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Escape from Europe: a calculus of consent model of the origins of liberal institutions in the North American colonies

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Abstract
The migration out of Europe and the establishment of North American colonies presents us with a great puzzle: why did the colonists establish democratic forms of governance? Considering that early democratic colonies appeared even before philosophical works such as those of Locke and Montesquieu were written, it is difficult to make the case that ideology was the driving factor. We show that the calculus of consent model proposed by Buchanan and Tullock (The calculus of consent, Liberty Fund, Indianapolis, 1962) offers a simple but subtle solution this puzzle. Because migrants formed much more homogeneous communities, and because, thanks to the large geographical expanse, the inter-jurisdictional externalities were small, the efficient level of consensus within each colony was much greater than in Europe, and the scope of efficient centralized decision-making was much smaller. Hence, a structure of decentralized democratic communities emerged as the efficient outcome.

Keywords Institutional formation · Federalism · Chesapeake Bay colonies · New England colonies

JEL Classification D02 · H41 · P16 · N41

1 Introduction

Our understanding of the origins of liberal institutions in the North American colonies is still inadequate. Many common explanations fail at closer inspection. For example, the colonists did not simply implement the *same* institutions they were

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used to. Instead, they introduced spectacular institutional changes in a relatively short period of time. However, and most puzzling, these changes were not simply driven by preexisting enlightened ideas. Most of these changes occurred *before* the prominent European writers we now associate with these ideas wrote their books. This makes the puzzle both interesting and significant: *Why has North American society in the 17th–18th centuries diverged in fundamental respects from England and Europe?*

This paper looks at the divergent *constraints* that political decision-making faced across the Atlantic, as well as across different North American colonies, building upon Congleton (2011). The British type of government failed to fully replicate in the colonies because it couldn't, and alternative governance structures emerged as a result. Can a cost-based theory explain why colonists created a more democratic and decentralized political system?

We argue that the calculus of consent perspective proposed by Buchanan and Tullock (1962) offers significant insight. *The Calculus of Consent* is often celebrated as one of the foundational texts in the economic analysis of politics (Wagner 1988). It followed the social choice revolution (Arrow 1951; Downs 1957; Black 1958), alongside Riker's (1962) analysis of political coalitions and Olson's (1965) logic of collective action, and opened the door for the field of constitutional political economy at the intersection between public choice and new institutional economics (Ostrom and Ostrom 2004).

We use the calculus to explain the institutional transformation of North American colonies before their independence by looking at the changes to the underlying decision-making and external costs. Due to the significant geographical differences between North America and Europe, the nature of these costs differed significantly in the two contexts, exerting significant pressure on the institutional structure and on the cultural legitimization of the institutional structure. We show that the details of this historical episode closely fit the pattern predictions that follow from the calculus of consent. We can explain (a) why North American colonies ended up more democratic than Britain, (b) why New England colonies were more democratic than the Chesapeake colonies, (c) why the colonies organized as a decentralized confederation rather than as a centralized empire, and (d) why there was a strong economic rationale for political independence. In this account, the institutional structure was the result of efficiency pressures, along the lines argued by Stigler (1992), and the ideology that legitimized this structure largely followed.

The paper proceeds as follows. In the next section we explain why the calculus of consent is particularly well suited to understand the institutional effects of mass migration, develop three calculus of consent theorems about how the equilibrium decision rules are affected by changes in the underlining costs, and show how these theorems can be used to make pattern predictions about changes in democracy, federalism and economic freedom. Section 3 shows how to apply the model to explain the differences between Britain and North American colonies. Section 4 shows that the model also provides useful insight about the differences between colonies, in particular between New England and Chesapeake colonies. The conclusion briefly discusses the fact that the calculus also provides a quick explanation for the

institutional evolution in United States and Europe, in particular for the growth of government.

2 The calculus of consent as a tool for institutional analysis

2.1 Mass migration and the supply and demand of social contracts

It is easy to imagine how resettling a group of people from a society with an established institutional structure to build a new society elsewhere, would simply result in a copy of the original society. For instance, the "colonial origins" theory makes precisely this assumption (Acemoglu et al. 2001, 2012).' Furthermore, institutional evolution is typically conceptualized as a gradual process taking place over many centuries, with emergent social patterns, structures, and orders arising bit by bit from the spontaneous interactions of countless actors. The American Revolution brought dramatic political change, but we also cannot overlook the social and institutional transformation of American society over the course of the 17th and 18th centuries. As noted by Gordon Wood (1993: 6–7):

> By the time the Revolution had run its course in the early nineteenth century, American society had been radically and thoroughly transformed. … It was in fact a new society unlike any that had ever existed anywhere in the world. … Far from remaining monarchical, hierarchy-ridden subjects on the margin of civilization, Americans had become, almost overnight, the most liberal, the most democratic, the most commercially minded, and the most modern people in the world.

