State Capacity and Identity: Assimilation vs Resistance of Tribal Rimlands*

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While the populations of wealthy modern states primarily identify with their nation, middle- and low-income countries often contain large populations that adhere to distinct subnational identities. We model a central government elite that has a conflictual relationship with its "tribal rimland." Elites share a dominant national identity, while members of tribes may hold alternative identities, with identities conferring psychological payoffs. Elite investment in state capacity increases material production, strengthens incentives for members of tribes to adopt the national identity, and facilitates extraction from those who continue to adhere to their own identity. Tribes, meanwhile, are better able to resist when their strategies of resistance, collective organization, and identity status remain strong. Increased democratic representation does not necessarily favor the persistence of tribal identity relative to elite rule. The model is consistent with accounts of incorporation and resistance from both history and the present, ranging from the Scottish and Southeast Asian highlands to past and present indigenous societies in the Americas.

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1 Introduction

With industrialization came the modern nation-state, which evolved alongside the modern economy. Its ideal type is characterized by universal citizenship, with an expectation of loyalty from its citizens. In practice, this is typically expressed in the form of *national identity*, ranging from inclusive ("unity in diversity") to narrower ethnic or linguistic conceptions. Yet, modern states rarely emerged over homogeneous populations. In nearly all cases, they were built atop traditional societies, differentiated by language or dialect, ethnic or tribal identification, economic and agricultural specialization, and religious or cultural practices.

These modern economies and states have generated enormous material gains—such as higher incomes, longer life expectancy, and reduced child mortality—while at the same time creating cultural and linguistic homogenization. Some of this homogenization has been voluntary, driven by the forces of urbanization. However, it has also frequently involved coercion by the state, being met with resistance from ethnic and tribal minorities. The work of James C. Scott emphasizes both the "high modernist"excesses of state planning (Scott, 1998) and, even more, the strategies of resistance employed among peasants and tribal communities at the margins of the modern state and economy (Scott, 1977; 1985; 2009). The costs associated with the ensuing coercion, suppression, and increasing homogenization are rarely taken into account in assessing the benefits and costs of modernity.

In this paper, we examine how two core features of the modern state—state capacity and national identification—interact as subnational ethnic groups (i.e., tribes) navigate and resist assimilation into the national political economy.[1] We develop a model in which a national elite controls the state yet faces conflict with a subnational group with a distinct identity, located in the "rimland": a peripheral region where the state lacks full control and does not monopolize the use of force.[2] Conflict is centered on land and other resources, while individuals have both material and psychological payoffs. The latter emanate from identity and include a group-level "status"value component, while members of the tribes also differ in their distaste for assimilation. For instance, those with higher levels of distaste for assimilation tend to adhere more strongly to their

[1]The use of "tribes" here is shorthand, to be used henceforth, to refer to a variety of minority group types, and not necessarily limited to indigenous tribes per se.

[2]Our use of "rimland" follows Findlay's (1996) model of empire, where the rimland denotes a periphery with uncertain state control. This differs from the earlier usage by Spykman (1944), who defined the Rimland as the coastal areas encircling Eurasia's "Heartland," which he viewed as strategically decisive in geopolitics.

group identity, with material payoffs shaped by the ensuing conflict with the state.

The conflict need not involve open rebellion, though that remains one possibility. Following Scott's (1985) account of Malaysian villagers, tribes may instead deploy the "weapons of the weak": non-confrontational tactics such as evasion, feigned ignorance, sabotage, or character assassination, which divert resources from state agents. Agricultural practices can likewise be tailored to reduce state intrusion while reinforcing group solidarity and cultural autonomy (Scott, 1977). Accordingly, our model incorporates variables capturing a tribe's capacity for resistance, collective organization, and the group-level status of their identity.

Meanwhile, state capacity, resource endowments, and the attractiveness of the national identity shape the extent of tribal assimilation. Complete separation of the tribe, for instance, can arise when state capacity and the material benefits of the modern economy are relatively low, while tribal resistance, organization, and identity remain strong. Cases consistent with this outcome include Scott's (1985) Malaysian villagers, as well as indigenous Andean communities in Bolivia, Peru, and Ecuador and "schedule tribes" in India's easternmost states.

At the opposite extreme, complete assimilation can occur when a powerful state confronts a weak and disorganized tribe—such as one already weakened economically, psychologically, or militarily. The conquest of the Scottish Highlands and the broader incorporation of the "Celtic fringe" in Britain (Hechter, 1975) exemplify this dynamic. Other European states similarly absorbed their own "rimlands" during national unification, including France and Italy.

In more intermediate cases, some tribe members (henceforth, "tribals") assimilate while others continue to adhere to their identity. The evolution of identity depends on how state capacity changes relative to the capabilities of subnational groups. In addition, elites' own national identification and their resources jointly shape investments in state-building and efforts to assimilate others in complementary ways. For instance, elite unity and strength can eventually produce complete tribal assimilation.

Modern states invest both in state capacity and in policies that strengthen allegiance among populations with weaker attachments to the national identity. We extend the model to allow for both forms of investment, showing that they are complementary: the marginal return to each increases with the stock of the other. As a result, depending on initial conditions and the marginal benefits and costs of those investments, states can prevent complete separation and increase assimilation of tribal populations through two channels: building state capacity and strengthening

national identity.

One might argue that broader democratic participation reduces assimilation pressure on subnational groups. Historically, however, democratic rights have often been extended to those who have already assimilated into the modern state and economy. We show that maximizing the social welfare of those who identify nationally leads to even greater investments in state capacity than when elites choose investment alone—and thus to greater assimilation of tribals than when the state is controlled by the elites. This is consistent with historical patterns in which the expansion of the democratic franchise has been associated with stronger national identification and reduced salience of minority or local identities.

We use the framework to examine three historical cases of attempted tribal incorporation: (i) the Southeast Asian Uplands, (ii) the Scottish Highlands, and (iii) Native American tribes during U.S. territorial expansion. The first builds on Scott (2009), where sophisticated resistance strategies, strong commitment to local identities, and dense social organization—combined with weak state capacity—enabled minority groups in Zomia to evade incorporation for centuries. The latter two cases, by contrast, illustrate how sustained investments in state capacity, alongside efforts to weaken tribal identification and organization, can overwhelm tribes and induce assimilation.

Our approach builds on the economics of identity and culture (Akerlof and Kranton, 2000; Bisin and Verdier, 2001) and engages a broad interdisciplinary literature on nationalism (Weber, 1976; Anderson, 1983; Gellner, 1983; Hobsbawm, 1990; Green, 2023). We also draw on economic models of cultural assimilation and identity conflict (Carvalho and Koyama, 2016; Carvalho, Koyama, and Williams, 2024), including formal work on national identity and conflict in our model (Sambanis and Shayo, 2013; Sambanis, Skaperdas, and Wohlforth, 2015, 2020; Alesina, Reich, and Riboni, 2020; Almagro and Andres-Cerezo, 2020). In particular, we build on and extend Skaperdas and Testa (2025) by differentiating the national identity of elites from that of common citizens and assimilated tribal populations, and by emphasizing the multiple forces that shape the choice between assimilation and adherence to a subnational identity.

