depends

[9] An alternative assumption is that agent 2 becomes the higher valuation agent when the cultural good is located in country 2 and therefore $\Theta_1 > \theta_2 > \theta_1 > \Theta_2$. Assumption 1 is reasonable for national treasures. We explore the alternative assumption in Section 5.2.

on who owns the cultural good. Full restitution occurs when also the ownership is transferred to country 1, 1:1. The Icelandic manuscripts are an example of this type of restitution. It is also possible for the host country to return the cultural good to the source country, but keep the ownership, i.e. return it as a loan, 2:1. This form of return is planned for the Benin bronzes. In addition to these common forms of return, our model offers further possibilities. First, the returned cultural good can be jointly owned, J:1. Second, ownership can be transferred to agent 1 but the cultural good can be kept in country 2 as a loan, 1:2.

We build on the property rights theory of Grossman and Hart (1986) and Hart and Moore (1990) and its application to public goods by Besley and Ghatak (2001). We assume that contracts are incomplete so that date 0 contracts can only be written on the ownership and location of the cultural good. The timing of the model is as follows.[10]

0. The agents contract on the ownership and location of the cultural good.
1. The agents invest in the cultural good.
2. The agents bargain and complete the cultural good project.

At date 0, the agents contract on surplus maximizing ownership and location of the cultural good and make any lump sum transfers to achieve it. At date 1 the agents make their investments anticipating date 2 division of surplus by Nash bargaining. Default payoffs play an important role in bargaining and depend on who owns the cultural good. If the agents fail to reach an agreement, the owner has the residual control rights to complete the project without the other agent. However, since the cultural good is a public good, both agents can benefit from it even under disagreement. The default payoffs under agent i ownership are $\Theta_k v(i, a)$ for $i, k = 1, 2$, if the cultural good is located in country 1 and $\theta_k v(i, a)$ if the cultural good is in country 2. $v(i, a)$ is increasing and concave in the investments and satisfies Inada endpoint conditions. We denote $v^k(i, a) = \partial v(i, a)/\partial y_k$ and assume $\partial^2 v(i, a)/\partial y_i \partial y_j = 0$ for $i, j, k = 1, 2, i \neq j$.

Assumption 3. $v^i(12, a) \geq max\, \{v^i(i, a), v^i(j, a)\}$ for $i, j = 1, 2, i \neq j$.

[10] We assume that the time period between dates 1 and 2 is too short for renegotiating location. In the context of cultural goods, such negotiations are lengthy, lasting for decades.

According to Assumption 3 the marginal return to investment is maximal when both agents participate in the project. The marginal return to agent i's investment when he works on his own, $v^i(i,a)$, depends on how dispensable agent j is. If agent j is dispensable, his absence does not affect the marginal return, $v^i(i,a) = v^i(12,a)$. While if agent j is indispensable, his absence reduces the marginal return to zero, $v^i(i,a) = 0$. An agent can be indispensable if he has considerable expertise that is crucial to the project or due to limited availability of alternative trading partners. We examine $v^i(i,a) \in [0, v^i(12,a)]$.

The marginal return to agent j's investment when he leaves the project, $v^j(i,a)$, depends on the type of investment. If the investment is in physical capital, the investment remains sunk in the cultural good if agent j leaves the project and $v^j(i,a) = v^j(12,a)$. While if the investment is in human capital, agent j leaves the project with his human capital and $v^j(i,a) = 0$. In what follows, we refer to $v^j(i,a)$ as the spillover from agent j's investment and allow for $v^j(i,a) \in [0, v^j(12,a)]$.

Under joint ownership each agent has a veto right and therefore they have to reach a unanimous decision about the completion of the project. Therefore, the default payoffs are zero for each agent.

In Nash bargaining each agent obtains his default payoff plus half of the gains from trade. The bargaining outcome depends on ownership via the default payoffs and therefore ownership – and location – affect investment incentives at date 1. Our aim is to find the ownership structure and location that give the agents the best incentives to invest in the cultural good.

3 Ownership, location and investment incentives

To determine the optimal ownership and location of the cultural good, we start by examining the investment incentives in each structure.

3.1 Source country ownership and location

Let us first analyze incentives to invest when the cultural good is both owned by and located in country 1, 1:1. Nash bargaining leads to the following payoffs for the agents.

$$u_1^{1:1} = \Theta_1 v(1,a) + \frac{1}{2}(\Theta_1 + \Theta_2)[v(12,a) - v(1,a)] - y_1$$

$$= \frac{1}{2}(\Theta_1 + \Theta_2)\, v(12,a) + \frac{1}{2}(\Theta_1 - \Theta_2)\, v(1,a) - y_1$$

$$u_2^{1:1} = \frac{1}{2}(\Theta_1 + \Theta_2)\, v(12,a) - \frac{1}{2}(\Theta_1 - \Theta_2)\, v(1,a) - y_2$$

The investment incentives are

$$\frac{1}{2}(\Theta_1 + \Theta_2)\, v^1(12,a) + \frac{1}{2}(\Theta_1 - \Theta_2)\, v^1(1,a) = 1, \tag{2}$$

$$\frac{1}{2}(\Theta_1 + \Theta_2)\, v^2(12,a) - \frac{1}{2}(\Theta_1 - \Theta_2)\, v^2(1,a) = 1. \tag{3}$$

The investments are lower than the first best given in (1) due to the holdup problem, which gives the first term in (2) and (3). The second term – positive for agent 1 and negative for agent 2 – arises from the nature of the public good: the agents can benefit from the cultural good even if they cannot agree how to work together. When agent 2 increases his investment, he increases high-valuation agent 1's default payoff more than his own, weakening his bargaining position. This negative bargaining effect reduces 2's investment even from the holdup level and is maximal when the investment is fully sunk in the project, $v^2(1,a) = v^2(12,a)$, e.g. when 2's investment is in physical capital such as restoration of the cultural good. In this case agent 2 has poor incentives and 1:1 may not be the optimal structure. We initially assume that $v^2(1,a)$ is large and explore how to improve 2's incentives for restoration.

The second term in (2) is positive for agent 1. When agent 1 increases her investment, her default payoff increases more than agent 2's, improving her bargaining position. The strength of this positive bargaining effect depends on how dispensable agent 2 is. If agent 2 is fully dispensable, $v^1(1,a) = v^1(12,a)$, the positive effect is strong. While if 2 is so indispensable that the marginal return to agent 1's investment is reduced to zero if 2 does not work on the project, $v^1(1,a) = 0$ and the second term equals zero.

Therefore, if agent 2 invests in restoration and is quite indispensable due to his technical expertise, both agents have poor incentives under 1:1. Next we will examine if the incentives can be improved by transferring ownership to agent 2 – but keeping location in country 1.

3.2 Loan to the source country

When country 2 owns the cultural good and loans it to country 1, 2:1, the default payoffs depend on $v(2,a)$, the benefit of the project in the absence of agent 1. Nash bargaining payoffs are

$$u_1^{2:1} = \frac{1}{2}(\Theta_1 + \Theta_2)\, v(12,a) + \frac{1}{2}(\Theta_1 - \Theta_2)\, v(2,a) - y_1,$$

$$u_2^{2:1} = \frac{1}{2}(\Theta_1 + \Theta_2)\, v(12,a) - \frac{1}{2}(\Theta_1 - \Theta_2)\, v(2,a) - y_2,$$

and the incentives to invest are

$$\frac{1}{2}(\Theta_1 + \Theta_2)\, v^1(12,a) + \frac{1}{2}(\Theta_1 - \Theta_2)\, v^1(2,a) = 1, \tag{4}$$

$$\frac{1}{2}(\Theta_1 + \Theta_2)\, v^2(12,a) - \frac{1}{2}(\Theta_1 - \Theta_2)\, v^2(2,a) = 1. \tag{5}$$

(3) and (5) show that if $v^2(1,a) \geq v^2(2,a)$, ownership improves 2's incentives by reducing the effect of agent 2's investment on his default payoff. The negative bargaining effect is reduced if agent 1 is not too dispensable so that 2's investment does not fully contribute to the default payoffs under 2:1.

Also agent 1's incentives are improved if agent 2 is quite indispensable, $v^1(1,a) \leq v^1(2,a)$, as shown by (2) and (4). Then owning the cultural good does not improve agent 1's bargaining position since her investment is not very valuable without agent 2. In this case ownership by agent 2 improves both agents' incentives.

Alternatively, if agent 2 is quite dispensable, $v^1(1,a) > v^1(2,a)$, ownership strengthens 1's positive bargaining effect and allocating ownership to agent 2 weakens 1's incentives.

3.3 Host country ownership and location

Let us now examine if agent 2's restoration incentives can be further improved by locating the cultural good in country 2. We can obtain the investment incentives under 2:2 from (4) and (5) by replacing Θ_i by θ_i.

$$\frac{1}{2}(\theta_1+\theta_2)\,v^1(12,a)+\frac{1}{2}(\theta_1-\theta_2)\,v^1(2,a)=1 \tag{6}$$

$$\frac{1}{2}(\theta_1+\theta_2)\,v^2(12,a)-\frac{1}{2}(\theta_1-\theta_2)\,v^2(2,a)=1 \tag{7}$$

Location in country 2 reduces the valuation difference, $(\theta_1-\theta_2)<(\Theta_1-\Theta_2)$, and mitigates the negative bargaining effect for agent 2. However, now also the first term in (7) is lower since $(\theta_1+\theta_2)<(\Theta_1+\Theta_2)$. Therefore 2:2 increases y_2 relative to 2:1 if and only if the negative bargaining effect is strong enough:

$$v^2\left(2,a\left|y_2^{2:2}\right.\right)>\theta^* v^2\left(12,a\left|y_2^{2:2}\right.\right), \tag{8}$$

where $\theta^*=\frac{(\Theta_1+\Theta_2)-(\theta_1+\theta_2)}{(\Theta_1-\Theta_2)-(\theta_1-\theta_2)}\in(0,1)$ and $y_2^{2:2}$ satisfies (7).