The American Revolution was not merely a coup or political revolution, but reflected a radical transformation of society over the previous two centuries, where a slew of traditional relationships and institutions unraveled after many centuries of entrenchment. But why? Interestingly, the North American colonists were not simply implementing enlightened ideas developed in Europe. As Congleton (2011: 526) notes, "Virginia's 1621 constitution was written well before Hobbes, Locke, or Montesquieu put their pens to paper, and nearly 2 decades before the Levellers' contract". Similarly, "the West New Jersey Charter of 1681 [was] adopted a decade before Locke finished his influential treatise on government and several years before England's Glorious Revolution" (Congleton 2011: 530). This does not mean that ideas are unimportant, as each individual institutional experiment is driven by ideas, but it does undermine the concept of a *broad and uniform climate of ideas* preceding and determining the institutional and economic outcomes, as it is often assumed (e.g. see Bailyn 1967; Appleby 1976, 1978, 1984; McCloskey 2006, 2010).

In contrast to the ideological explanation, Congleton (2011) proposes that, to understand the origins of liberal institutions in North America, we have to better understand *the underlying costs* for organizing under different institutions, and particularly how "the mobility of labor and the interests of large landowners … induced the emergence of relatively liberal forms of representative government" (Congleton

2011: 529). Our contribution in this paper is to show that we can indeed understand *the broad patterns* of this transformation by using the deceptively simple framework provided by the calculus of consent (Buchanan and Tullock 1962).

More specifically, Congleton makes the crucial remark that the underlying costs driving the institutional change from Europe to North American colonies can be grasped by noting that "[i]n Europe, land was normally the constraining resource constraint, which is part of the reason that territorial wars in Europe were commonplace. … In the colonies, labor was the constraining factor and had to be attracted from elsewhere" (2011: p. 524). The importance of this difference cannot be overstated. It means that the colonies were closer to a consent model—as they needed to attract workers—while Europe was closer to a conflict model. While mercantilist Europe can be understood, as a first approximation, through the lens of the "stationary bandit" model (Olson 1993) and as rent-seeking societies (Ekelund and Tollison 1981; Nye 1997, 2007), the North American colonies are better understood using a consent model.

But these North American colonists were not modern enlightened liberals, and, hence, the liberal societies they built were more a reflection of the constraints they faced rather than of the ideas they started with. As noted by Diamond (1967), in order to recruit and maintain a productive labor force, colonial leaders found it necessary to offer a number of concessions to laborers, including expanded economic freedom, land, and political rights. Immigration was thus an important factor in reinforcing the values and institutions of economic freedom and democracy (Diamond 1967: pp. 574–575). Immigration pushed the colonial institutional structure beyond or even against what might have been the original intentions of those with political power in the colonies. Other authors have described a similar mechanism operating more recently for improving women's rights in the 19th century United States (Lemke 2016). To understand the origins of liberal institutions it is not necessary to assume liberal intentions or a preexisting liberal ideology.

In Buchanan's (1987) assessment, social choice theory had "presumed, without inquiry, that the individual was locked into membership in a political community and that the range and the scope of the collective's activities were beyond the control of the individual" (p. 69). By contrast, "[t]he *Calculus* sought to outline, at least in very general terms, the conditions that must be present for the individual to find it advantageous to enter into a political entity with constitutionally delineated ranges of activity or to acquiesce in membership in a historically existent polity" (p. 70). The typical social contract analyses discuss *hypothetical* constructions of communities. Migration offers real-world examples.

We focus on the migration of disaffected people from Europe (such as the English Puritans) to North America and their establishment of (relatively) democratic communities and liberal institutions (particularly in New England). This historical episode allows us to examine the process of endogenous constitutional formation where individuals are *not* locked into membership in a political community, and thus illustrate in a particularly clear fashion Buchanan's point about how individuals choose and create constitutional arrangements. Buchanan and Tullock (1962) have framed their theory of institutional efficiency in abstract terms, invoking the hypothetical creation of a social contract out of thin air by individuals behind a "veil

of uncertainty". This is obviously unrealistic, but as Buchanan's (1987) remarks, cited above, suggest, we can use mass migration as a real-world substitute for people choosing among alternative social contracts. As noted by Diamond (1967), Congleton (2011) and Lemke (2016), migration is creating a demand pressure on the suppliers of alternative institutional arrangements.

We should emphasize from the beginning that the calculus is a *very simple model*. It would be hopeless to assume that it can account for all the historical details. The value of the model—and here its simplicity is a feature—rests in revealing the *broad economic structure* that might lie behind the complexities of historical events: how external and decision-making costs are shaping emerging institutions. Without the help of a sound theoretical framework, historical events appear hopelessly complex. In the same way as a map does not need to reproduce the terrain in all its features in order to be useful, the calculus of consent model need not reproduce all the details of real-world political processes to provide a useful analysis of some of the main factors involved.