Our paper is also related to research on civil conflict and state capacity. Alesina and Spolaore (2005), in their work on the "size of nations," allow for population heterogeneity and conflict but abstract from state capacity and identity change through assimilation. Besley and Persson (2011) allow for different types of state capacity and demonstrate complementarities among them, but do not consider competing identities or the incorporation of one group by another—central to our framework. Michalopoulos

and Papaioannou (2016) examine ethnic groups divided across African state borders and show how such marginalized groups increase the likelihood of civil war and conflict with the central states; our model helps to interpret those empirical results, as many African states exhibit low levels of state capacity, limiting their ability to incorporate tribal minorities into a national identity. Finally, Garfias and Sellars (2024) examine differential legal legibility in Mexico, a form of state capacity that enables taxation and centralization; our model is consistent with their findings, showing how different levels of legal legibility can shape both the economic incorporation of peripheral regions and rates of assimilation into the Mexican national identity.

In the next section, we develop the basic model and characterize the outcome of conflict between elites and tribals who retain their identity. Section 3 describes the resulting identity equilibria and their determinants. Section 4 extends the model to allow elites to invest in both state capacity and national identity. Section 5 introduces democratic representation and its implications for elite investment. Section 6 presents the three case studies, and Section 7 concludes.

2 The basic model

We consider a state that is controlled by a unified group of elites of size $\beta > 0$, each having resources $R \geq 1$. There is a group of common citizens of size $c > 0$, each with one unit of resource, who participate in the modern economy and, initially, lack political power. A third group consists of inhabitants of a tribal rimland that has a tenuous connection with the modern economy and a conflictual relationship with the state and the elites that control that state. They are of size 1, so that the total population is of size $\beta + c + 1$.

The elites are the ones who define and adhere to the national identity. For simplicity and ease of exposition, we assume that there is a single tribal identity, although as we shall see there are different degrees of attachment to that identity; those with lower attachment could choose to enter the formal economy and adopt the national identity (with a generally reduced intensity compared to the elites). Those tribals who assimilate into the formal economy and national identity have one unit of resource, the same as common citizens. The total material income of the formal economy depends on the resources of the elite, the common citizens, and those tribals who assimilate, and is enhanced by an all-encompassing variable we denote as *state capacity*, which is meant to include factors such as the protection of property of all those in the formal economy, adminis-

trative competence (including Garfias and Sellars', 2024, fiscal legibility) , infrastructural public goods, investments in health and education, as well as the capacity for violent repression. Letting $\nu \in [0, 1]$ denote the fraction of tribals who choose to assimilate, the total output of the formal economy is

$$\kappa(\beta R + c + \nu) \tag{1}$$

where $\kappa > 0$ denotes the level of state capacity.

Our model is meant to apply to the interaction of a modern state with a peripheral group that has a different sense of collective identity than the national identity. That different collective identity can be due to perceived kinship among the members of the group (and hence our usage of the term "tribe" or "tribal"). However, our model could be applied to groups that might not have as strong a sense of kinship as members of a tribe typically have. More populous (than a typical tribe) ethnic or linguistic groups that have a sense of separate identity from the dominant national identity could fit the model as long as there is high population density of the group in a given area. For example, the model could be applied to the Mayans of Chiapas in Mexico, the Kurds of Southeast Turkey, or—going back in history—to the Bretons of France. An additional ingredient of the model is that the group's material well-being is threatened or is in conflict with the state.

The payoffs of all agents have both material and psychological components. Before specifying the payoffs all three types of agents, we begin with determining the material payoff components that are due to the conflict between the non-assimilated tribals and the elites, which are separable from all other payoffs.

2.1 Conflict between state and tribes

The source of conflict between elites and tribals are resources, indicated by T, which could be natural resources such as land, timber, water, minerals, or it could include sources of income such as smuggling revenue. These resources, along with their labor, are the main source of livelihood for the tribes but are contested by the central government and the elites that control it. The conflict between the two sides involves the expenditures by both the state and the tribes that determine the distribution of resources between the two sides. These expenditures and the distribution of resources depend on several factors. On the part of the state, state capacity—especially its administrative, police, and military capabilities—can function as a force multiplier in increasing its share of the resources claimed against the tribes. On the part of the tribes, their ability to *resist*

in the various ways that Scott (1985) has described is one factor that can increase their share of resources. The ability to organize collectively and their sheer number also affect how much utility they receive from their share of the resource they can keep.

With such considerations in mind, we model the conflict between the state and the tribes as a contest (see, e.g., Konrad, 2009, Sekeris, 2014) in which the payoffs of the elites and the tribes are the following:

$$\begin{aligned} \pi_{ec} &= \frac{\kappa x_s}{\kappa x_s + \rho x_t}\beta T - x_s \\ \pi_{tc} &= \frac{\rho x_t}{\kappa x_s + \rho x_t}\phi(1-\nu)T - x_t \end{aligned} \tag{2}$$

where $\rho > 0$ is a measure of the resistance capabilities by the tribe; $\phi \in (0, 1]$ is a measure of the collective organization of the tribe; and x_s and x_t are, respectively, the expenditures by the state and the tribes in the contest. The parameter ρ could include factors such as mountainous terrain, defensive ability, language, and cultural distance that could all be used by the tribe to resist and deceive the state and its emissaries. The parameter ϕ is also a measure of the social cohesion of the tribe in its ability to organize, reduce free-riding, and represent its collective interest; the lower ϕ is, the lower is the perceived (and real) marginal benefit of the conflict payoff that the tribe can receive, because of some free-riding and the ability to organize and properly distribute the share of their payoff among its members.

The resource T is divided according to an asymmetric "Tullock" function, whereby the asymmetries depend on state capacity and the resistance capabilities of the tribes. The inclusion of the size of the elites and tribals, β and $1-\nu$, in the payoff functions is meant to allow for complementarities between the contested resource and the populations of each group.[3]

Because this conflict between the state and the tribe is separable from other decisions, the game with the payoff functions in (2) has a unique Nash equilibrium in strategies (x_s, x_t) and the equilibrium payoffs can be readily calculated. In Proposition 1, we characterize these payoffs with the details shown in the Appendix.

Proposition 1 *For the game in (2), there is a unique Nash equilibrium* (x_s^*, x_t^*).

[3]The alternative of not including the size of the two groups would not change our qualitative results. Not including β would just leave with absence of comparative static effects of that variable in Proposition 1 below. Not including $1-\nu$ would not change the comparative statics results in any of the Propositions but it would make some derivations more complicated because the per capita payoff of tribals who adhere to their identity would depend on their number. (Part of the complication is that that per capita payoff would converge to infinity as $1-\nu$ converges to 0, an intuitively implausible possibility.)

The resultant equilibrium payoffs for the elites and the tribes are:

$$\begin{aligned} \pi^*_{ec} &= q_e(\kappa, \beta, \rho, \phi, 1-\nu)\beta T \\ \pi^*_{tc} &= q_t(\kappa, \beta, \rho, \phi, 1-\nu)\phi(1-\nu)T \end{aligned}$$

where (i) $q_e(\kappa, \beta, \rho, \phi, 1-\nu) \in (0,1)$ *is increasing in state capacity* κ *and elite size* β*, and decreasing in tribal resistance capability* ρ*, collective organization* ϕ*, and non-assimilated tribals* $1-\nu$*; and (ii)* $q_e(\kappa, \beta, \rho, \phi, 1-\nu) \in (0,1)$ *is decreasing in* κ *and* β*, and increasing in* ρ, ϕ*, and* $1-\nu$*.*

The comparative static results in Proposition 1 about the effects of the various variables on the sharing of rents are all intuitive. We note that the sum of the shares q_e and q_t is considerably less than 1 because the equilibrium payoffs incorporate the expenditure of resources on the contest by the two sides.