Agent 1's investment is lower under 2:2 relative to 2:1 since both the first and the second term are lower in (6) as compared to (4). However, since in any structure agent 2's investment is lower than agent 1's, $y_2^{i:j}\leq y_1^{i:j}$, and the value function is concave, increasing the lower y_2 can be optimal even if it results in some reduction in the higher y_1.

Finally, if $v^2(2, a\,|y_2^{2:2}) \leq \theta^* v^2(12, a\,|y_2^{2:2})$, both agents' investments are higher under 2:1 and 2:2 cannot be optimal.

3.4 Joint ownership

Under joint ownership the agents have to reach a unanimous decision. Therefore, the default payoffs are zero and the agents split the surplus 50:50. If the cultural good is located in country 1, the payoffs are

$$u_i^{J:1} = \frac{1}{2}\left(\Theta_1 + \Theta_2\right) v(12, a) - y_i \;\; i = 1, 2$$

and the investment incentives are

$$\frac{1}{2}\left(\Theta_1 + \Theta_2\right) v^i(12, a) = 1 \;\; i = 1, 2. \tag{9}$$

(9) shows that joint ownership provides the maximal incentives to agent 2 by eliminating the negative bargaining effect. However, also agent 1's positive bargaining effect is eliminated. Therefore, joint ownership may be too costly in terms of poor incentives for agent 1.

Note that location in country 1 maximizes the investments given joint ownership since $(\Theta_1 + \Theta_2) > (\theta_1 + \theta_2)$.

4 Return of the cultural good

Section 3 showed that host country ownership and location, 2:2, can provide good investment incentives when agent 2 invests in the restoration of the cultural good and has indispensable technical skills. We summarize these results in Lemma 1. We denote investments under $o : \ell$ by $y_1^{o:\ell}$ and $y_2^{o:\ell}$ and for clarity include the relevant investment explicitly in the notation.

Lemma 1 *(i)* $y_2^{1:1} \leq y_2^{2:1}$ *if and only if* $v^2(2, a\,|y_2) \leq v^2(1, a\,|y_2)$. $y_2^{2:1} \leq y_2^{2:2}$ *if and only if* $\theta^* v^2(12, a\,|y_2^{2:2}) \leq v^2(2, a\,|y_2^{2:2})$. $y_2^{2:2} < y_2^{J:1}$.

(ii) $y_1^{J:1} \leq y_1^{1:1}$. $y_1^{1:1} \leq y_1^{2:1}$ *if and only if* $v^1(1, a\,|y_1) \leq v^1(2, a\,|y_1)$. $y_1^{2:2} < y_1^{2:1}$.

All the proofs are in the Appendix.

When agent 2 invests in the cultural good, his investment increases high-valuation agent 1's default payoff more than his own, improving 1's bargaining position. This negative bargaining effect weakens 2's incentives and is significant under 1:1 when the spillover from 2's investment to the default payoffs is large, $v^2(1, a) = v^2(12, a)$. Lemma 1 shows that 2:2 can mitigate this incentive problem. The negative bargaining effect is reduced by 2-ownership if agent 1 is not too dispensable, $v^2(2, a) < v^2(1, a)$. Location in country 2 further decreases the negative bargaining effect by reducing the valuation difference. Joint ownership would eliminate the negative bargaining effect but it can be too costly in terms of poor incentives for agent 1.

Agent 1's incentives are improved by 2-ownership when 2 is quite indispensable, $v^1(1, a) < v^1(2, a)$, as 2's indispensability limits 1's positive bargaining effect under 1-ownership. Locating the cultural good in country 2 weakens 1's incentives, but given the concavity of the benefit function it can be more than compensated by improvement in the lower investment by agent 2.

Lemma 1 summarizes the main tradeoffs and demonstrates that a fine balance of incentives is required for 2:2 to be optimal. In Section 4.1 we introduce specific functional forms and show that such balance can indeed be stricken. While 2:2 can maximize surplus, we cannot apply this result to justify the historic removal of cultural goods from their country of origin. First, contracting on the surplus maximizing structure at date 0 involves a lump sum transfer in order for both parties to benefit from any change in ownership or location. While some cultural goods were acquired legally, e.g. Icelandic manuscripts, some were looted, e.g. Benin bronzes. Second, our model is about mitigating inefficiencies in a joint cultural goods project. While this is a relevant model for current times, it does not speak to the situation in the 19th century or earlier when source countries did not have any role with the Western museums holding their cultural goods. Therefore, optimality of 2:2 in our model simply implies that restitution is not always surplus maximizing.

Suppose that initially agent 2 invests in restoration and has indispensable skills so that 2:2 is optimal. What changes are needed for the return of the cultural good to become optimal? Proposition 2 explores technological changes that can trigger restitution.

Proposition 2 *(i) Source country ownership and location, 1:1, is optimal if there is no spillover from agent 2's investment,* $v^2(1, a) = 0$*, and agent 2 is sufficiently dispensable,* $v^1(1, a) \geq v^1(2, a)$*.*

(ii) Loan to the source country, 2:1, is optimal if agent 1 is fully indispensable, $v^2(2, a) = 0$*, and agent 2 is sufficiently indispensable,* $v^1(1, a) \leq v^1(2, a)$*.*

When agent 2 completes the restoration stage, $v^2(1, a) = 0$, 1:1 provides the best incentives for agent 2 as it eliminates the negative bargaining effect. Also agent 1 has maximal incentives under 1:1 if completion of the restoration also makes 2 quite dispensable, $v^1(1, a) \geq v^1(2, a)$, strengthening the positive bargaining effect for agent 1 under 1-ownership. Therefore, full restitution is optimal.

In Section 6 we argue that in the case of Icelandic manuscripts, Denmark became relatively dispensable as Iceland developed expertise through close cooperation with Denmark. Furthermore, restoration of the manuscripts was largely completed by the time they were returned to Iceland. According to Proposition 2(i), full restitution provides the best incentives for both Iceland and Denmark in such circumstances.

Return can also be triggered by a change in agent 1's role. When it is important for the cultural good to engage with its original culture, agent 1 becomes indispensable, $v^2(2, a) = 0$. Then 2's negative bargaining effect is removed under 2-ownership as 2's investment is valuable only with agent 1. Since the negative bargaining effect is eliminated, location in country 2 cannot improve upon that and therefore 2:1 provides the best incentives for agent 2. Also agent 1's incentives are maximal under 2:1 if agent 2 remains quite indispensable, $v^1(1, a) \leq v^1(2, a)$. In this case, return in the form of loan to country 1 maximizes surplus.

In Section 6 we discuss the proposed loan of Benin bronzes to Nigeria in the light of this result. We argue that Nigeria has become indispensable as in the current era it is crucial for these artefacts to engage with their original culture. This can trigger the return of Benin bronzes to Nigeria in our model. If the European museums continue to have indispensable expertise, e.g. in conservation and exhibition design, the optimal return takes the proposed form of a loan. Relinquishing ownership to Nigeria would require that the European museums are quite dispensable – as only then ownership strengthens Nigeria's incentives.

Valuation changes can also trigger the return of the cultural good. However, its form is not pinned down but depends on the technological factors discussed above. First, even if 2:2 maximized the investments, it cannot be optimal if the value of given investments is sufficiently higher in country 1, i.e. $(\Theta_1 + \Theta_2) - (\theta_1 + \theta_2)$ is sufficiently large. The second effect is more subtle. In Section 3.3 we showed that 2:2 increases agent 2's investment relative to 2:1 if and only if $v^2(2, a\,|y_2^{2:2}) > \theta^* v^2(12, a\,|y_2^{2:2})$. This inequality can be satisfied only if $\theta^* < 1$. $\theta^* = \frac{(\Theta_1+\Theta_2)-(\theta_1+\theta_2)}{(\Theta_1-\Theta_2)-(\theta_1-\theta_2)}$ is the cost-benefit ratio of moving location to country 2. If $\theta^* \to 1$, the cost of lower value of given investments outweighs the benefit of reduced valuation difference – and y_2 is larger under 2:1 relative to 2:2. Then 2:2 cannot be optimal since y_1 is always larger under 2:1. Given the ranking of valuations in Assumption 1, we can define $\theta_2 = \Theta_2 + \delta_1$, $\theta_1 = \Theta_2 + \delta_1 + \delta_2$ and $\Theta_1 = \Theta_2 + \delta_1 + \delta_2 + \delta_3$. Therefore,[11]

$$\theta^* = \frac{\delta_3 - \delta_1}{\delta_3 + \delta_1} \tag{10}$$

and, consequently, $\lim_{\delta_1 \to 0} \theta^* = \lim_{\delta_3 \to \infty} \theta^* = 1$.[12] Accordingly, when θ_2 is sufficiently close to Θ_2 or Θ_1 is sufficiently large, 2:2 cannot be optimal. Proposition 3 summarizes the above analysis.

Proposition 3 *Host country ownership and location, 2:2, cannot be optimal if* $(\Theta_1 + \Theta_2) - (\theta_1 + \theta_2)$ *is sufficiently large.*

A reduction in agent 2's valuation for the cultural good located in the host country, θ_2, can trigger the return of the cultural good. θ_2 can be reduced e.g. by

[11] Note that by Assumption 2 $\delta_3 > \delta_1$.
[12] Furthermore, $\partial\theta^*/\partial\theta_2 < 0$ and $\partial\theta^*/\partial\Theta_1 > 0$.

increased opportunities to encounter other cultures. Such opportunities were limited in the 19th century and early 20th century when, for example, Picasso saw an African mask in an exhibition inspiring his African era. Alternatively, a rise in national identity – such as when Iceland gained independence from Denmark – increases agent 1's valuation for the cultural good located in the source country, Θ_1. Both changes can trigger the return of the cultural good but its optimal form depends on the technological factors.