The calculus is not the *only* economic model useful for understanding historical events and institutional developments, as other models can help us understand other aspects of the matter. In particular, conflict theory offers an important theoretical complement (Olson 1993; Nye 1997; Hirshleifer 2001), and we also do not wish to completely dismiss the importance of ideas (Denzau and North 1994; Tarko 2015). Our purpose here is to show that an often neglected part of the explanation, the tendency towards efficient self-governing consensual institutions, actually provides significant insight. Focusing *solely* on conflict or ideas leads to a distorted perspective of history. The positive-sum collaboration toward building new communities or reforming existing ones is also an important factor of history, and this is what the calculus captures while the other perspectives do not (Buchanan 1987).

2.2 Three key institutional predictions

Buchanan and Tullock's (1962) fundamental insight is that collective decision-making faces a trade-off between two types of costs: (a) political external costs, E, suffered by those who disagree with the collective decision but have to obey it nonetheless, and (b) decision-making costs, D, the transaction costs involved in reaching and enforcing the collective decision.

These costs are functions of the *level of consensus*, n, with which a collective decision is taken, and of the *composition* of the group involved in the decision-making process. The level of consensus is "the proportion of the group required to reach agreement" (Buchanan and Tullock 1962: p. 82), i.e. the number of people who need to agree with a policy in order for it to be adopted, divided by the size of the entire population affected by that policy. External costs are assumed to be monotonically declining as n increases, while decision costs are assumed to be monotonically increasing as n increases (Fig. 1).

Importantly, the external costs are of two different types, depending on whether those harmed by the collective decision are themselves members of the political unit, but have been outvoted or coerced, or are outsiders suffering from negative spillover

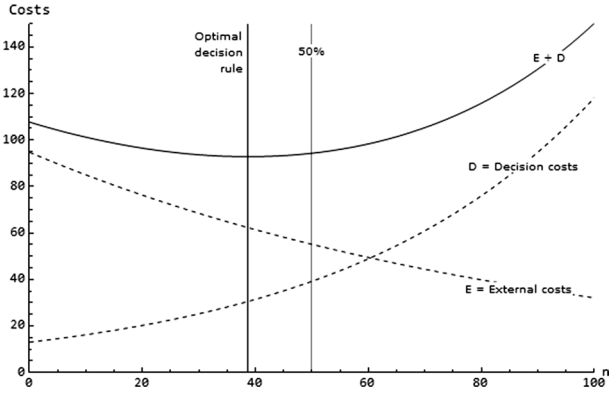

Fig. 1 The calculus of consent efficient decision rule, minimizing total cost

effects and lacking effective means of objecting. The first type of external cost is relevant for analyzing the optimal level of consensus (for different issues) *within* a community, while the second one is useful for analyzing *federalism* by looking at the effects of decentralization and at inter-jurisdictional interactions. Reaching consensus takes time. Decision-making costs refer to the individuals' opportunity costs of the time and other resources spent in the process of reaching consensus. We take collective decisions with less than unanimity because this total opportunity cost is prohibitive.

The calculus of consent model is often assumed to be a normative theory. By contrast, we follow Buchanan (1968) and assume that, by using the "politics as exchange" assumption, we "can predict, first, the emergence of [an institutional structure], and, secondly, the characteristics of the outcomes that such a structure will tend to produce". The main conceptual tool for this purpose is *efficiency*, "a descriptive term that is used to specify the existence of certain relationships among variables and among institutions which are produced through the process of voluntary exchange", and which provides "a prediction of results … not a criterion for telling us what should be present in order to further some externally derived value norm" (Buchanan 1968 [1999]: 5–6). To put it differently, we can use the calculus as a tool for institutional analysis by adopting Stigler's (1992) perspective that, abstracting from all the complexities of social-political processes, but bearing the transaction costs in mind, enduring institutions have a tendency towards efficiency.