2.2 Material and psychological payoffs

In addition to the rents they obtain from the conflict with the tribes, the elites have another sources of material payoff, their own income, $\kappa\beta R$,, so that their total material payoff is

$$\pi_{em} = \kappa\beta R + \pi^*_{ec}$$

where π^*_{ec} is the conflict payoff from Proposition 1.

The material payoff of a tribal who chooses to participate in the modern economy and assimilate is their income, κ, whereas the material payoff of a tribal who adheres to their identity is the per-capita equilibrium payoff for the tribes, $\frac{\pi^*_{tc}}{1-\nu} = q_t(\kappa, \beta, \rho, \phi, 1-\nu)\phi T$.

We turn next to the psychological payoffs associated with each identity. Based on the psychological and economics literatures on identity, we include two types of psychological payoffs. One type is *status* or *prestige* payoffs that are associated with the perceived achievements of the particular group identity. For the case of the elites, we suppose that each of its members values the total income generated in the formal economy in (1) ("GDP") so that the payoff derived from that equals $\sigma\kappa(\beta R + c + \nu)$ where $\sigma > 0$. The tribals who adhere to their own alternative identity have a similar status payoff that is proportional to their own material payoff that equals $\sigma_t \pi^*_{tc}$ for some $\sigma_t > 0$. For the tribals who assimilate into the modern economy and national identity, the status payoff is similar to that of the elites, $\sigma_n\kappa(\beta R + c + \nu)$ where $\sigma_n \geq 0$, but perhaps with a lower intensity than the elites or even with an absence of such a payoff (that is, when $\sigma_n = 0$).

In addition to status payoffs, there are *alienation* payoffs. Only the tribals face a choice of identity in our model and those who assimilate to the national identity face such a negative payoff that is denoted by $\delta \geq 0$. The value of δ varies across the tribal population according to a cumulative distribution function $F(\delta)$ with support in $[0, \Delta]$ for some $\Delta > 0$.

Thus, the total payoffs for elite as a whole and for individual tribals of the two identities are the following:

$$\begin{aligned} \pi_e &= \kappa\beta R + \sigma\kappa\beta(\beta R + c + \nu) + q_e(\kappa, \beta, \rho, \phi, 1-\nu)\beta T \\ \pi_{nt\delta} &= \kappa + \sigma_n\kappa(\beta R + c + \nu) - \delta \\ \pi_{tt} &= q_t(\kappa, \beta, \rho, \phi, 1-\nu)\phi T(1+\sigma_t) \end{aligned} \tag{3}$$

We initially consider the choice between the two identities that the tribals have, to which we now turn.

3 The tribal's choice of identity: Assimilate or keep separate?

An individual tribe member compares their total payoffs between $\pi_{nt\delta}$ and π_{tt} in (3) for given values of the parameters and makes the decision whether to assimilate into the modern economy or state with the tribe. The individual choices give rise to three possible broad outcomes: (i) *Complete Separation* of all tribal members from the modern economy and state; (ii) *Complete Assimilation* of all tribal members into the modern economy and state; and (ii) *Partial Assimilation*, whereby some tribal members assimilate while the rest keep their tribal identity. We examine the conditions under which each outcome occurs.

3.1 Complete separation

This case occurs when for all $\delta \in [0, \Delta]$ and, therefore, for all tribal members the total payoff under the national identity is lower than that of the tribal one. That is, we have $\pi_{nt\delta} \leq \pi_{tt}$ for all $\delta \in [0, \Delta]$ or that

$$\kappa + \sigma_n\kappa(\beta R + c) \leq q_t(\kappa, \beta, \rho, \phi, 1)\phi T(1+\sigma_t) \tag{4}$$

Note that in this case ν (the number of tribal members who choose the national identity) is necessarily 0.

The parameter values under which (4) occurs can be straightforwardly determined. We summarize the sources of this outcome in the form of a Proposition.[4]

[4]The equilibria in terms of the fraction of tribals who choose to assimilate (ν) in our

Proposition 2 *Complete separation of tribal members occurs for (i) sufficiently low levels of state capacity (κ), the size of elites (β), income of the formal economy ($\kappa(\beta R + c + \nu)$), status of national identity for tribal members (σ_n) and (ii) sufficiently high levels resistance capabilities (ρ), collective organization of the tribe (ϕ), status of tribal identity (σ_t), and size of the resource (T).*

The sources of complete separation are, we think, rather straightfoward. It occurs when the attractions of the modern economy as well as the sense of national identity are low while the opposite is true for the material and psychological rewards of retaining the tribal identity. Such an outcome is likely to occur in low income countries with short histories of statehood and strong tribal or regional identities.

3.2 Complete assimilation

This opposite case occurs when for all $\delta \in [0, \Delta]$ and, therefore, for all tribal members the total payoff under the national identity is higher than that of the tribal one. That is, we have $\pi_{nt\delta} \geq \pi_{tt}$ for all $\delta \in [0, \Delta]$ or that[5]

$$\kappa + \sigma_n \kappa(\beta R + c + 1) - \Delta \geq q_t(\kappa, \beta, \rho, \phi, 1)\phi T(1 + \sigma_t) = 0 \tag{5}$$

The conditions under which complete assimilation of the tribals occurs are the opposite of those found in Proposition 2: A modern economy and state with high enough national status that overcomes both the alienation sensed by even the most affected member of the tribe (the one with the maximum possible level Δ) and generally weak resistance capabilities, collective organization, and status of the tribe as well as possibly low contestable resources. This case applies to some high-income countries in Europe that no longer have geographically concentrated indigenous minorities that might provide organized resistance and claims on regional resources.[6]

model can be thought of as the steady state (long-run) equilibria of explicitly dynamic two-period overlapping generations or other specifications in which the relevant players make decisions for one or more periods ahead. Then, complete separation is perfectly compatible with long-run equilibrium (under the parametric conditions described in Proposition 2). The investments in state capacity and national identity in the next section can also be incorporated into such a dynamic framework (Proposition 4) and still end up with complete separation of tribals. In Skaperdas and Testa (2025) we developed an overlapping generations model that takes explicit account of time and we could similarly do that in this paper but at a much higher notational and mathematical cost and without any substantive difference in results and intuition.

[5]The right-hand-side of (5) equals 0 because, by definition, there are no tribals left to contest the resource T.

[6]A different type of identity groups has been emerging more recently in some European countries are immigrant communities with considerable cultural distance—due to religion,

3.3 Partial assimilation

In this case some of the tribal population assimilates into the formal economy and national identity and v^* is a fraction strictly between 0 and 1. For the marginal tribal who is indifferent between the two identities and $\delta = \delta^*$ we have[7]

$$\kappa + \sigma_n \kappa(\beta R + c + F(\delta^*)) - \delta^* = q_t(\kappa, \beta, \rho, \phi, 1 - F(\delta^*))\phi T(1 + \sigma_t) \qquad (6)$$

where $F(\delta^*) = v^*$ because all those with $\delta \leq \delta^*$ choose assimilate into the national identity while those with $\delta > \delta^*$ continue to adhere to their tribal identity.

Comparative static results on the fraction of tribals who choose to assimilate are summarized in Proposition 3.