4.1 Parametric example

We will now introduce specific functional forms and demonstrate that location in country 2 – requiring a fine balance of incentives – can indeed be optimal. We assume that $v(12, a) = (y_1)^{\frac{1}{2}} + (y_2)^{\frac{1}{2}}$ and $v(i, a) = \lambda_j (y_i)^{\frac{1}{2}} + \mu_j (y_j)^{\frac{1}{2}}$ where $\lambda_j \in [0, 1]$ is the degree of agent j's dispensability and $\mu_j \in [0, 1]$ is the degree of spillover from agent j's investment.

Proposition 4 finds when 2:2 is optimal.

Proposition 4 *Host country ownership and location, 2:2, is optimal if* $\lambda_1 \in \left[\underline{\lambda}, min\left\{\mu_2, \overline{\lambda}\right\}\right]$, $\lambda_2 \leq \mu_1$ *and* $(\Theta_1 + \Theta_2) - (\theta_1 + \theta_2) < \overline{\Theta}$*, where* $0 < \underline{\lambda} < \overline{\lambda} < 1$ *and* $\overline{\Theta} > 0$.

According to Proposition 4, optimality of 2:2 requires firstly that the spillover from 2's investment is large enough, $\mu_2 \geq \underline{\lambda}$, so that the negative bargaining effect under 1-ownership is significant. The negative bargaining effect can be reduced by 2-ownership if $\lambda_1 < \mu_2$ as a smaller proportion of 2's investment goes to the default payoffs. Location in country 2 further decreases the negative bargaining effect by reducing the valuation difference. 2:2 is then optimal if λ_1 is so large that it is necessary to change also the location to curb the negative bargaining effect, $\lambda_1 \geq \underline{\lambda}$, but not so large that it would be better to eliminate it by joint ownership, $\lambda_1 \leq \overline{\lambda}$.

Agent 1's incentives are not weakened by 2-ownership when 2 is quite indispensable, $\lambda_2 \leq \mu_1$, as 2's indispensability limits 1's positive bargaining effect under 1-ownership. Locating the cultural good in country 2 weakens 1's incentives, but 2:2 is optimal when this is outweighed by increase in agent 2's lower investment. If additionally the value of given investments in country 2 is not too low compared to country 1, $(\Theta_1 + \Theta_2) - (\theta_1 + \theta_2) < \overline{\Theta}$, 2:2 maximizes the surplus.

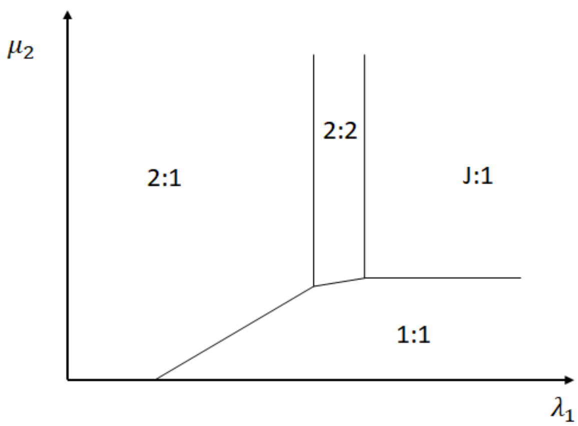

Figure 1*(a)*: Optimal structure $\mu_1 > \lambda_2$

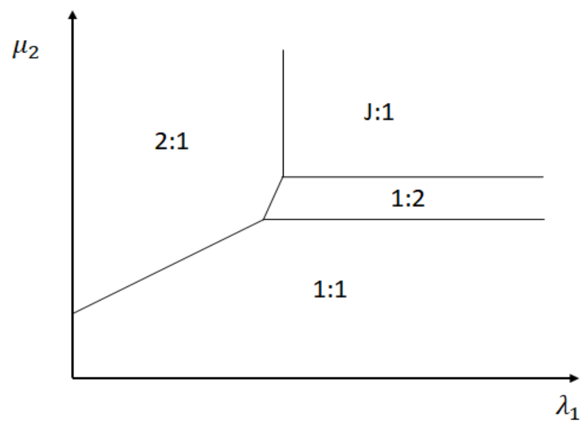

Figure 1*(b)*: Optimal structure $\mu_1 < \lambda_2$

Figure 1*(a)* illustrates Propositions 2 and 4. Parameter λ_1 measures the strength of 2's negative bargaining effect under 2-ownership while μ_2 measures it under 1-ownership. As per Proposition 4, optimality of 2:2 requires large enough μ_2 and intermediate λ_1.[13] 2:1 is optimal if λ_1 is small as then 2's negative bargaining effect is small under 2-ownership and location in country 2 is not needed to further curb it, as per Proposition 2(ii). Finally, if μ_2 is small, agent 2's incentives are not weakened much by 1-ownership and therefore 1:1 is optimal, as per Proposition 2(i).[14]

[13]Figure 1*(a)* is drawn for $\mu_1 = 0.7$ and $\lambda_2 = 0.4$ satisfying the condition in Proposition 4. Figure 1*(b)* is drawn for $\mu_1 = 0.4$ and $\lambda_2 = 0.7$.

[14]The exception is when λ_1 is very small as also 2:1 is effective in limiting the negative bargaining

Let us explore further the case where agent 1 is indispensable. Proposition 2(ii) showed that in that case 2:1 provides maximal incentives for both agents if also $\lambda_2 \leq \mu_1$. However, if agent 2 is relatively dispensable so that $\lambda_2 > \mu_1$ – and μ_1 is sufficiently small – agent 1 has much better incentives under 1:1. If furthermore μ_2 is sufficiently small so that 2's negative bargaining effect is limited – even if not eliminated – under 1:1, then surplus is maximized under 1:1 even though agent 1 is indispensable. This result is proved in Proposition 5 and illustrated in Figure 1*(b)*.

Proposition 5 *Suppose agent 1 is indispensable,* $\lambda_1 = 0$. *1:1 is optimal if agent 2 is sufficiently dispensable,* $\lambda_2 \in \left(\hat{\lambda}, 1\right]$, *and the spillover from the agents' investments is sufficiently small,* $\mu_1 \in [0, \tilde{\mu})$ *and* $\mu_2 \in [0, \hat{\mu})$, *where* $\hat{\lambda} > \mu_1$ *and* $max\{\tilde{\mu}, \hat{\mu}\} < 1$.

In the context of Benin bronzes, Proposition 5 demonstrates that while Nigeria's indispensability leads to the return of the artefacts in our model, its form depends crucially on how indispensable the host country is. If the Western museums have relatively indispensable skills, e.g. in conservation and exhibition design, then the optimal form of return is loan as per Proposition 2(ii). However, if the Western museums are quite dispensable, e.g. due to plans to avoid Western 'glass box' exhibition style – and the spillovers are low – full restitution is optimal according to Proposition 5.

Finally, while full restitution and loan to the source country are the common forms of return, our model includes further possibilities which are examined in Proposition 6.

Proposition 6 *(i) Joint ownership and source country location, J:1, is optimal if* $\lambda_1 \in \left[\overline{\lambda}, 1\right]$ *and* $\mu_2 \in [\overline{\mu}, 1]$.

(ii) Loan to the host country, 1:2, is optimal if $\mu_2 \in \left[\underline{\mu}, min\left\{\overline{\mu}, \lambda_1\right\}\right]$, $\lambda_2 \geq \mu_1$ *and* $(\Theta_1 + \Theta_2) - (\theta_1 + \theta_2) < \widetilde{\Theta}$, *where* $0 < \underline{\mu} < \overline{\mu} < 1$ *and* $\widetilde{\Theta} > 0$.

Joint ownership may be the only way to curb 2's negative bargaining effect. This is the case when agent 1 is quite dispensable, $\lambda_1 > \overline{\lambda}$, and the spillover from agent

effect. Then 2:1 is optimal, as in Figure 1*(a)* – unlike in Proposition 2(i) – $\mu_1 > \lambda_2$ and therefore agent 1's investment is higher under 2:1 than under 1:1.

2 is large, $\mu_2 > \overline{\mu}$. Then joint ownership is optimal as demonstrated in Figures 1*(a)* and 1*(b)*.

The final form of return is to transfer ownership to the source country but keep the cultural good in the host country as a loan, 1:2.[15] If agent 1 is quite dispensable, $\lambda_1 \geq \underline{\mu}$, the negative bargaining effect is large under 2-ownership. While it can be reduced by 1-ownership when $\mu_2 < \lambda_1$, it remains relatively large if $\mu_2 \geq \underline{\mu}$ and can be mitigated by location in country 2. Joint ownership would eliminate the negative bargaining effect, but also reduce agent 1's investment as 1-ownership motivates her when 2 is quite dispensable, $\lambda_2 \geq \mu_1$. Under these conditions, loan to the host country maximizes the investments – and also the surplus if the value of given investments is sufficiently high in country 2. Figure 1*(b)* illustrates that 1:2 is optimal for large enough λ_1 and intermediate μ_2.

5 Extensions

5.1 Asymmetric costs

One of the most frequently cited arguments against restitution is that the source countries have weaker resources to take care of their cultural treasures. This argument has, however, been challenged in recent times as the source countries have made significant investments, e.g. in the form of dedicated institutions such as the Árni Magnússon Institute in Reykjavik and the planned Edo Museum for West African Art. In this Section, we allow the two countries to differ in terms of their investment costs and examine how cost asymmetry affects incentives and restitution.

Suppose costs are now given by $c(y_i) = \frac{1}{\gamma_i} y_i$ for $i = 1, 2$. Suppose γ_1 increases as a result of the development of technical and scholarly resources by the source country. As agent 1's investment has become less costly, her investment increases under all the structures. Since also her first-best investment increases, the optimal structure gives more weight to agent 1's incentives. Figures 2*(a)* and 2*(b)* show how the optimal boundaries move in favour of the structure where agent 1's investment

[15] The investment incentives under 1:2 can be obtained from (2) and (3) by replacing Θ_i by θ_i.

is higher.