The calculus of consent efficiency criterion states that the deciding group is expanded (including more members) up to the point where the marginal decision costs of including more members in the decision-making process become larger than the marginal benefits due to the reduction of external harms:

$$\text{Equilibrium}: \frac{\delta D}{\delta n} = -\frac{\delta E}{\delta n}$$

The composition of the deciding group also matters because depending on who exactly is added to the deciding group both decision costs and external costs can

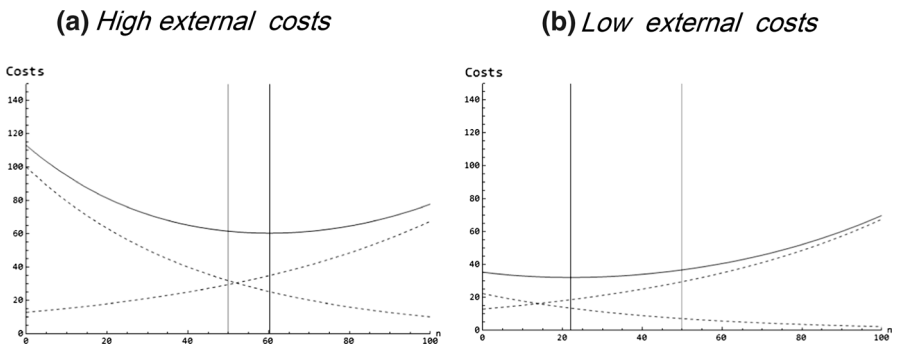

Fig. 2 The optimal rule decreases when external costs are decreasing. Possible interpretations: #1: inter-jurisdictional spillovers: **a** size of jurisdictions increases; **b** size of jurisdictions decreases, #2: political external costs inside a jurisdiction: **a** more inclusive decision-making (e.g., to counter-act the potential for rent-seeking); **b** less inclusive decision-making

change more or less rapidly.[1] From the equilibrium condition it follows that the optimum level of consensus, n^*, also known as the optimal "decision rule", corresponds to the point where the total cost, $T = E + D$, is minimized (Fig. 1). Changes to both the size of the group as a whole and to the composition of the group can affect the optimal decision rule. The calculus of consent logic is entirely agnostic about *why* the decision-making costs or the external costs might change—hence leading to a change of the optimum level of consensus. This is one of the great strengths of this model, as we can use it to understand a wide range of situations differing with respect to why the costs might have changed. This equilibrium decision rule can take any value between one person (which we identify with authoritarian rule) and unanimity (rule by consensus).

To apply the model to our historical analysis, we need, first, to see what happens theoretically when decision costs and external costs change, and, second, compare the theoretical patterns to the historical facts. In a nutshell, the key theoretical patterns, illustrated by the figures (see "Appendix" for proofs), are as follows:

Theorem 1 *If external costs decrease, the efficient size of the deciding group decreases* (Fig. 2).

Theorem 2 *If decision costs increase, the efficient size of the deciding group decreases* (Fig. 3).

Theorem 3 *Increased homogeneity leads to an increase in the size of the deciding group* (Fig. 4).

[1] Mathematically, this means that δD and δE are inexact differentials, i.e. they (as well as their integrals) are path dependent. They depend not just on the sheer number of people (or jurisdictions), but also on *which* people (jurisdictions) *specifically* are added (or subtracted). For example, adding a small group of people that is culturally very different from the existing population, would increase the decision-making costs much more than adding a small group of the same size but of culturally similar people.

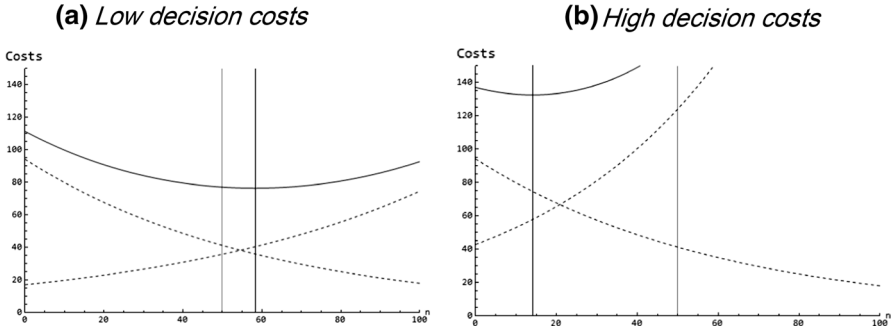

Fig. 3 The optimal decision rule declines when decision-making costs increase. Possible interpretations: #1: centralized management of many jurisdictions: **a** size of jurisdictions increases; **b** size of jurisdictions decreases, #2: within a jurisdiction: **a** more inclusive decision-making; **b** less inclusive decision-making

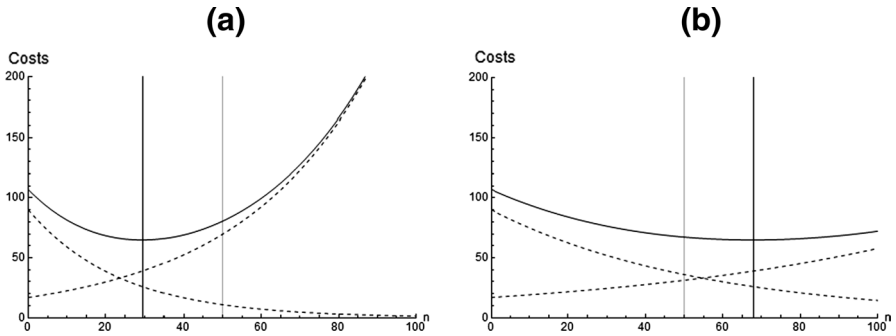

Fig. 4 The effect of increasing homogeneity: the optimal decision rule increases. **a** High heterogeneity (steeper curves), **b** high homogeneity (flatter curves)