Proposition 3 *The fraction of tribal members who assimilate, $F(\delta^*)$, is (i) increasing in state capacity (κ), the size of elites (β), the income of the formal economy ($\kappa(\beta R + c + \nu)$), the status of national identity for tribal members (σ_n) and (ii) decreasing in resistance capabilities (ρ), the collective organization of the tribe (ϕ), the status of tribal identity (σ_t), and the size of rents (T).*

These results are qualitatively similar to those of Proposition 2 and show how as an economy becomes more "modernized," more tribals would be expected to assimilate. In particular, state capacity increases the income of prospective tribals who assimilate, increases their sense of national status as state capacity enhances national income, and decreases the share of resources received by adherents to the tribal identity. The size of elites increases national income and the status of national identity while it also

ethnicity, or class—from the mainstream national identities. Although such groups are urban, their relative geographic isolation and conflicts with the state could make our analysis applicable to those cases as well.

[7] Assuming (4) and (5) do not hold, to ensure that there is a unique $\delta^* \in (0,1)$ that satisfies (6) it is sufficient that the difference $\pi_{nt\delta} - \pi_{tt}$ as a function of δ is decreasing. That is the case when

$$F'(\delta) < \frac{1}{\sigma_n \kappa + \frac{\partial q_t}{\partial(1-v)}\phi T(1 + \sigma_t)}.$$

The denominator of the right-hand-side is always positive. We continue to assume this condition in the rest of the paper.

It appears that the larger the support of the distribution $F(\delta)$ is (that is, the greater Δ is), the more likely is that this inequality will hold. For example, in the case of the uniform distribution (where $F(\delta) = \frac{\delta}{\Delta}$), the inequality reduces to $\Delta > \sigma_n \kappa + \frac{\partial q_t}{\partial(1-v)}\phi T(1 + \sigma_t)$, where the right-hand-side is independent of Δ and, therefore, the inequality will hold for large enough Δ.

decreases the share of resources received by tribals. Factors that discourage assimilation include higher tribal resistance capabilities, collective organization, status of tribal identity, and the size of the contested resource.

4 Investing in state capacity and national identity

Up to this point all of the variables of the model have been assumed to be exogenous. We now allow for the elites to use the state to further improve their total collective payoff by investing in state capacity. Furthermore, the elites invest to enhance the sense of status by tribals who assimilate into the national identity.

State capacity covers the administrative capabilities of the state, be their fiscal, legal, enforcement, or benefits delivery. (See Besley and Persson, 2011, McBride et. al., 2011, and Johnson and Koyama, 2017, Skaperdas and Vaidya, 2020). Thus, our κ is a portmanteu variable that enhances private resources through various means as well as helps extract greater amount of resources in conflict with the tribes.

Meanwhile the content and status of national identity often has its roots in historical contingency but, as a voluminous literature demonstrates, it also has involved "top down" measures by states to "construct" such identities. Weber (1976), Anderson (1983), and Hobsbawm (1990) are classic treatments of the topic. More recently economists have provided both empirical (Bazzi et. al, 2019, Blanc and Kubo, 2024, Kersting and Wolf, 2024) and theoretical (Alesina, Reich, and Riboni, 2020, Almagro and Andres-Cerezo, 2020, Skaperdas and Testa, 2025) approaches to the topic. Investments in national identity can include schooling, media campaigns, construction of monuments and other symbols.

Suppose that we begin from certain levels of state capacity (κ^o) and national status for assimilated tribals (σ_n^o). The cost of investing in extra state capacity is $\xi(\kappa - \kappa^o)$ and investing in (also extra) national status is $\psi(\sigma_n - \sigma_n^o)$, where κ and σ_n denote the intended levels of the two variables after undertaking the investments. Both functions are strictly convex and twice continuously differentiable. The cost of the investments is assumed to be financed by lump-sum taxes.[8] Further we suppose that for all considered investments we are in a partial assimilation case whereby $\nu^* = F(\delta^*) \in (0,1)$. The elite's maximization problem is then the following:

$$\max_{\kappa,\sigma_n} \pi_e - \xi(\kappa - \kappa^o) - \psi(\sigma_n - \sigma_n^o) \text{ subject to } \nu^* = F(\delta^*)$$

[8]The elite could also tax itself with marginal tax rates. Skaperdas and Testa (2025) allow for endogenous balanced-budget taxation in an overlapping-generations model with similar generic characteristic to the model here.

where $F(\delta^*)$ and δ^* are determined by (6).

Substituting π_e from (3) and using the constraint, the problem is modified as follows:

$$\begin{aligned}&\max_{\kappa,\sigma_n} \kappa\beta R + \sigma\kappa\beta(\beta R + c + F(\delta^*)) + q_e(\cdot)\beta T \\ &-\xi(\kappa - \kappa^o) - \psi(\sigma_n - \sigma_n^o) \end{aligned} \tag{7}$$

To examine the incentives for investing in κ and σ_n, we first consider the marginal benefit of investing in each variable.

$$\begin{aligned} MB(\kappa) &\equiv \beta R + \sigma\beta(\beta R + c + F(\delta^*)) + \frac{\partial q_e}{\partial \kappa}\beta T \\ &\quad + [\sigma\kappa\beta - \frac{\partial q_e}{\partial(1-\nu)}\beta T]F'(\delta^*)\frac{\partial \delta^*}{\partial \kappa} \\ MB(\sigma_n) &\equiv [\sigma\kappa\beta - \frac{\partial q_e}{\partial(1-\nu)}\beta T]F'(\delta^*)\frac{\partial \delta^*}{\partial \sigma_n} \end{aligned}$$

The first two terms of $MB(\kappa)$, are the marginal benefits to the income of the elites and to their national status. The third term represents the marginal revenue from the conflict with the tribe. The fourth term is the marginal benefit they would receive from attracting more tribals into the national identity while decreasing the number of tribals who would resist conflict. Similarly to this last effect, the marginal benefit of investing in national identity comes solely from the effect it has in attracting more tribals to the national identity while reducing those that adhere to the tribal identity and resist the state.[9]

Note that the first term of $MB(\sigma_n)$ is increasing in state capacity and, as it turns out, the whole marginal benefit is increasing in state capacity. Moreover, $MB(\kappa)$ is also increasing in σ_n, and in that sense we can think of two investments as *complementary*. We establish this and another result in Proposition 4 below.

The FOC at the optimum κ^* and σ_n^* are

$$\begin{aligned} MB(\kappa^*) &= \xi'(\kappa^* - \kappa^o) \\ MB(\sigma_n^*) &= \psi'(\sigma_n^* - \sigma_n^o) \end{aligned}$$

[9]Note that the terms involving the partial derivative with respect to $1-\nu$ come from the differentiation of $q_e(\cdot)\beta T$ with respect to the two choice variables. Observe that q_e depends on $1-\nu$ from Proposition 1. In turn in an interior equilibrium, $F(\delta^*) = v^*$ depends on κ and σ_n by Proposition 3. Therefore, differentiation of $q_e(\cdot)\beta T$ with respect to κ yields

$$-\frac{\partial q_e}{\partial(1-\nu)}(-F'(\delta^*))\frac{\partial \delta^*}{\partial \kappa}\beta T$$

which, after rearrangement is the same as in MB(κ). The term in MB(σ_n) is similarly derived.

Proposition 4 *Suppose* $F''(\delta^*) \geq 0$ *and* $\sigma \geq \bar{\sigma}$ *for some* $\bar{\sigma} > 0$. *Then, (i)* $MB(\kappa)$ *is increasing in* σ_n *and* $MB(\sigma_n)$ *is increasing in* κ. *(ii) The optimal investments in state capacity* (κ^*) *and in tribal national identity* (σ_n^*) *are increasing in the elite's own sense of national identity* (σ), *in the elite's aggregate resources* (βR), *and in the resources of common citizens* (c).