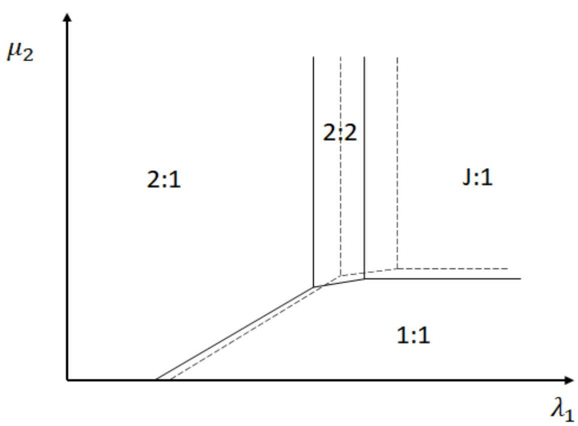

Figure 2*(a)*: Optimal structure $\mu_1 > \lambda_2$

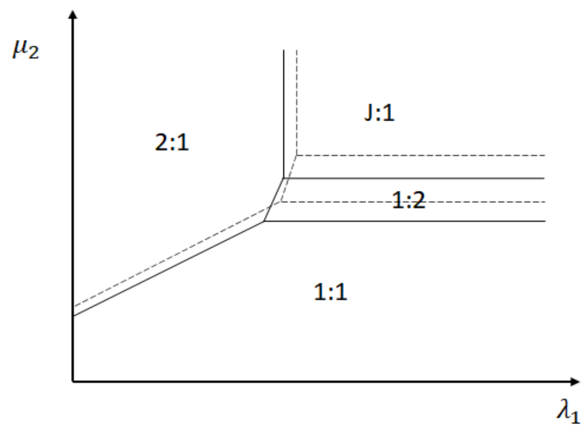

Figure 2*(b)*: Optimal structure $\mu_1 < \lambda_2$

Consider the two main forms of restitution, 1:1 and 2:1. Agent 1's investment under 2:1 is higher than under 1:1 if $\lambda_2 < \mu_1$, as 1's positive bargaining effect is minimal under 1-ownership when agent 2 is relatively indispensable. Therefore, in Figure 2*(a)* higher γ_1 shifts 1:1-2:1 boundary in favour of 2:1. Also 2:1-2:2 boundary moves in favour of 2:1 as location in country 2 reduces 1's positive bargaining effect.

In Figure 2*(b)* the effect is the opposite since agent 1's investment is higher under 1:1 than under 2:1 when agent 2 is relatively dispensable, $\lambda_2 > \mu_1$. Therefore, 1:1-2:1 boundary moves in favour of 1:1 when γ_1 increases. Also 1:1-1:2 boundary moves in favour of 1:1 since location in country 2 reduces 1's incentives. We summarize the above analysis in the following Proposition.

Proposition 7 *A reduction in agent 1's investment costs, higher γ_1,*

(i) moves 1:1-2:1 boundary in favour of 2:1 (resp. 1:1) if and only if agent 2 is sufficiently indispensable, $\lambda_2 < \mu_1$ (resp. sufficiently dispensable, $\lambda_2 > \mu_1$),

(ii) moves 2:1-2:2 boundary is favour of 2:1 and

(iii) moves 1:1-1:2 boundary in favour of 1:1.

While the development of technical and scholarly resources by agent 1 makes either full restitution, 1:1, or loan to the source country, 2:1, more likely, it may not affect 2:2 adversely. Figure 2*(a)* shows that the effect of higher γ_1 on 2:2 is ambiguous. Although 2:1-2:2 boundary shifts against 2:2, 2:2-J:1 boundary moves in favour of 2:2 as joint ownership eliminates 1's positive bargaining effect. Furthermore, by reverse argument, agent 1's poor resources do not necessarily favour 2:2, as implied by the common argument against restitution. Due to agent 2's cost advantage, the optimal structure gives greater emphasis on providing good incentives for agent 2. However, this is not necessarily achieved by 2:2.

5.2 Higher valuation host

We have assumed that the source country has a higher valuation for the cultural good irrespective of its location. We now explore an alternative assumption.

Assumption 1'. $\Theta_1 > \theta_2 > \theta_1 > \Theta_2$.

According to Assumption 1', agent 2 becomes the higher valuation agent when the cultural good is located in country 2. This is a reasonable assumption for artefacts that are not of a major cultural significance to the source country. Under Assumption 1' the second terms in the first order conditions (6) and (7) for 2:2 – and the respective equations for 1:2 – change sign. Therefore, it is agent 2 who has the positive bargaining effect under 2:2 and 1:2, while agent 1 has the negative bargaining effect. In what follows we show that our results regarding the form of restitution are robust to this alternative assumption, while 2:2 is no longer optimal under the conditions of Proposition 4.

Under Assumption 1' 1:2 dominates 2:2 when agent 2 invests in restoration, $v^2(1,a) = v^2(12,a)$, and is indispensable due to technical expertise, $v^1(1,a) = 0$. Agent 2's large negative bargaining effect under 1:1 can be turned to a large positive bargaining effect by locating the cultural good in country 2, 1:2. Allocating also ownership to agent 2, 2:2, would weaken 2's positive bargaining effect since $v^2(2,a) \leq v^2(1,a) = v^2(12,a)$. Also agent 1 has stronger incentives under 1:2 relative to 2:2 since 1's negative bargaining effect is eliminated, $v^1(2,a) \geq v^1(1,a) = 0$. Therefore, loan to the host country provides good incentives for both agents when the host is restoring a cultural good which is not of a major significance to the source country.

Full restitution remains optimal under broadly similar conditions as in Proposition 2(i). Suppose agent 2 completes restoration, $v^2(1,a) = 0$, and becomes relatively dispensable, $v^1(1,a) \geq v^1(2,a)$. Now the main comparison is between 1:1 and 2:2.[16] Maximizing the surplus implies minimizing the negative bargaining effect and maximizing the positive bargaining effect. Therefore, it is useful to compare the investments with the negative bargaining effect, $y_2^{1:1}$ and $y_1^{2:2}$, and with the positive bargaining effect, $y_1^{1:1}$ and $y_2^{2:2}$. $y_2^{1:1} > y_1^{2:2}$ since 2's negative bargaining effect is eliminated under 1:1 given $v^2(1,a) = 0$ and the value of investments is higher in country 1. $y_1^{1:1} > y_2^{2:2}$ if agent 2 is sufficiently dispensable, $v^1(1,a) \geq v^2(2,a)$. Therefore, 1:1 remains optimal when agent 2 completes restoration with the adjusted sufficient condition of $v^1(1,a) \geq max[v^1(2,a), v^2(2,a)]$.

In a similar manner and consistent with Proposition 2(ii), 2:1 is optimal when agent 1 is indispensable, $v^2(2,a) = 0$, eliminating the negative bargaining effect and $v^1(2,a) \geq max[v^1(1,a), v^2(1,a)]$ guaranteeing that the positive bargaining effect is larger under 2:1 than under 1:2.

[16] 1:2 cannot be optimal since 2's positive bargaining effect is eliminated. Furthermore, the tradeoff between 1:1 and 2:1 does not change under Assumption 1'.

6 Restitution cases

Restitution of cultural goods to their country of origin is a fiercely debated topic. Source countries, armed with historical and moral reasons have requested the return of cultural property. Host countries, on the other hand, have in many cases rejected such requests based on legal and historical grounds. For example, in the case of the Icelandic manuscripts, the largest restitution of cultural goods to day, Iceland's request for their return was primarily based on historical and moral grounds. The manuscripts were seen as a central part of Icelandic cultural tradition and their return as an issue of utmost importance. In the words of a leading modern Icelandic historian, *"next to the issues of fishing boundaries around and the defence of Iceland itself, the return of the manuscripts [was] the biggest and most serious problem in the foreign relations of independent Iceland"* (Nielsen, 2002, p. 5). Furthermore, Iceland claimed that Denmark had a moral obligation to return the manuscripts, especially after the ending of the monarchical union with Denmark in December 1944. Opponents of the return argued that the manuscripts constituted a pan-Scandinavian heritage and that Iceland had no legal claim to them. They also claimed that Iceland lacked both the technical resources to conserve the manuscripts and scholarly resources to study and publish them, while Copenhagen was a recognized centre for Old Norse studies (Greenfield, 2007).

Similar arguments have also been presented in the most famous amongst restitution cases – the Parthenon marbles located in the British Museum. The main argument for restitution has been that the marbles are an important part of Greek cultural heritage that were removed by Lord Elgin at a time when Greece was under Ottoman control and under dubious circumstances. The British Museum's response has been that the Parthenon marbles had been legally acquired by Lord Elgin and furthermore, the museum's trustees do not have the right to dispose of any objects.

While the case of the Parthenon marbles remains at standstill, the discussions regarding another long-standing restitution case, that of the Benin bronzes, are progressing. The Benin bronzes were taken by British forces in 1897, following a punitive expendition. The importance of these objects to the Edo people – the descendants of the founders of the ancient Kingdom of Benin – cannot be underestimated. According to Godwin Nogheghase Obaseki, the governor of the Edo state[17], *"these works of art embody what we are: our people, our culture, our religion, also part of our political structure, they are symbols of our identity... What happened in 1897 traumatized all of our people."*[18] Opponents of the return argue that Nigeria does not have the necessary resources to adequately take care of them.

Such lines of arguments are by no means unique in the cultural restitution literature. Modelling cultural goods as public goods and applying the property rights theory provides a new economic perspective to the restitution question. UNESCO defines cultural property as *"historical and ethnographical objects and documents including manuscripts, works of the plastic and decorative arts, paleontological and archaelogical objects and zoological, botanical and mineralogical speciments"* (UNESCO, 2001, p. 9). In essence, cultural goods are public goods. Our framework abstracts from the historical, legal and moral background and focuses on whether restitution would improve the incentives to invest in restoration, protection and study of the cultural good. In other words, abstracting from its past, we emphasize the future of the cultural good. However, we are not claiming that the historical, legal and moral arguments are not important, they are simply not part of our model. Therefore, our results should be interpreted as introducing a new economic argument to the debate. Furthermore, our framework can speak to different forms of restitution, in particular full restitution and loan.