Homogeneity is understood here as determining *how quickly* the external costs decline and the decision-making costs increase. To get an intuitive feel of theorem 3, consider how homogeneity operates upon both types of costs. Consider first its effect upon decision-making costs. If the group is homogeneous, it can reach collective decisions easier, as there are fewer sources of disagreement. This means that, when the homogeneity increases, the decision-making costs curve becomes flatter (growing slower), i.e. homogenous groups reach decisions easier even if they are larger. This means that the size of the deciding group can be expanded without significant increases in the decision-making costs.

Consider now the influence of homogeneity upon external costs. If a group is homogeneous, there are fewer dissenters, who disagree with (and are harmed by) the group decision. This means that, when homogeneity increases, the external costs curve also becomes flatter (declines slower). To understand why, suppose we gradually expand the deciding group by adding random people to the group chosen from the population, i.e. the network of mutually beneficial political exchanges

is gradually expanded. The external costs reflect the interests of those *left out* of this deciding group. But, if the population is homogeneous, the gains from adding another person to the deciding group are relatively small because the probability of adding someone with a radically different interest than the existing members of the deciding group is small. We need to add many people to significantly reduce the harms of the collective decision making, i.e. external costs are flatter.

A rather subtle, and potentially unintuitive, point is at work here, resting on the distinction between a *level* effect and a *marginal* effect. Our entire discussion is marginalist—what happens when we add one more person to the decision-making group. But our intuition tends to work better thinking about levels. So, in terms of a level effect, it might seem intuitive that collective decision-making in a more heterogeneous group has higher external costs. But what matters here is the *marginal* effect: the fact that, in a heterogeneous group, adding another person to the decision-making group brings more to the table than it would in a homogeneous group. The impact of homogeneity is on *how fast* the curves increase or decrease. It is not about shifting *the curve as a whole* higher or lower.

Putting together these considerations about external and decision-making costs, we can get a better intuitive feel of Theorem 3. In a more homogeneous population, we need to increase the size of the decision group to significantly reduce the harms *and* it is also easier to do so. The effect of homogeneity upon both types of costs points in the same direction. Conversely, in a more heterogeneous population, the decision group cannot be easily expanded, but, also, as long as diverse interests are included in the decision group (rather than the decision-making group being created in a deliberately biased and discriminatory fashion), it is less necessary to do so because each new member brings more to the table.[2]

It is also worth pointing out that heterogeneity can occur across many dimensions, and "[w]hich dimensions matter more depends on the context in which persons find themselves" (Leeson 2014: p. 18). However, because, with a few exceptions, most of the relevant dimensions of homogeneity can actually be altered by choice (usually involving a more or less expensive investment), we can still talk about "degrees of homogeneity" (Leeson 2014: p. 17). The key idea here is that the social pressure to conform is higher in some societies than others, and, hence, these societies end up with greater homogeneity *across many dimensions*. Because of this endogeneity we do not need to worry about *which* dimensions matter the most, because the pressure to conform chooses the relevant dimensions for us. The importance of the fact that homogeneity is endogenous has been argued at greater length by Leeson (2006) and by Kossinets and Watts (2009). As we shall see, such pressure to conform indeed characterized New England colonies to a greater extent than the Chesapeake colonies. For our purposes here, the relevant point made by Leeson, Kossinets and Watts

[2] We can also think of this through the lens of knowledge rather than incentives (Page 2007). The external cost of a collective decision is due to taking a mistaken decision. This is made less likely if more points of view are included, hence avoiding groupthink. But if the population is relatively homogeneous, more people are needed for securing a diversity of viewpoints. If the population is relatively heterogeneous, even a small (random) sampling will lead to a diverse set of perspectives.

is that the endogeneity of homogeneity makes it possible to refer to "degrees of homogeneity" rather than to the highly complex multi-dimensional array of possible differences between people. In the calculus of consent framework, this "degree of homogeneity" affects how quickly the cost curves change as more people are added to the decision group.