The complementarity between investing in state capacity and in national identity in (i) is an instance of how the institutions of the modern nation-state can be thought of coming as a "package" of attributes that reinforce one another. Besley and Persson (2011) have argued how different types of state capacity have such complementarities while Skaperdas and Testa (2025) have similarly argued by including investments in national identity. Boyd (2017) has argued more broadly for the complementarity between many aspects of culture and political institutions favored by evolutionary forces and Skaperdas and Vaidya (2020) have shown how salvation religions and state capacity could have been complementary in pre-modern states. Given that tribal identity shrinks in the presence of stronger state capacity and assimilation capabilities (through higher σ_n), the prognosis for the preservation and independence of tribal identities is not positive.

Another factor that affects both types of investment is shown in part (ii) of Proposition 4: the status of national identity by the elites themselves (σ), a factor that had not appeared to play a role up to now (although, in practice, it could be correlated with σ_n). Both investments increase as a function of the status of national identity by the elites, a factor that can also be related to the unity of the elites.[10] This is an important variable that, through state capacity and national status, determines both the degree of economic and psychological attraction of the modern economy and state have on tribe members. Other variables that part (ii) shows to be relevant for both types of investment are the aggregate economic resources commanded by the elites that are a function of their size (β) and their resources per person (R) as well as those of common citizens (c); both types of resources increase incomes in the formal economy and are enhanced both by state capacity and, indirectly, through the sense of national identity by assimilated tribals.

In summary, then, we see that the main driver behind the assimilationist powers of state capacity and national identity is a unified elite with a

[10] Greenfeld (1992, 2001) has argued that the English elites appear to have been the first to unify around a common modern national identity, not coincidentally also developing the first modern nation state. Other European elites followed in unifying, often after internal conflicts were resolved, subsequently followed by struggles for elite unification in much of the rest of the world.

strong sense of national identity and economic resources.

5 Would a democratic state be more favorable to a tribal identity?

Thus far we have examined a state that is controlled by an elite whose decisions are in its self-interest. Would a state that is more representative of its population be less likely to take measures to assimilate tribals? There is no single way of thinking of how better representation would function in our model and we are presenting two possibilities. One possibility is that the choices made by the state are determined by the total welfare of those participating in the modern economy, by an *encompassing* interest in the words of McGuire and Olson (1996). The other possibility is to have the median voter determine policy.

5.1 Encompassing interest

In this case the total payoff of those involved in the modern economy include the elite, the common citizens, and the assimilated tribals. We introduce the common citizen' psychological payoff—which we did not have to introduce earlier—as that of assigning the same level of status to national identity as the assimilated tribals do (i.e., σ_n). Then, the total payoff of elite, common citizens, and assimilated tribals is

$$SW = \pi_e + \kappa(c + F(\delta^*) + \sigma_n(c + F(\delta^*))\kappa(\beta R + c + F(\delta^*)) \tag{8}$$

The first term is the payoff of the elite from (3), the second term consists of the material payoffs of the common citizens and assimilated tribals while the third term is their psychological payoffs. Then, the marginal benefit of investing in state capacity is

$$MSW(\kappa) = MB(\kappa) + MBC(\kappa)$$

where $MBC(\kappa) \equiv (c + F(\delta^*)(1 + \sigma_n(\beta R + c + F(\delta^*)) + [\kappa + \sigma_n\kappa(\beta R + 2c + 2F(\delta^*))]F'(\delta^*)\frac{\partial\delta^*}{\partial\kappa}$. Each of the terms of $MBC(\kappa)$ are positive. Therefore, given the strict convexity of the cost function $\xi(\kappa - \kappa^o)$, maximizing SW with respect to κ (given a constant σ_n) would yield a $\hat{\kappa}$ such that

$$MSW(\hat{\kappa}) = MB(\hat{\kappa}) + MBC(\hat{\kappa}) = \xi'(\hat{\kappa} - \kappa^o)$$

Given that $MBC(\kappa)$ is everywhere positive and $\xi(\kappa - \kappa^o)$, we must have $\hat{\kappa} > \kappa^*$. In turn, this implies that the number of assimilated tribals ($F(\delta^*)$) would increase under maximization of the social welfare function of all

those included in the modern economy. Moreover, this qualitative result would survive even if the welfare of assimilated tribals were not taken into account into the maximization of social welfare; just including the welfare of the common citizens in social welfare is sufficient to increase investments in state capacity relative to the case the elites make the decision by themselves. We summarize this result in the form of a Proposition.

Proposition 5 *Suppose Social Welfare is maximized in (8) in order to invest in state capacity at cost $\xi(\kappa - \kappa^o)$. Then the optimal state capacity $\hat{\kappa}$ is higher than the optimal state capacity under elite rule κ^*. Therefore, a greater number of tribals will be assimilated under Social Welfare maximization than under elite maximization.*

5.2 Median voter

Now suppose the median voter decides on investment in state capacity. If the median voter were an elite member, we would not expect the same outcome as in section 4. However, given the small size of the elite, this scenario is unlikely unless the democratic franchise is severely restricted. We therefore consider the case where a common citizen is the median voter.

A common citizen's payoff consists of their material payoff (κ times their resource of 1) plus their national status payoff:

$$\kappa + \sigma_n \kappa(\beta R + c + F(\delta^*))$$

Common citizens have both lower resources and a weaker sense of national identity than elites ($\sigma_n \leq \sigma$). Additionally, elite members receive rents from conflict with the tribe, which depends on state capacity. Consequently, a common citizen's payoff is lower—likely far lower—than an elite member's payoff. Therefore, when the median voter decides on state capacity, the marginal benefit would be correspondingly lower than when elite members decide by themselves.

However, the median voter scenario differs from social welfare maximization in an important way. Under social welfare maximization, the costs of investing in state capacity can be distributed broadly without necessarily affecting incentives. This approach is less defensible when the median voter makes decisions. The median voter would attempt to shift as much of the tax burden as possible onto others, especially onto elites who can better afford it. Meanwhile, elites might willingly accept this extra tax burden if it incentivizes the median voter to invest more in state capacity than they would otherwise. Thus, even if the median voter ultimately decides the level of state capacity investment, elites have strong incentives to subsidize that investment. The ultimate result remains unclear.

The expansion of the democratic franchise over the past two centuries is associated with a larger state sector, greater state capacity, and assimilation of tribes and smaller ethnic groups in many states. That is more consistent with either the elites continuing to exert a measure of control even when the median voter is not one of them or with the welfare maximization case.

6 Case studies

In this section, we explore three cases of attempted tribal incorporation throughout modern history: (i) the Southeast Asian Uplands, (ii) the Scottish Highlands, and (iii) Native American tribes during U.S. territorial expansion.

6.1 Southeast Asian Uplands

Across the Southeast Asian Uplands of Burma, Laos, Thailand, and Vietnam, various ethnic minorities have retained distinct identities in the face of state centralization and forced assimilation efforts. Scott (2009) describes efforts to integrate the peoples of the "Zomia" region, made by lowland states seeking revenue gains through increased landholdings and taxable incomes. Despite these efforts, various strategies of resistance were employed by these groups to evade incorporation, including the retention of local oral languages and traditional religious practices, and myths that valorized independence, augmented by tribal political organizational that bolstered local collective action.