The value that different countries place on the cultural good is an important determinant for restitution in our model. This is consistent with the reasoning of UNESCO's Intergovernmental Committee for the Return of Cultural Property, the main body dealing with restitution claims from source countries. It takes an active role in resolving restitution claims by mediating between source and host countries. The committee's role is to evaluate the claim and recommend return if the cultural good is *"highly charged with cultural (or natural) significance ... the removal of [such*

[17]Benin City is part of the Edo state.

[18]Mükke, Lutz and Maria Wiesner. 2018. "Die Beute Bronzen." *Frankfurter Allgemeine Zeitung*, January 15. https://www.faz.net/aktuell/gesellschaft/kriminalitaet/benin-die-beute-bronzen-15359996.html. Accessed 2021-12-08.

an] object from its original cultural context irrevocably divests that culture of one of its dimensions" (Greenfield, 2007, p. 365). We can safely interpret this condition as meaning that recommendation for return will only be granted for goods highly valued by the source country, high Θ_1 in our model.

Greenfield (2007), a leading authority, uses a similar argument when calling for the return of cultural goods to their country of origin. According to her *"... cultural property is most important to the people who created it or for who it was created or whose particular identity and history it is bound with. This cannot be compared with the scholastic or even inspirational influence on those who merely acquire such objects or material"* (Greenfield, 2007, p. 411). In terms of our model, Θ_1 is significantly greater than θ_2. Greenfield argues for return of (*i*) historic records or manuscripts of a nation, (*ii*) objects torn from immovable property and (*iii*) paleontological materials.

Consistent with these arguments, Proposition 3 finds that restitution is optimal when Θ_1 is sufficiently high or θ_2 is sufficiently low. The form of restitution, however, depends on technological factors. In what follows, we apply our theoretical results to two significant restitution cases – the Icelandic manuscripts that were returned to Iceland in 1971, and the proposed return of the Benin bronzes to Nigeria.

6.1 The Icelandic manuscripts

The Icelandic manuscripts, made of vellum or paper, hold the medieval saga literature of Iceland, and were first collected for the most part by Icelander Árni Magnússon in the early 18th century. A professor at the University of Copenhagen (then the only university serving Iceland, being part of the Danish kingdom), Magnússon was sent to Iceland to compile a register of its farms and estates. Being a keen antiquarian, he used his spare time to search the country for manuscripts, and on his return to Copenhagen brought back fifty-five crates full. He continued to add to this collection, and though two thirds were destroyed by fire in 1728, the collection was still large when left to the university after his death in 1730.

Beginning in the 19th century, requests were made for the manuscripts' return to Iceland, and on the country's independence in 1944 the campaign became an uppermost priority. Finally in 1971, after much wrangling, a Danish law was ratified which required that all manuscripts held to be 'Icelandic cultural property' would be returned to Iceland. These were generally defined as works composed or translated by an Icelander, whose content was wholly or chiefly concerned with Iceland. A committee of two Danish and two Icelandic scholars decided which manuscripts satisfied these conditions.

Iceland was clearly the country which valued the manuscripts most. Desire for their return had been a running theme throughout Iceland's path to independence, and when the first manuscripts finally arrived in the country it was a national event. *"Shops and schools were closed. The whole nation ... was listening to the radio or watching television for a live account of the historic event which was taking place"* (Greenfield, 2007, p. 1).

Return was in the form of full restitution. According to Proposition 2(i), full restitution is optimal if $v^2(1, a) = 0$ and $v^1(1, a) \geq v^1(2, a)$. Denmark's investment in restoration was largely completed by the time the manuscripts were returned to Iceland in 1971, $v^2(1, a) = 0$. Furthermore, through close cooperation between the two sides – the Árni Magnússon Institute for Icelandic Studies in Iceland and the Arnamagnæan Institute at the University of Copenhagen – Iceland developed expertise to further study and publish the manuscripts, thus making Denmark relatively dispensable, $v^1(1, a) \geq v^1(2, a)$. Therefore, full restitution provides the best incentives to invest in the manuscripts.

6.2 The Benin bronzes

The Benin bronzes are a collection of sculptures and plaques – made of ivory, brass and wood – that once adorned the royal palace of the Oba, in the ancient Kingdom of Benin, now in modern-day Nigeria. The bronzes are the equivalent of the archives of the ancient Kingdom of Benin as the Edo people did not use written language but instead recorded all important events on them.[19]

[19] Mükke, Lutz and Maria Wiesner. 2018. "Die Beute Bronzen." *Frankfurter Allgemeine Zeitung*, January 15. https://www.faz.net/aktuell/gesellschaft/kriminalitaet/benin-die-beute-bronzen-15359996.html. Accessed 2021-12-08.

In 1897, following a punitive expedition, Benin City was taken and the Benin bronzes looted by British forces. The artefacts ended up all over the world with the British Museum and the Ethnological Museum in Berlin possessing the largest collections, 950 and more than 500 pieces respectively.

In 2007, the Benin Dialogue Group was formed to bring together the Nigerian government and the current Oba with a number of European museums holding Benin bronzes to find a compromise that would allow some of these to return to Benin City. In 2018, an agreement was reached by which the European museums would lend some of them on a rotating basis.[20] The loaned Benin bronzes will be exhibited in the yet to be built Edo Museum for West African Art in Benin City.

The proposed return seems to be primarily motivated by a feeling among the Europeans that the Benin bronzes *"have become an embarrassment"*.[21] In terms of our model, θ_2 – host country's valuation for the cultural good located in their country – has reduced. A reduction in θ_2 leads to the return of the cultural good but its form depends on technology and in particular on the degree of dispensability. In the current era, it has become crucial for these artefacts to engage with their original cultural environment, thus making Nigeria indispensable, $v^2(2, a) = 0$. If the European museums, having extensive expertise in the conservation and exhibition of the Benin bronzes, continue to be relatively indispensable, $v^1(1, a) \leq v^1(2, a)$, return in the form of a loan maximizes the investments in Benin bronzes according to Proposition 2(ii).[22] However, if the European museums become relatively dispensable, full restitution is optimal according to Proposition 5 – if furthermore the spillovers are

[20] It should be noted that despite this agreement, Nigeria has not given up their claim for ownership of the Benin bronzes.

[21] A Nigerian negotiator described the eagerness of some of the Europeans to relocate the Benin bronzes to Nigeria in the following characteristic way: *"Quite frankly, if Obaseki set up a shed at the back of his house, they'd hand them over to him. Just to be rid of them."* BBC. 2020. "Nigeria's Opportunity for Return of Benin Bronzes." September 11. https://www.bbc.co.uk/news/world-africa-54117905. Accessed 2021-12-08.

[22] As part of the loan agreement, the European partners have also agreed to *"provide advice, as requested, in areas including building and exhibition design. European and Nigerian partners will work collaboratively to develop training, funding, and legal frameworks to facilitate the permanent display of Benin works of art in the new museum."* Museum Volkenkunde. 2018. "Statement from Benin Dialogue Group." October 19. https://www.volkenkunde.nl/en/about-volkenkunde/press/statement-benin-dialogue-group-0. Accessed 2021-12-08.

limited. Sir David Adjaye, the architect of the planned museum, speaks of a different type of museum: "*It cannot happen as a kind of Western glass box, a vitrine, it would mean nothing, it would be totally disregarded by the community*" (Phillips, 2021, p. 292). If the European museums have a relatively dispensable role in such a museum, return in the form of full restitution provides maximal incentives to invest in Benin bronzes.

7 Conclusions

In this paper, we examine the issue of restitution of cultural goods to the country of origin. We model cultural goods as public goods and using the property rights theory of Grossman and Hart (1986) and Hart and Moore (1990) determine the optimal ownership and location for the cultural good.

We show that restitution can be triggered by a change in the role of the source country, completion of restoration by the host country or valuation changes. The optimal form of restitution depends on technological factors. Full restitution is optimal if the host country's restoration is complete and furthermore the host is quite dispensable. We argue that both conditions are consistent with the restitution of the Icelandic manuscripts. Restoration by Denmark was largely completed by the time the manuscripts were returned and Denmark became dispensable as Iceland developed the necessary expertise.

Restitution in the form of a loan to the country of origin is optimal if, in addition to the host country being indispensable, the country of origin becomes indispensable. However, if the host country is relatively dispensable, full restitution that transfers also ownership can be optimal. This result throws light on the proposed loan of the Benin bronzes to Nigeria. We argue that Nigeria has become indispensable because of the importance of having the bronzes engaging with their original cultural environment. European museums could be considered indispensable due to their expertise or, alternatively, they may become more dispensable as there are plans to avoid 'the Western glass box' exhibition style. Optimal form of return depends critically on how dispensable European museums are.

We furthermore address one of the most commonly cited arguments against restitution – that source countries have weaker resources to take care of their cultural treasures. We show that such an argument does not necessarily work against restitution. Given host country's cost advantage, the optimal structure gives greater emphasis on providing the host country with better incentives. However, this is not necessarily achieved by host country ownership and location.

Our model allows us to also examine less common forms of restitution, such as returning the cultural good to the source country under joint ownership or keeping the cultural good in the host country but transferring ownership to the source country, i.e. a loan to the host country. Although such arrangements have received limited attention in the restitution debate, they have proved more popular among cultural institutions building up their collections, as the recent joint acquisition of two Rembrandt portraits by the Louvre and the Rijksmuseum illustrate.[23]

Our paper takes a novel economic approach to restitution of cultural goods. However, the issue of restitution is also political, especially for significant cultural treasures. An important direction for future work is to extend the analysis to include political considerations.

[23]A further example is the joint acquisition of two Titian paintings by the National Gallery and the National Galleries of Scotland in 2009 and 2012.

Appendix

Proof of Lemma 1.