2.3 Federalism, democracy, and economic freedom

We can use the calculus of consent efficiency criterion to determine both the *internal institutional structure of a single political jurisdiction* (Buchanan and Tullock 1962: ch. 6), and the *nature of the federal system embedding many jurisdictions* (Buchanan and Tullock 1962: ch. 8; V. Ostrom 1987). The costs within one jurisdiction depend on the size of the jurisdiction (both in terms of population and geography), and, as such, we actually need to address the size of jurisdictions problem *before* addressing the question about the internal structure of each jurisdiction. It is rather unfortunate that the application of the calculus of consent to the problem of federalism is far less well-known, although Buchanan (1987) himself has emphasized this aspect, and despite the fact that Vincent Ostrom (1987) has also used the calculus logic in his well-known analysis of American federalism (see especially chapter 5 in *The Political Theory of the Compound Republic*).

2.3.1 Pattern predictions about nature of the federal system

By the "nature of the federal system" we mean the distribution of issues among local governments and the more centralized levels of government: which issues are addressed at which levels of government. One key question regarding any given collective issue is: Should it be centralized, addressed at state level, kept at local levels, or left to private individuals? External costs, in the form of inter-jurisdictional externalities, and decision-making costs, in the form of managerial costs of centralization, are the key concepts for answering such questions. As Buchanan and Tullock's put it, "[t]he group should be expanded so long as the expected costs of the spillover effects from excluded jurisdictions exceed the expected incremental costs of decision-making resulting from adding the excluded jurisdictions" (1962: p. 113). The optimal size of a jurisdiction for a given set of issues is, hence, theoretically determined by adding more and more people and geographical areas up until decision costs become too large compared to the benefits in terms of reducing negative spillovers onto other jurisdictions. The calculus thus provides a theory of the *emergence* of political units, and of overlapping units at different scales addressing different types of issues—i.e. the emergence of a federal political order. As Buchanan and Tullock (1962: p. 113) put it, the calculus allows us to build "a theory of the optimum size of the collective unit".

2.3.2 Pattern predictions about the internal institutional structure of a given political unit

By the "internal institutional structure" of a given jurisdiction we mean (a) which issues are addressed by markets or by political means, and, (b) when political means are used, how inclusive is political decision-making. If, for a given issue, the total cost of private actions (i.e. of market failures) is lower than the total cost of political actions (i.e. of government failure), the issue is optimally addressed by markets (Buchanan and Tullock 1962: p. 85). If the opposite holds, the issue is optimally addressed by government. But how representative the government optimally is depends on the exact shape of the decision costs and external costs for that issue (Figs. 2, 3).

We thus see how the *same underlining transaction-costs mathematics* can be used for a variety of purposes, in particular for addressing (a) questions of federalism and (b) questions of democracy and economic freedom within jurisdictions. When decision costs are high (e.g. due to primitive communication technology) the optimal size of the deciding group declines (Theorem 2, Fig. 3). This means two things: On one hand, more issues are left to markets, despite the market failures. For example, if in Fig. 3 the cost of a market failure is around 100, in the case depicted in Fig. 3a the issue is optimally addressed by government, while in the case depicted in Fig. 3b it is left to the market. On the other hand, for those issues that *are* addressed by political means, when decision costs are higher, the government becomes more authoritarian. For example, if in Fig. 3 the cost of a market failure is 150 instead of just 100, the issue is optimally addressed by political means in both situations, but in the case depicted in Fig. 3b the group that takes the political decision is much smaller (i.e. a less inclusive, more authoritarian government is predicted).

3 The origin of inclusive political institutions in North American colonies

The calculus of consent model implies that we should focus our attention on a number of specific independent variables, which, presumably, determine the emerging institutional structure. As such, to apply the three theorems to our historical case, we need as empirical *inputs*: how external costs and decision-making costs, both within jurisdictions and across jurisdictions, differ between colonies and Europe, and how homogeneity differs between colonies and Europe. The *outputs* of the model are the institutional predictions about federalism, democracy and economic freedom of the ways in which the colonies should be different from Europe, and how they differ from one another. The relevant basic facts, i.e. the empirical inputs, organized according to this perspective, are summarized in Table 1.

Based on these facts, the model predicts that, first, the governance in the colonies will be more local and decentralized than in Britain. Because of the larger geographical expanse in the colonies, inter-jurisdictional external costs tend to be smaller than in Europe. Consequently (Theorem 1, Fig. 2), the optimal size of the deciding group decreases across a wide range of issues, and, hence, we get more local governance

Table 1 Basic historical facts, and the calculus of consent predictions

	Underlining causes	Calculus of consent costs	Europe	North American colonies	Predictions
Determine the *size* of jurisdictions	Larger geographical expanse in the colonies	Spillover effects between jurisdictions	Large (small geographical expanse, relatively high population density)	Small (large geographical expanse, relatively low population density)	In Europe the jurisdictions are larger, and the system as a whole is more centralized
		Decision costs across jurisdictions	Small (small geographical expanse)	Large (large geographical expanse)	
Determine *how authoritarian* each jurisdiction is	Mass migration with geographical sorting leads to more homogeneous jurisdictions + High demand for labor leads to rights concessions	Political external costs within a jurisdiction	Mercantilist society with small elite franchise: small external costs among those with political power	Small (uncertainty and low state capacity, hard to enforce rents + Tie-bout competition)	The North American colonies are less authoritarian
		Decision costs within a jurisdiction	Large (relatively large jurisdictions)	Small (emigrants self-selected into homogeneous communities)	