Geography also played an important role. Rugged hills and forests limited the ability of states to monitor and tax, increasing the costs to state investment in roads and military patrols (Leach, 1960; Lieberman, 2003). Efforts to implement corvee labor or appropriate grain yields were frequently met with evasion through field-burning or migration. Unlike the Scottish Highlands or Native American tribes in the U.S. explored next, the Upland peoples of Southeast Asia succeeded in sustaining their autonomy for centuries, chiefly because central state capacity remained weak relative to the costs of extending it (Scott 2009). Representation in lowland political institutions, when it did emerge in the 20th century, often coincided with nation-building projects that renewed assimilation pressures (Keyes, 1979).

Overall, this combination of well-organized tribal settlements ($\uparrow \phi$), sophisticated resistance strategies ($\uparrow \rho$), strong tribal identities ($\uparrow \sigma_t$) and rough geography in the face of weak state capacity ($\downarrow \kappa$) facilitated sus-

tained alternative identification and state avoidance in the case of the Southeast Asian Uplands.

6.2 Scottish Highlands

After the 1707 Acts of Union, the rugged Scottish Highlands remained a frontier of resistance to the British state. Unique history and culture, characterized by Gaelic language, Jacobite loyalties, and cohesive kinship-based clan structures meant Scottish Highlanders retained a distinct identity in the face of the region's formal incorporation into Great Britain, which contrasted greatly with the nascent British national identity of the time (Devine, 1999; Pittock, 2014). Jacobite uprisings in 1715 and 1745 served to further reveal the strength and salience of this alternative identity (Lenman, 1980).

In their aftermath, the British state increasingly invested in extending its state capacity northward. New forts and roads were constructed, and English judicial and fiscal institutions were imposed (Lenman, 1980). These investments enabled more effective suppression of rebellion, while also expanding the reach of British taxation and conscription. Meanwhile, new legal measures beginning with the 1746 Acts of Proscription were enforced outlawing weapons-carrying, banning "Highland Dress", restricting the use of Gaelic, and stripping the feudal powers of clan chiefs, together undercutting the payoffs of Highland identification and further incentivizing assimilation into the British nation (Magnusson, 2003; Trevor-Roper, 1983). Meanwhile, extraction by British came in new forms. Land enclosures and the Highland Clearances in the latter half of the 18th century displaced traditional tenants in favor of commercial sheep farming (Devine, 2018; Richards, 2000). With Scotland's de jure integration with England, formal representation in Parliament meant that Scottish elites tended to embrace Northern British language and culture with time (Jones, 1995).

Ultimately, despite strategies of resistance ($\uparrow \rho$) supported by deeply-rooted clan structures and rugged geography, efforts to diminish tribal identification ($\downarrow \sigma_t$) and organization ($\downarrow \phi$) combined with sustained British state capacity investment ($\uparrow \kappa$) eventually succeeded in overwhelming the traditional languages and culture of the Scottish Highlands.

6.3 Native Americans during U.S. expansion

As the United States extended its territorial reach across the continent in the 19th century, it confronted vast indigenous populations with long-standing cultural identities. Tribes, such as the Cherokee, the Lakota, and

the Navajo, each maintained distinct languages, religious traditions, and modes of collective organization. Confederacies and councils of Native American groups offered some coordinated resistance ($\uparrow \rho$), while the mobility of some Great Plains groups offered temporary evasion capacity (Graymont, 1972; Hamalainen, 2008; Perdue and Green, 2001).

Over time, however, U.S. elites succeeded in growing its state capacity on the frontier, especially as the transcontinental railroad reduced geographic constraints to expansion. The Indian Removal Act of 1830 and the Dawes Act of 1887 further facilitated extraction of tribal lands and converted broad swathes of the frontier into parcels for white settlement and new military installations (Prucha, 1984). State-led programs, such as boarding schools and religious missions, further reduced the psychological payoffs associated with indigenous identification, accelerating assimilation (Adams, 1995). In the meantime, the expansion of suffrage and democracy did not extend to tribes. When it eventually did following the Indian Citizenship Act of 1924, it was tied to assimilationist policies rather than the protection of indigenous identities.

Together, heterogeneous and increasingly-diminished tribal organization ($\downarrow \phi$) and identification ($\downarrow \sigma_t$) in the face of democratic governance and vast state investment in infrastructure and territorial expansion ($\uparrow \kappa$) saw the eventual broad-based erasure of tribal society among many Native American groups.

7 Concluding remarks

As the modern economy and the modern nation-state have come to dominate the world, the movement toward ever fewer spoken languages and the disappearance of smaller cultures may seem inexorable. Yet modern national identities are not fixed: they evolve, and the incorporation or persistence of subnational identities varies systematically across places and over time. This paper formalizes that variation by studying how state capacity and national identification jointly shape conflict, resistance, and assimilation between central elites and tribal "rimlands."

The model predicts three broad classes of outcomes. When state capacity is weak and the modern economy offers little in material gains—while tribal organization, resistance capability, and identity status are high—separation can in fact persist. But when state capacity is high and tribal organization is weak or has been eroded, assimilation becomes dominant, facilitated by improved monitoring and extraction, as well as by increased incentives for tribals to adopt the national identity. In intermediate cases, partial assimilation arises, with the evolution of identity depending on

how state capacity and nation-building investments develop relative to tribal resistance and organization. Multiple mechanisms are central in promoting assimilation, including investments in state capacity as well as in national identity itself. Democratic participation, meanwhile, need not protect tribal identity when political influence is concentrated among those already identifying nationally.

Our framework connects closely with the insights of James C. Scott, including his analysis of the Southeast Asian Uplands in Scott (2009). Scott emphasizes how factors such as weak state capacity, difficult geography, and sophisticated evasion strategies allowed Upland societies to resist incorporation for centuries. The model captures these mechanisms explicitly, showing how limited state capacity combined with strong tribal identities, collective organization, and resistance strategies, can sustain long-run separation even in the presence of material incentives to assimilate.

Our framework also generalizes beyond the work of Scott, helping to understand patterns of incorporation and resistance elsewhere, from the Scottish Highlands and Native American tribes during U.S. territorial expansion to contemporary conflicts in low-capacity states. It sheds light on why marginalized ethnic groups in such settings—such as those studied by Michalopoulos and Papaioannou (2016) across African state borders—face higher risks of civil conflict and confrontation with central governments, as weak capacity limits incorporation while identity-based resistance remains strong. Likewise, it helps to clarify how national identity itself may evolve in response to constraints on state power: Mexico's embrace of a *mestizo* national identity illustrates how lower state capacity may leave room for elements of tribal identity to shape the national project, rather than being fully suppressed.