(i) Equations (3) and (5) imply that

$$\frac{1}{2}\left(\Theta_1+\Theta_2\right)v^2(12,a\left|y_2^{1:1}\right)-\frac{1}{2}\left(\Theta_1-\Theta_2\right)v^2(1,a\left|y_2^{1:1}\right)=$$

$$\frac{1}{2}\left(\Theta_1+\Theta_2\right)v^2(12,a\left|y_2^{2:1}\right)-\frac{1}{2}\left(\Theta_1-\Theta_2\right)v^2(2,a\left|y_2^{2:1}\right) \tag{11}$$

If $v^2(1,a\,|y_2)>v^2(2,a\,|y_2)$ for a given y_2, (11) is not satisfied for $y_2^{1:1}=y_2^{2:1}$ but the right-hand-side is greater than the left-hand-side. Concavity of the payoff function, and the assumption that $\partial^2 v(12,a)/\partial y_1\partial y_2=\partial^2 v(i,a)/\partial y_1\partial y_2=0$, imply that $y_2^{1:1}<y_2^{2:1}$ for the equality to be satisfied. This proves that $y_2^{1:1}\leq y_2^{2:1}$ if and only if $v^2(1,a\,|y_2)\geq v^2(2,a\,|y_2)$.

Equations (5) and (7) imply that

$$\frac{1}{2}\left(\Theta_1+\Theta_2\right)v^2(12,a\left|y_2^{2:1}\right)-\frac{1}{2}\left(\Theta_1-\Theta_2\right)v^2(2,a\left|y_2^{2:1}\right)=$$

$$\frac{1}{2}\left(\theta_1+\theta_2\right)v^2(12,a\left|y_2^{2:2}\right)-\frac{1}{2}\left(\theta_1-\theta_2\right)v^2(2,a\left|y_2^{2:2}\right) \tag{12}$$

If $y_2^{2:1}=y_2^{2:2}$, (12) is satisfied if and only if $v^2(2,a\,|y_2^{2:2})=\theta^* v^2(12,a\,|y_2^{2:2})$, where $\theta^*=\frac{(\Theta_1+\Theta_2)-(\theta_1+\theta_2)}{(\Theta_1-\Theta_2)-(\theta_1-\theta_2)}\in(0,1)$. If $v^2(2,a\,|y_2^{2:2})>\theta^* v^2(12,a\,|y_2^{2:2})$, the right-hand-side of (12) is greater than the left-hand-side. Equality then requires $y_2^{2:1}<y_2^{2:2}$. Therefore, $y_2^{2:1}\leq y_2^{2:2}$ if and only if $v^2(2,a\,|y_2^{2:2})\geq\theta^* v^2(12,a\,|y_2^{2:2})$.

Finally, it is obvious from (7) and (9) that $y_2^{2:2}<y_2^{J:1}$.

Lemma 1 combines these rankings.

(ii) Equations (2) and (4) imply that

$$\frac{1}{2}\left(\Theta_1+\Theta_2\right)v^1(12,a\left|y_1^{1:1}\right)+\frac{1}{2}\left(\Theta_1-\Theta_2\right)v^1(1,a\left|y_1^{1:1}\right)=$$

$$\frac{1}{2}\left(\Theta_1+\Theta_2\right)v^1(12,a\left|y_1^{2:1}\right)+\frac{1}{2}\left(\Theta_1-\Theta_2\right)v^1(2,a\left|y_1^{2:1}\right) \tag{13}$$

If $v^1(1,a\,|y_1)<v^1(2,a\,|y_1)$ for a given y_1, (13) is not satisfied for $y_1^{1:1}=y_1^{2:1}$ but the

right-hand-side is greater than the left-hand-side. Concavity of the payoff function implies that $y_1^{1:1} < y_1^{2:1}$ for the equality to be satisfied. Thus, $y_1^{1:1} \leq y_1^{2:1}$ if and only if $v^1(1, a\,|y_1) \leq v^1(2, a\,|y_1)$.

It is obvious from (2) and (9) that $y_1^{J:1} \leq y_1^{1:1}$. (4) and (6) prove that $y_1^{2:1} > y_1^{2:2}$ since $(\Theta_1 + \Theta_2) > (\theta_1 + \theta_2)$ and $(\Theta_1 - \Theta_2) > (\theta_1 - \theta_2)$.

Q.E.D.

Proof of Proposition 2.

(i) If $v^2(1, a) = 0$, 1-ownership eliminates the negative second term in (3) and location in country 1 maximizes the first term. Therefore, y_2 is maximal under 1:1, $y_2^{1:1} = y_2^{J:1}$.

From Lemma 1(ii), $y_1^{1:1} \geq y_1^{2:1}$ if and only if $v^1(1, a) \geq v^1(2, a)$, and furthermore, $y_1^{2:1} > y_1^{2:2}$ and $y_1^{1:1} \geq y_1^{J:1}$. Finally, we can obtain $y_1^{1:2}$ from (2) by replacing Θ_i by θ_i. Since this replacement reduces both the first and the second term in (2), it follows that $y_1^{1:1} > y_1^{1:2}$. Combining these inequalities, it follows that 1:1 maximizes y_1 if and only if $v^1(1, a) \geq v^1(2, a)$.

In sum, 1:1 is optimal if $v^2(1, a) = 0$ and $v^1(1, a) \geq v^1(2, a)$ since both agents' investments are maximal.

(ii) If $v^2(2, a) = 0$, 2-ownership eliminates the negative second term in (5) and y_2 is maximal under 2:1, $y_2^{2:1} = y_2^{J:1}$.

From Lemma 1(ii) and part (i) of this proof, it follows that y_1 is maximal under 2:1 if and only if $v^1(1, a) \leq v^1(2, a)$.

Therefore, $v^2(2, a) = 0$ and $v^1(1, a) \leq v^1(2, a)$ are sufficient conditions for 2:1 to maximize the surplus.

Q.E.D.

Proof of Proposition 4.

Substituting $v^i(12, a) = \frac{1}{2}(y_i)^{-\frac{1}{2}}$, $v^1(1, a) = \frac{1}{2}\lambda_2(y_1)^{-\frac{1}{2}}$ and $v^2(1, a) = \frac{1}{2}\mu_2(y_2)^{-\frac{1}{2}}$ in (2) and (3), we obtain

$$y_1^{1:1} = \frac{1}{16}\left[(\Theta_1 + \Theta_2) + (\Theta_1 - \Theta_2)\,\lambda_2\right]^2,$$

$$y_2^{1:1} = \frac{1}{16}\left[(\Theta_1+\Theta_2) - (\Theta_1-\Theta_2)\,\mu_2\right]^2.$$

Therefore, surplus under 1:1 is equal to

$$S^{1:1} = \frac{1}{2}(\Theta_1+\Theta_2)^2 + \frac{1}{4}(\Theta_1+\Theta_2)(\Theta_1-\Theta_2)(\lambda_2-\mu_2) - \frac{1}{16}\left[(\Theta_1+\Theta_2)+(\Theta_1-\Theta_2)\,\lambda_2\right]^2$$

$$-\frac{1}{16}\left[(\Theta_1+\Theta_2)-(\Theta_1-\Theta_2)\,\mu_2\right]^2$$

$$= \frac{3}{8}(\Theta_1+\Theta_2)^2 + \frac{1}{8}(\Theta_1+\Theta_2)(\Theta_1-\Theta_2)(\lambda_2-\mu_2) - \frac{1}{16}(\Theta_1-\Theta_2)^2\left[(\lambda_2)^2+(\mu_2)^2\right] \tag{14}$$

By similar calculations,

$$S^{2:1} = \frac{3}{8}(\Theta_1+\Theta_2)^2 + \frac{1}{8}(\Theta_1+\Theta_2)(\Theta_1-\Theta_2)(\mu_1-\lambda_1) - \frac{1}{16}(\Theta_1-\Theta_2)^2\left[(\mu_1)^2+(\lambda_1)^2\right] \tag{15}$$

$$S^{2:2} = \frac{3}{8}(\theta_1+\theta_2)^2 + \frac{1}{8}(\theta_1+\theta_2)(\theta_1-\theta_2)(\mu_1-\lambda_1) - \frac{1}{16}(\theta_1-\theta_2)^2\left[(\mu_1)^2+(\lambda_1)^2\right] \tag{16}$$

$$S^{J:1} = \frac{3}{8}(\Theta_1+\Theta_2)^2 \tag{17}$$

$$S^{1:2} = \frac{3}{8}(\theta_1+\theta_2)^2 + \frac{1}{8}(\theta_1+\theta_2)(\theta_1-\theta_2)(\lambda_2-\mu_2) - \frac{1}{16}(\theta_1-\theta_2)^2\left[(\lambda_2)^2+(\mu_2)^2\right] \tag{18}$$

Step 1. Note that $v^i(i,a) = \lambda_j v^i(12,a)$ and $v^j(i,a) = \mu_j v^j(12,a)$. Therefore, it is straightforward that $y_1^{2:\ell} \geq y_1^{1:\ell}$ for $\ell = 1,2$ if and only if $\mu_1 \geq \lambda_2$ and $y_2^{2:\ell} \geq y_2^{1:\ell}$ for $\ell = 1,2$ if and only if $\mu_2 \geq \lambda_1$. Thus, $S^{2:2} \geq S^{1:2}$ and $S^{2:1} \geq S^{1:1}$ if $\mu_1 \geq \lambda_2$ and $\mu_2 \geq \lambda_1$. 2:2 is therefore optimal if additionally $S^{2:2} \geq max\left\{S^{J:1}, S^{2:1}\right\}$. We will establish that in Steps 2 and 3.

Step 2. Suppose initially that $(\Theta_1+\Theta_2) = (\theta_1+\theta_2) = \sigma$. Denote $\Delta = (\Theta_1-\Theta_2)$ and $\delta = (\theta_1-\theta_2) < \Delta$.