External costs have two distinct sources: (a) those excluded from the decision-making process can be exploited as a consequence of their lack of political rights, and (b) those with political rights can still suffer external costs when they are on the losing side of some collective decisions

and less centralization. Furthermore, the larger geographical expanse and lower population density also increases decision costs, making governance across a variety of issues more difficult (Theorem 2, Fig. 3). This effect works in the same direction as the inter-jurisdictional externalities effect, thus further contributing to the pressure to decentralize and keep government local.[3]

Secondly, the model also predicts more inclusive governance *within* each colony, although, as we detail in the next section, it also predicts some important differences between the colonies. As a result of self-selection effects in migration, the North American communities are more homogeneous. Theorem 3 (Fig. 4) predicts that governance would, as a result, be more inclusive. This explains the puzzling fact that the colonies, instead of importing the European system of authoritarian governance, they developed instead more liberal democratic institutions. As discussed in the previous section, this effect occurs via both types of costs. In the next section, we provide some of the historical details explaining why the colonies, and especially the New England ones, ended up more homogeneous.

Apart from the effect of homogeneity, it is also useful to discuss how rent-seeking can be included within the calculus, as a form of political external costs. In Buchanan and Tullock (1962: p. 82) telling, people "tend to choose somewhat more restrictive rules for social choice-making in such areas of potential political activity", i.e. higher level of consensus, when they "anticipate greater possible damage from collective action", especially when such collective action "amounts to the creation and confiscation of human and property rights" or when "legislative action may … produce severe capital losses or lucrative capital gains to separate individuals and groups". Under such conditions, "[f]or the rational individual, unable to predict his future position, the imposition of some additional and renewed restraints on the exercise of such legislative power may be desirable". In other words, people will give up the potential of gaining from rent-seeking, and they will create market-preserving constitutional rules, if they are highly uncertain of who will actually gain the privilege to extract the rents. The calculus of consent indeed shows that when expected external costs increase, the optimal decision rule increases (Theorem 1, Fig. 2), i.e. political decision-making becomes more inclusive.

This logic applies well to our historical case. First of all, the higher levels of uncertainty and lower state capacity in the colonies made the political process resemble more the idealized calculus of consent social contracting behind a "veil of uncertainty". Secondly, the mercantilist system in Britain created significant rent-seeking costs, but the relatively entrenched nature of the economic elites and relatively stable relations to political power actually limited the rent-seeking waste, and the privileges were predictable. As noted by Tullock (1980a, b, 1989, 1991) the rent-seeking inefficiency is greatest when there is free-entry in the rent-seeking market. A common way of limiting this inefficiency is to limit access to rent-seeking by making it conditional on preexisting "crony" relations (Aligica and Tarko 2014). By contrast, the economic and political elites in the

[3] These two effects occur simultaneously, but, for clarity of exposition, Figs. 2 and 3 illustrate two special cases when only one of the cost curves changes, while the other is kept constant.

North American colonies were far less entrenched. As such, the less transparent "veil of uncertainty" made the rent-seeking danger greater. If political institutions had been as mercantilist as they were in Britain, the political external costs due to rent-seeking would have been much greater (at least for a while).

Hence, on one hand, the colonies could have more inclusive political institutions because intra-jurisdictional decision-making costs were lower, and, on the other hand, various individuals in the colonies also had a stronger vested interest to achieve the more inclusive politics in order to avoid an unpredictable rent-seeking society. Furthermore, as also seen in Fig. 2, when the external costs curve is higher, leading to a higher total cost curve, the scope of markets expands—as collective decision-making becomes costlier, even under the optimal level of consensus, it becomes efficient to tolerate greater market failures.

This indeed matches the historical situation. For example, the Massachusetts General Court adopted measures in 1620s–30s that secured a considerable degree of economic freedom, secured property rights from government confiscation, allowed free labor mobility and contracting, and allowed prices and wages to be set by markets (Innes 1995: pp. 192–193). Some mixed attempts in 1630s to intervene in economic affairs proved largely ineffective and were reversed by 1640s. Similarly, in 1641, the Puritans in the Bay Colony adopted the Body of Liberties, a formal legal code reflecting their anti-authoritarian attitudes and fear of arbitrary government power. The Body of Liberties specified various rights of individuals, and established a number of legal protections against government violation of their rights (Innes 1995: pp. 210–216). These early market-oriented and democratic institutions fostered economic growth and development, and American colonies rapidly expanded their populations and economies.