APPENDIX

Proof of Proposition 1: Taking the derivative of each payoff function in (2) with respect to each player's strategy and setting equal to 0 at equilibrium we obtain:

$$\begin{aligned}\frac{\partial \pi_{ec}(x_s^*, x_t^*)}{\partial x_{s\rho}} &= \frac{\kappa\rho x_s^*}{(\kappa x_s^* + \rho x_t^*)^2}\beta T - 1 = 0 \\ \frac{\partial \pi_{tc}(x_s^*, x_t^*)}{\partial x_t} &= \frac{\kappa\rho x_s^*}{(\kappa x_s^* + \rho x_t^*)^2}\phi(1-v)T - 1 = 0\end{aligned}$$

from which we can solve for the unique Nash equilibrium strategy combination:

$$\begin{aligned}x_s^* &= \frac{\kappa\rho\phi(1-\nu)\beta}{(\kappa\beta + \rho\phi(1-\nu))^2}\beta T \\ x_t^* &= \frac{\kappa\rho\phi(1-\nu)\beta}{(\kappa\beta + \rho\phi(1-\nu))^2}\phi(1-\nu)T\end{aligned}$$

By substitution, the shares for the elites and the tribals are, respectively, as follows:

$$\begin{aligned}\frac{\kappa x_s^*}{\kappa x_s^* + \rho x_t^*} &= \frac{\kappa\beta}{\kappa\beta + \rho\phi(1-\nu)} \\ \frac{\rho x_t^*}{\kappa x_s^* + \rho x_t^*} &= \frac{\rho\phi(1-\nu)}{\kappa\beta + \rho\phi(1-\nu)}\end{aligned}$$

yielding the equilibrium payoffs

$$\begin{aligned}\pi_{ec}^* &\equiv \pi_{ec}(x_s^*, x_t^*) = \frac{\kappa\beta}{\kappa\beta + \rho\phi(1-\nu)}\beta T - \frac{\kappa\rho\phi(1-\nu)\beta}{(\kappa\beta + \rho\phi(1-\nu))^2}\beta T \\ &= q_e(\kappa, \beta, \rho, \phi, 1-\nu)\beta T \\ \pi_{tc}^* &\equiv \pi_{tc}(x_s^*, x_t^*) = \frac{\rho\phi(1-\nu)}{\kappa\beta + \rho\phi(1-\nu)}\phi(1-\nu)T - \frac{\kappa\rho\phi(1-\nu)\beta}{(\kappa\beta + \rho\phi(1-\nu))^2}\phi(1-\nu)T \\ &= q_t(\kappa, \beta, \rho, \phi, 1-\nu)\phi(1-\nu)T\end{aligned}$$

where $q_e(\kappa, \beta, \rho, \phi, 1-\nu) \equiv \frac{(\kappa\beta)^2}{(\kappa\beta+\rho\phi(1-\nu))^2}$ and $q_t(\kappa, \beta, \rho, \phi, 1-\nu) \equiv \frac{(\rho\phi(1-\nu))^2}{(\kappa\beta+\rho\phi(1-\nu))^2}$.

The properties reported in the Proposition are readily derived from these two functional forms. QED

Proof of Proposition 3: To show the results reported in the Proposition, we need to totally differentiate the following form of (6):

$$\kappa + \sigma_n\kappa(\beta R + c + F(\delta^*) - \delta^* - q_t(\kappa, \beta, \rho, \phi, 1 - F(\delta^*))\phi T(1 + \sigma_t) = 0$$

Note that for $x = \kappa, \sigma_n, \beta, \rho, \phi, \sigma_t$, and T, $\frac{\partial \delta^*}{\partial x} = -\frac{A_x}{D}$ where $D \equiv [\sigma_n \kappa + \frac{\partial q_t}{\partial(1-v)} \phi T(1+\sigma_t)]F'(\delta^*) - 1$ and A_x represents the derivative of the equation above with respect to x.

We have already assumed D to be negative in order to guarantee uniqueness of δ^* (see footnote 7). We derive the other derivatives below for the two parts of the Proposition.

Part (i):

$A_\kappa = \sigma_n(\beta R + c + F(\delta^*)) - \frac{\partial q_t}{\partial \kappa} \phi T(1+\sigma_t) > 0.$

$A_{\sigma_n} = \kappa(\beta R + c + F(\delta^*)) > 0$

$A_\beta = \sigma_n \kappa R > 0$

Thus, given $D < 0$ and the positive values of $A_x's$, the derivatives of δ^* with respect to those three variables and, trivially, with respect to $\kappa(\beta R + c + F(\delta^*))$ must be positive.

Part (ii):

$A_\rho = -\frac{\partial q_t}{\partial \rho} \phi T(1+\sigma_t) < 0$

$A_\phi = - - \frac{\partial q_t}{\partial \phi} \phi T(1+\sigma_t) - q_t(\kappa, \beta, \rho, \phi, 1 - F(\delta^*))T(1+\sigma_t)\sigma_t < 0$

$A_{\sigma_t} = -q_t(\kappa, \beta, \rho, \phi, 1 - F(\delta^*))\phi T < 0$

$A_T = -q_t(\kappa, \beta, \rho, \phi, 1 - F(\delta^*))\phi(1+\sigma_t) < 0$

Then, given $D < 0$ and the negative values of $A_x's$, the derivatives of δ^* with respect to those five variables are negative, as reported in the Proposition. QED

Lemma 6 *If* $F''(\delta^*) \geq 0$, *then* $\frac{\partial^2 \delta^*}{\partial \kappa \partial \sigma_n} > 0$.

Proof: From the proof of Proposition 3, $\frac{\partial \delta^*}{\partial \kappa} = -\frac{A_\kappa}{D}$, where

$A_\kappa = \sigma_n(\beta R + c + F(\delta^*)) - \frac{\partial q_t}{\partial \kappa} \phi T(1+\sigma_t) > 0$

and

$D \equiv [\sigma_n \kappa + \frac{\partial q_t}{\partial(1-v)} \phi T(1+\sigma_t)]F'(\delta^*) - 1 < 0$

Therefore, we have:

$$\frac{\partial^2 \delta^*}{\partial \kappa \partial \sigma_n} = \frac{\partial(\frac{\partial \delta^*}{\partial \kappa})}{\partial \sigma_n} = \frac{\partial(-\frac{A_\kappa}{D})}{\partial \sigma_n} = \frac{-\frac{\partial A_\kappa}{\partial \sigma_n} D + A_\kappa \frac{\partial D}{\partial \sigma_n}}{D^2}$$

We can show that

$$\frac{\partial A_\kappa}{\partial \sigma_n} = \beta R + c + F(\delta^*) + \sigma_n F'(\delta^*) \frac{\partial \delta^*}{\partial \sigma_n}$$

which is positive, given that the first three terms are positive, $\sigma_n \geq 0$, $F'(\delta^*) > 0$,and, by Proposition 3(i), $\frac{\partial \delta^*}{\partial \sigma_n} > 0$.

Moreover, we have

$$\frac{\partial D}{\partial \sigma_n} = \kappa F'(\delta^*) + [\sigma_n \kappa + \frac{\partial q_t}{\partial(1-v)} \phi T(1+\sigma_t)]F''(\delta^*) \frac{\partial \delta^*}{\partial \sigma_n}$$

The first term is negative, the term inside the brackets is positive (given that, by Proposition 1(ii), $\frac{\partial q_t}{\partial(1-v)} > 0$), $F''(\delta^*)$ is by assumption non-negative, and, by Proposition 3(i), $\frac{\partial \delta^*}{\partial \sigma_n} > 0$. Therefore, $\frac{\partial D}{\partial \sigma_n}$ is positive.

Taking all this into account, we have: The numerator of $\frac{\partial^2 \delta^*}{\partial \kappa \partial \sigma_n}$ $(-\frac{\partial A_\kappa}{\partial \sigma_n} D + A_\kappa \frac{\partial D}{\partial \sigma_n})$ must be positive (given that $\frac{\partial A_\kappa}{\partial \sigma_n} > 0$, $D < 0$, $A_\kappa > 0$, and $\frac{\partial D}{\partial \sigma_n} > 0$), while its denominator (D^2) is also positive. Therefore, we must have $\frac{\partial^2 \delta^*}{\partial \kappa \partial \sigma_n} > 0$.