From (16) and (17), $S^{2:2} \geq S^{J:1}$ if and only if

$$\frac{1}{8}\sigma\delta\left(\mu_1 - \lambda_1\right) - \frac{1}{16}\delta^2\left[(\mu_1)^2 + (\lambda_1)^2\right] \geq 0$$

$$f(\lambda_1, \mu_1) = \sigma\left(\mu_1 - \lambda_1\right) - \frac{1}{2}\delta\left[(\mu_1)^2 + (\lambda_1)^2\right] \geq 0 \tag{19}$$

From (15) and (16), $S^{2:2} \geq S^{2:1}$ if and only if

$$\frac{1}{8}\sigma\delta\left(\mu_1 - \lambda_1\right) - \frac{1}{16}\delta^2\left[(\mu_1)^2 + (\lambda_1)^2\right] \geq \frac{1}{8}\sigma\Delta\left(\mu_1 - \lambda_1\right) - \frac{1}{16}\Delta^2\left[(\mu_1)^2 + (\lambda_1)^2\right]$$

$$\frac{1}{8}\sigma\left(\Delta - \delta\right)\left(\mu_1 - \lambda_1\right) - \frac{1}{16}\left(\Delta^2 - \delta^2\right)\left[(\mu_1)^2 + (\lambda_1)^2\right] \leq 0$$

$$g(\lambda_1, \mu_1) = \sigma\left(\mu_1 - \lambda_1\right) - \frac{1}{2}\left(\Delta + \delta\right)\left[(\mu_1)^2 + (\lambda_1)^2\right] \leq 0 \tag{20}$$

From standard properties of a quadratic function, $f(\lambda_1, \mu_1)$ and $g(\lambda_1, \mu_1)$ obtain their maximum value for $\lambda_1 < 0$ and $\partial g/\partial\lambda_1 < 0$, $\partial f/\partial\lambda_1 < 0$ for all $\lambda_1 \in [0, 1]$.

First, suppose $\mu_1 = 0$. Since $f(0, 0) = 0$ and $\partial f/\partial\lambda_1 < 0$, $f(\lambda_1, 0) < 0$ for all $\lambda_1 \in (0, 1]$ and 2:2 cannot be optimal.

Then, consider $\mu_1 > 0$. Note that then $g(0, \mu_1) > 0$ since $\sigma > \Delta$. Therefore, since $\partial g/\partial\lambda_1 < 0$, there exists $\underline{\lambda} > 0$ such that $g(\lambda_1, \mu_1) \leq 0$ if and only if $\lambda_1 \geq \underline{\lambda}$.

Note that $f(\lambda_1, \mu_1) > g(\lambda_1, \mu_1)$. Therefore, there exists $\overline{\lambda} > \underline{\lambda}$ such that $f(\lambda_1, \mu_1) \geq 0$ if and only if $\lambda_1 \leq \overline{\lambda}$. Therefore, assuming $(\Theta_1 + \Theta_2) = (\theta_1 + \theta_2)$ and $\mu_1 > 0$, $S^{2:2} \geq max\left\{S^{J:1}, S^{2:1}\right\}$ if and only if $\lambda_1 \in \left[\underline{\lambda}, \overline{\lambda}\right]$.

Finally, we verify that $\overline{\lambda} < 1$. It is obvious from (16) and (17) that $\lambda_1 < \mu_1$ is a necessary condition for $S^{2:2} \geq S^{J:1}$ and thus for $f(\lambda_1, \mu_1) \geq 0$. Therefore, $\overline{\lambda} < \mu_1 \leq 1$.

Step 3. Now allow for $(\Theta_1 + \Theta_2) > (\theta_1 + \theta_2)$ by increasing Θ_i. $\partial S^{J:1}/\partial\Theta_i > 0$ and $\partial S^{2:1}/\partial\Theta_i > 0$ while $\partial S^{2:2}/\partial\Theta_i = 0$. Therefore 2:2 can remain optimal for sufficiently small increase in Θ_i. Define $\overline{\Theta}$ such that $S^{2:2} = max\left\{S^{J:1}, S^{2:1}\right\}$ if $(\Theta_1 + \Theta_2) - (\theta_1 + \theta_2) = \overline{\Theta}$ and $\lambda_1 \in \left[\underline{\lambda}, \overline{\lambda}\right]$. Then, $S^{2:2} \geq max\left\{S^{J:1}, S^{2:1}\right\}$ if and only if $\lambda_1 \in \left[\underline{\lambda}, \overline{\lambda}\right]$, $\mu_1 > 0$ and $(\Theta_1 + \Theta_2) - (\theta_1 + \theta_2) < \overline{\Theta}$. Furthermore, in Step 1 we established that $S^{2:2} \geq S^{1:2}$ and $S^{2:1} \geq S^{1:1}$ if $\mu_1 \geq \lambda_2$ and $\mu_2 \geq \lambda_1$. Proposition

1 combines these conditions. Q.E.D.

Proof of Proposition 5.

Assume $\lambda_1 = 0$. $S^{2:1} \geq S^{J:1}$ since $y_2^{2:1} = y_2^{J:1}$ if $\lambda_1 = 0$ (see (5) and (9) for $v^2(2,a) = 0$) and $y_1^{2:1} \geq y_1^{J:1}$ for all parameter values (see (4) and and (9)). Equation (8) simplifies to $\lambda_1 > \theta^*$ in our parametric example and thus cannot be satisfied for $\lambda_1 = 0$. Therefore, both $y_2^{2:1} > y_2^{2:2}$ and $y_1^{2:1} > y_1^{2:2}$ and accordingly, $S^{2:1} > S^{2:2}$.

Next we will compare 1:1 and 2:1. From (14) and (15) and setting $\lambda_1 = 0$,

$$S^{1:1} - S^{2:1} = \frac{1}{8}(\Theta_1 + \Theta_2)(\Theta_1 - \Theta_2)(\lambda_2 - \mu_2) - \frac{1}{16}(\Theta_1 - \Theta_2)^2 \left[(\lambda_2)^2 + (\mu_2)^2\right]$$

$$-\frac{1}{8}(\Theta_1 + \Theta_2)(\Theta_1 - \Theta_2)\mu_1 + \frac{1}{16}(\Theta_1 - \Theta_2)^2(\mu_1)^2. \quad (21)$$

Using the notation from the proof of Proposition 4, we obtain

$$S^{1:1} - S^{2:1} = \frac{1}{8}\sigma\Delta(\lambda_2 - \mu_2) - \frac{1}{16}\Delta^2\left[(\mu_2)^2 + (\lambda_2)^2\right] - \frac{1}{8}\sigma\Delta\mu_1 + \frac{1}{16}\Delta^2(\mu_1)^2. \quad (22)$$

Therefore $S^{1:1} \geq S^{2:1}$ if and only if

$$h(\lambda_2, \mu_1, \mu_2) = (\lambda_2 - \mu_1)\left[\sigma - \frac{1}{2}\Delta(\lambda_2 + \mu_1)\right] - \mu_2(\sigma + \frac{1}{2}\Delta\mu_2) \geq 0. \quad (23)$$

Let us examine the properties of $h(\lambda_2, \mu_1, \mu_2)$. By standard calculations, $\partial h/\partial\lambda_2 > 0$ for relevant parameter values. Therefore, if $h(1, \mu_1, \mu_2) > 0$, there exist a range of values of $\lambda_2 \in \left(\hat{\lambda}, 1\right]$ for which $h(\lambda_2, \mu_1, \mu_2) > 0$. If $\lambda_2 = \mu_1$, $h(\lambda_2, \mu_1, \mu_2) < 0$ by (23). Therefore, $\hat{\lambda} > \mu_1$.

When is $h(1, \mu_1, \mu_2) > 0$? By standard calculations, $h(1,1,1) = -(\sigma + \frac{1}{2}\Delta) < 0$ and $h(1,0,0) = \sigma - \frac{1}{2}\Delta > 0$. Since $\partial h/\partial\mu_i < 0$ for $i = 1, 2$, there exists μ' such that $h(1, \mu_1, \mu_2) > 0$ if and only if $\mu_2 < \mu'$, where $\partial\mu'/\partial\mu_1 < 0$. $\mu' < 1$ since even for minimum $\mu_1 = 0$ μ_2 cannot equal 1 as $h(1,0,1) = -\Delta < 0$. $\mu' > 0$ if and only if $\mu_1 < \tilde{\mu}$, where $\tilde{\mu} < 1$, since $h(1,1,\mu_2) < 0$ for all $\mu_2 \in (0,1]$ given $h(1,1,0) = 0$.

Therefore, we have proved that given $\lambda_1 = 0$ $S^{1:1} \geq S^{2:1}$ if and only if $\lambda_2 \in \left(\hat{\lambda}, 1\right]$, $\mu_1 \in [0, \tilde{\mu})$ and $\mu_2 \in [0, \mu')$, where $\hat{\lambda} > \mu_1$ and $max\{\mu', \tilde{\mu}\} < 1$.

Finally, let us compare 1:1 and 1:2. From (14) and (18), assuming $(\Theta_1 + \Theta_2) = (\theta_1 + \theta_2)$, $S^{1:1} \geq S^{1:2}$ if and only if $g(\mu_2, \lambda_2) \geq 0$ (see (20)). Following the proof of Proposition 4, $g(\mu_2, \lambda_2) \geq 0$ is satisfied if and only if $\mu_2 \in \left[0, \underline{\mu}\right]$. Finally, taking into account that $(\Theta_1+\Theta_2) > (\theta_1+\theta_2)$, $\mu_2 \in \left[0, \underline{\mu}\right]$ is a sufficient condition for $S^{1:1} \geq S^{1:2}$.

In sum, we have proved that 1:1 is optimal given $\lambda_1 = 0$ if $\lambda_2 \in \left(\hat{\lambda}, 1\right]$, $\mu_1 \in [0, \tilde{\mu})$ and $\mu_2 \in [0, \hat{\mu})$, where $\hat{\lambda} > \mu_1$, $\tilde{\mu} < 1$ and $\hat{\mu} = min\left\{\mu', \underline{\mu}\right\} < 1$.

Q.E.D.

Proof of Proposition 6.

(i) Let us first compare J:1 and 2:2. If $\mu_1 = 0$, $y_1^{J:1} = y_1^{2:1} > y_1^{2:2}$ and $S^{J:1} > S^{2:2}$ since J:1 maximizes y_2. If $\mu_1 > 0$, we can employ Step 2 of the proof of Proposition 4. It showed that $S^{J:1} \geq S^{2:2}$ if and only if $f(\lambda_1, \mu_1) \leq 0$ and the condition is satisfied if and only if $\lambda_1 \in \left[\overline{\lambda}, 1\right]$. Step 2 assumed $(\Theta_1 + \Theta_2) = (\theta_1 + \theta_2)$. Allowing for $(\Theta_1 + \Theta_2) > (\theta_1 + \theta_2)$, $\lambda_1 \in \left[\overline{\lambda}, 1\right]$ is a sufficient condition for $S^{J:1} \geq S^{2:2}$.

From (17) and (18), assuming $(\Theta_1 + \Theta_2) = (\theta_1 + \theta_2)$, $S^{J:1} \geq S^{1:2}$ if and only if

$$\sigma(\lambda_2 - \mu_2) - \frac{1}{2}\delta\left[(\lambda_2)^2 + (\mu_2)^2\right] \leq 0. \tag{24}$$

(24) is equivalent to $f(\mu_2, \lambda_2) \leq 0$, see (19). Following the proof of Proposition 4, $f(\mu_2, \lambda_2) \leq 0$ if and only if $\mu_2 \in [\overline{\mu}, 1]$. Taking into account that $(\Theta_1+\Theta_2) > (\theta_1+\theta_2)$ $\mu_2 \in [\overline{\mu}, 1]$ is a sufficient condition for $S^{J:1} \geq S^{1:2}$.

Comparing J:1 and 1:1 we obtain an inequality similar to (24) where δ is replaced by Δ. Therefore, $\mu_2 \in [\mu'', 1]$ is a sufficient condition for $S^{J:1} \geq S^{1:1}$, where $\mu'' < \overline{\mu}$ since $\Delta > \delta$. In a similar manner we can prove that $\lambda_1 \in [\lambda', 1]$ is a sufficient condition for $S^{J:1} \geq S^{2:1}$, where $\lambda' < \overline{\lambda}$.

In sum, J:1 is optimal if $\lambda_1 \in \left[\overline{\lambda}, 1\right]$ and $\mu_2 \in [\overline{\mu}, 1]$.

(ii) **Step 1.** From the proof of Proposition 4, $y_1^{2:\ell} \leq y_1^{1:\ell}$ for $\ell = 1, 2$ if and only if $\mu_1 \leq \lambda_2$ and $y_2^{2:\ell} \leq y_2^{1:\ell}$ for $\ell = 1, 2$ if and only if $\mu_2 \leq \lambda_1$. Thus, $S^{1:2} \geq S^{2:2}$ and $S^{1:1} \geq S^{2:1}$ if $\mu_1 \leq \lambda_2$ and $\mu_2 \leq \lambda_1$. 1:2 is therefore optimal if additionally $S^{1:2} \geq max\left\{S^{J:1}, S^{1:1}\right\}$. We will establish that in steps 2 and 3.

Step 2. Suppose initially that $(\Theta_1+\Theta_2) = (\theta_1+\theta_2)$. From (17) and (18), we can establish that $S^{1:2} \geq S^{J:1}$ if and only if $f(\mu_2, \lambda_2) \geq 0$. From (14) and (18) $S^{1:2} \geq S^{1:1}$ if and only if $g(\mu_2, \lambda_2) \leq 0$. Therefore, we can employ Step 2 of the proof of Proposition 4. Assuming $(\Theta_1+\Theta_2) = (\theta_1+\theta_2)$ and $\lambda_2 > 0$, $S^{1:2} \geq max\left\{S^{J:1}, S^{1:1}\right\}$ if and only if $\mu_2 \in \left[\underline{\mu}, \overline{\mu}\right]$.

Step 3. As in the proof of Proposition 4, we define $\widetilde{\Theta}$ such that $S^{1:2} = \max\left[S^{J:1}, S^{1:1}\right]$ if $(\Theta_1+\Theta_2)-(\theta_1+\theta_2) = \widetilde{\Theta}$ and $\mu_2 \in \left[\underline{\mu}, \overline{\mu}\right]$. Combining the conditions from all the steps, 1:2 is optimal if $\mu_2 \in \left[\underline{\mu}, min\left\{\overline{\mu}, \lambda_1\right\}\right]$, $\lambda_2 \geq \mu_1$ and $(\Theta_1+\Theta_2)-(\theta_1+\theta_2) < \widetilde{\Theta}$.

Q.E.D.

Proof of Proposition 7.

(i) Given investment costs $\frac{1}{\gamma_i} y_i$, the investments under 1:1 equal

$$y_1^{1:1} = \frac{(\gamma_1)^2}{16}\left[(\Theta_1+\Theta_2)+(\Theta_1-\Theta_2)\lambda_2\right]^2, \tag{25}$$

$$y_2^{1:1} = \frac{(\gamma_2)^2}{16}\left[(\Theta_1+\Theta_2)-(\Theta_1-\Theta_2)\mu_2\right]^2. \tag{26}$$

The surplus under 1:1 is equal to

$$S^{1:1} = \frac{3(\gamma_1+\gamma_2)}{16}(\Theta_1+\Theta_2)^2 + \frac{1}{8}(\Theta_1+\Theta_2)(\Theta_1-\Theta_2)(\gamma_1\lambda_2-\gamma_2\mu_2) - \frac{1}{16}(\Theta_1-\Theta_2)^2\left[\gamma_1(\lambda_2)^2+\gamma_2(\mu_2)^2\right]. \tag{27}$$

By similar calculations,

$$S^{2:1} = \frac{3(\gamma_1+\gamma_2)}{16}(\Theta_1+\Theta_2)^2 + \frac{1}{8}(\Theta_1+\Theta_2)(\Theta_1-\Theta_2)(\gamma_1\mu_1-\gamma_2\lambda_1) - \frac{1}{16}(\Theta_1-\Theta_2)^2\left[\gamma_1(\mu_1)^2+\gamma_2(\lambda_1)^2\right]. \tag{28}$$

At the optimal boundary between 1:1 and 2:1 $S^{1:1} = S^{2:1}$. In what follows, we show that $\frac{\partial S^{1:1}}{\partial \gamma_1} - \frac{\partial S^{2:1}}{\partial \gamma_1}$ has the same sign as $(\lambda_2 - \mu_1)$. From (27) and (28) we obtain

$$\frac{\partial S^{1:1}}{\partial \gamma_1} - \frac{\partial S^{2:1}}{\partial \gamma_1} = \frac{1}{8}\left(\Theta_1 + \Theta_2\right)\left(\Theta_1 - \Theta_2\right)\lambda_2 - \frac{1}{16}\left(\Theta_1 - \Theta_2\right)^2\left(\lambda_2\right)^2$$

$$-\frac{1}{8}\left(\Theta_1 + \Theta_2\right)\left(\Theta_1 - \Theta_2\right)\mu_1 + \frac{1}{16}\left(\Theta_1 - \Theta_2\right)^2\left(\mu_1\right)^2, \tag{29}$$

which is equivalent to

$$\left(\Theta_1 + \Theta_2\right)\left(\lambda_2 - \mu_1\right) - \frac{1}{2}\left(\Theta_1 - \Theta_2\right)\left(\lambda_2 - \mu_1\right)(\lambda_2 + \mu_1)$$

$$= \left(\lambda_2 - \mu_1\right)\left[\left(\Theta_1 + \Theta_2\right) - \frac{1}{2}\left(\Theta_1 - \Theta_2\right)\left(\lambda_2 + \mu_1\right)\right]. \tag{30}$$

Note that the expression in the square brackets is positive even for $\lambda_2 = \mu_1 = 1$. Therefore, (30) has the same sign as $(\lambda_2 - \mu_1)$. Thus, if $\lambda_2 < \mu_1$ (resp. $\lambda_2 > \mu_1$) the boundary between 1:1 and 2:1 moves in favour of 2:1 (resp. 1:1) when γ_1 increases.

(ii) Next we consider 2:1-2:2 boundary. $S^{2:2}$ can be obtained from (28) by replacing Θ_i by θ_i. Using (28), $g(\lambda_1, \mu_1)$ from the proof of Proposition 4 (equation (20)) becomes

$$\hat{g}(\lambda_1, \mu_1) = \sigma\left(\gamma_1 \mu_1 - \gamma_2 \lambda_1\right) - \frac{1}{2}\left(\Delta + \delta\right)\left[\gamma_1\left(\mu_1\right)^2 + \gamma_2\left(\lambda_1\right)^2\right]. \tag{31}$$

Therefore,

$$\frac{\partial \hat{g}(\lambda_1, \mu_1)}{\partial \gamma_1} = \mu_1[\sigma - \frac{1}{2}(\Delta + \delta)\mu_1] > 0. \tag{32}$$

Accordingly, $\frac{\partial \lambda}{\partial \gamma_1} > 0$ and 2:1-2:2 boundary moves in favour of 2:1 when γ_1 increases.

(iii) Finally, we examine 1:1-1:2 boundary. $S^{1:2}$ can be obtained from from (27) by replacing Θ_i by θ_i. $g(\mu_2, \lambda_2)$ from Step 2 of the proof of Proposition 6 becomes

$$\hat{g}(\mu_2, \lambda_2) = \sigma\left(\gamma_1 \lambda_2 - \gamma_2 \mu_2\right) - \frac{1}{2}\left(\Delta + \delta\right)\left[\gamma_1\left(\lambda_2\right)^2 + \gamma_2\left(\mu_2\right)^2\right]. \tag{33}$$

and, accordingly,

$$\frac{\partial \hat{g}(\mu_2, \lambda_2)}{\partial \gamma_1} = \lambda_2[\sigma - \frac{1}{2}(\Delta + \delta)\lambda_2] > 0. \tag{34}$$

This implies that $\frac{\partial \mu}{\partial \gamma_1} > 0$ and 1:1-1:2 boundary moves in favour of 1:1 when γ_1 increases.

Q.E.D.

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