Proof of Proposition 4: *(i)* First note that $\frac{\partial MB(\kappa)}{\partial \sigma_n} = \frac{\partial(\frac{\partial \pi_e}{\partial \kappa})}{\partial \sigma_n} = \frac{\partial^2 \pi_e}{\partial \sigma_n \partial \kappa} = \frac{\partial(\frac{\partial \pi_e}{\partial \sigma_n})}{\partial \kappa} = \frac{\partial MB(\sigma_n)}{\partial \kappa}$. Therefore, in order to determine the sign of the two derivatives, we only need to consider one of them. Let us consider the effect of σ_n on $MB(\kappa)$:

$$\begin{aligned}\frac{\partial MB(\kappa)}{\partial \sigma_n} &= [\sigma\beta - \frac{\partial^2 q_e}{\partial(1-\nu)\partial\kappa}\beta T]F'(\delta^*)\frac{\partial \delta^*}{\partial \sigma_n} + \\ &\quad [\sigma\kappa\beta - \frac{\partial q_e}{\partial(1-\nu)}\beta T][F''(\delta^*)\frac{\partial \delta^*}{\partial \kappa}\frac{\partial \delta^*}{\partial \sigma_n} + F'(\delta^*)\frac{\partial^2 \delta^*}{\partial \kappa \partial \sigma_n}]\end{aligned}$$

We consider the second term first. Its first part in brackets is positive given that $\frac{\partial q_e}{\partial(1-\nu)} < 0$ from Proposition1(i). The first term inside the second set of brackets is non-negative given that, by assumption, $F''(\delta^*) \geq 0$ and, by Proposition 3(i), $\frac{\partial \delta^*}{\partial \kappa} > 0$ and $\frac{\partial \delta^*}{\partial \sigma_n} > 0$. By Lemma 6, we have $\frac{\partial^2 \delta^*}{\partial \kappa \partial \sigma_n} > 0$ which, along with $F'(\delta^*) > 0$,implies that the second term inside the second set of brackets is positive. Hence the whole second term is positive.

Next consider the first term of $\frac{\partial MB(\kappa)}{\partial \sigma_n}$. Its sole component that can be negative is $-\frac{\partial^2 q_e}{\partial(1-\nu)\partial\kappa}\beta T$, which from the proof of Proposition 1 equals $\frac{2\kappa\beta^2\rho\phi(2\rho\phi(1-\nu)-\kappa\beta)}{(\kappa\beta+\rho\phi(1-\nu))^4}\beta T$. Thus, if $2\rho\phi(1-\nu) - \kappa\beta < 0$, then $-\frac{\partial^2 q_e}{\partial(1-\nu)\partial\kappa}\beta T < 0$. However, even then, the whole term $[\sigma\beta - \frac{\partial^2 q_e}{\partial(1-\nu)\partial\kappa}\beta T]$ is positive for any $\sigma \geq \bar{\sigma} \equiv -\frac{2\kappa\beta^2\rho\phi(2\rho\phi(1-\nu)-\kappa\beta)}{(\kappa\beta+\rho\phi(1-\nu))^4}T$. Then, given that $F'(\delta^*)$ is always positive and $\frac{\partial \delta^*}{\partial \sigma_n} > 0$ from Proposition 3(i), the first term would be positive as well and we must have $\frac{\partial MB(\kappa)}{\partial \sigma_n} > 0$. Given that $\frac{\partial MB(\kappa)}{\partial \sigma_n} = \frac{\partial MB(\sigma_n)}{\partial \kappa}$, we also have $\frac{\partial MB(\sigma_n)}{\partial \kappa} > 0$.

(ii) We will be totally differentiating the following system of two equations:

$$\begin{aligned}MB(\kappa^*) - \xi'(\kappa^* - \kappa^o) &= 0 \\ MB(\sigma_n^*) - \psi'(\sigma_n^* - \sigma_n^o) &= 0\end{aligned} \tag{9}$$

For $x = \sigma, \beta R$, and c, we can obtain $\frac{\partial \kappa^*}{\partial x}$ and $\frac{\partial \sigma_n^*}{\partial x}$ from the following

types of matrices:

$$\begin{pmatrix} C_{1\kappa} & C_{1\sigma_n} \\ C_{2\kappa} & C_{2\sigma_n} \end{pmatrix} \begin{pmatrix} \frac{\partial \kappa^*}{\partial x} \\ \frac{\partial \sigma_n^*}{\partial x} \end{pmatrix} = \begin{pmatrix} -C_{1x} \\ -C_{2x} \end{pmatrix}$$

where C_{iy} denotes the derivative of equation $i = 1, 2$ of (9) with respect to variable y.

Note that $C_{1\kappa} < 0$ and $C_{2\sigma_n} < 0$ as part of the SOC of the optimization problem which is ensured by the strict convexity of the $\xi(\kappa - \kappa^o)$ and $\psi(\sigma_n - \sigma_n^o)$ functions. Moreover, also as part of the SOC, is that the determinant of the matrix $C \equiv C_{1\kappa}C_{2\sigma_n} - C_{2\kappa}C_{1\sigma_n}$ is positive. Finally, note that $C_{2\kappa} = C_{1\sigma_n} = \frac{\partial MB(\kappa)}{\partial \sigma_n} = \frac{\partial MB(\sigma_n)}{\partial \kappa} > 0$, as shown in part (i) of this Proposition.

We next calculate the following derivatives, with their signs easily determined:

$$\begin{aligned} C_{1\sigma} &= \beta(\beta R + c + F(\delta^*)) + \kappa^* \beta F'(\delta^*) \frac{\partial \delta^*}{\partial \kappa} > 0 \\ C_{2\sigma} &= \kappa \beta F'(\delta^*) \frac{\partial \delta^*}{\partial \sigma_n} > 0 \\ C_{1\beta R} &= 1 + \sigma\beta > 0 \\ C_{2\beta R} &= 0 \\ C_{1c} &= \sigma\beta \\ C_{2c} &= 0 \end{aligned}$$

The comparative static results then follow from the properties of the different quantities we have derived above:

$$\begin{aligned} \frac{\partial \kappa^*}{\partial \sigma} &= \frac{-C_{1\sigma}C_{2\sigma_n} + \frac{\partial MB(\kappa)}{\partial \sigma_n} C_{2\sigma}}{|C|} > 0 \\ \frac{\partial \sigma_n^*}{\partial \sigma} &= \frac{-C_{1\kappa}C_{2\sigma} + \frac{\partial MB(\sigma_n)}{\partial \kappa} C_{1\sigma}}{|C|} > 0 \\ \frac{\partial \kappa^*}{\partial \beta R} &= \frac{-C_{1\beta R}C_{2\sigma_n} + \frac{\partial MB(\kappa)}{\partial \sigma_n} C_{2\beta R}}{|C|} > 0 \\ \frac{\partial \sigma_n^*}{\partial \beta R} &= \frac{-\frac{\partial MB(\sigma_n)}{\partial \kappa} C_{1\beta R}}{|C|} > 0 \\ \frac{\partial \kappa^*}{\partial c} &= \frac{-C_{1c}C_{2\sigma_n} + \frac{\partial MB(\kappa)}{\partial \sigma_n} C_{2c}}{|C|} > 0 \\ \frac{\partial \sigma_n^*}{\partial c} &= \frac{-\frac{\partial MB(\sigma_n)}{\partial \kappa} C_{1c}}{|C|} > 0 \end{aligned}$$

QED

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