Putting all these elements together, we obtain the following picture. First, because of small inter-jurisdictional externalities, making centralized government unnecessary, combined with the difficulty to govern many colonies across a large geographical area (high decision costs across jurisdictions), the colonies developed as a confederacy, i.e. as a decentralized system that allocated to local governance the responsibility to deal with most public issues. The very large decision-making costs involved in trying to govern the colonies from across the ocean naturally led to independence. Second, because the colonies were relatively homogenous, the colonies could develop much more democratic and inclusive forms of governance. The higher uncertainty and lower state capacity to enforce privileges also undermined the rent-seeking logic of mercantilism, leading to greater economic freedom in the colonies.

As we discuss in the next section, the Puritans' *beliefs* also favored more economic freedom, but the calculus logic implies that significant institutional cost constraints were at work as well. Although this is beyond the scope of this paper, an important piece of evidence that a *purely* ideological explanation would be incomplete, and that the constraints revealed by the calculus are indeed a crucial part of the explanation, is that other unrelated cultures have also zeroed-in on similar institutions. For example, the Iroquois Native American tribes were indeed also organized as a loose confederacy and had inclusive political decision-making (Fenton 1998; Richter and Merrell 2003; Brascoupé and Etmanskie 2006).

Not all colonies succeeded. One prediction that follows from our account is that one of the key factors explaining the failures is that they have adopted political institutions with consensus levels far from the calculus of consent optimum. But the model is not historically deterministic—it does not claim that all societies will by necessity reach the calculus of consent institutional equilibrium. The claim, instead, is that societies that do not zero-in on the calculus of consent optimum are more likely to fail. For instance, one of the most famous failures, the Jamestown colony, was due to the adoption of overly collectivist decision-making. It is beyond the scope of this paper to thoroughly test this prediction about failures, but it is worth pointing out that the calculus opens the door for such possible empirical tests.

4 Why the North American colonies were not all the same

While all North American colonies were more democratic and decentralized than European countries at the time, they were far from identical. Interestingly, the broad differences between colonies can also be explained by the same calculus of consent logic, once we account for the difference between the nature of collective problems that the political power in each colony faced. This will help us explain why Southern colonies were less inclusive than the Northern colonies.

4.1 The New England migration: geography, cultural homogeneity, and the invention of liberal democracy

Most migration to New England occurred in seventeenth century during the Great Migration (1630–41) and the rest of the population growth of New England was natural reproduction from these initial settlers (Innes 1995: pp. 23–24). The migrants were Puritans who came in families, groups, and communities. They were largely of the "middling sort", artisans, independent farmers, shopkeepers (Taylor 2001: pp. 161–162), and more than half of the Puritans who emigrated during the Great Migration came from "market towns or large commercial centers" (Innes 1995: pp. 61).

Like the southern colonies, New England lacked gold and other precious metals that could yield a quick profit. But New England was also dominated by a hilly terrain with a rocky, thin soil that was poorly suited to large-scale commercial agriculture. Even more importantly, New England was exceptionally cold, which was exaggerated by the fact that the area was undergoing what was called a "little ice age," during which time average temperatures were several degrees lower than those of the twentieth century (Fischer 1989: pp. 50–54). This translated into a short growing season that provided barely enough time to produce enough to feed one's own family, let alone yield surpluses that could be sold for profit. Still, the cold did have the advantage of reducing the disease load, and the mortality rate from disease among New England immigrants was significantly lower than in Chesapeake (Fischer 1989: pp. 50–54).

The difficult terrain and harsh climate of New England figured prominently in the minds of the British considering the voyage to America (Innes 1995: pp. 86–87). As such, it is not surprising that the Puritans were among the first groups to establish themselves in America, given that they shared strong religious beliefs in the virtues of hard work, thrift, and discipline (Taylor 2001: pp. 166–167). Indeed, some of the earliest efforts to organize large-scale emigration to New England were explicitly marketed to devout Puritans highlighting New England's difficult geography, necessitating hard work in order to thrive, or even survive, and promising only modest material rewards in return (Innes 1995: pp. 86–87). Many of these early Puritan settlers openly expressed their gratitude at having settled in New England, where the difficult land would only reward those who had truly exerted themselves (Taylor 2001: pp. 159–160).

In other words, the attractiveness of New England for Puritans, rather than coming from the productivity of land, came from the opportunities to live by their values. Although later settlers would not necessarily share the Puritans' purported love for toil and exhausting labor, this emphasis on self-determination and independence continued to remain a popular theme of their histories, and early American culture grew to reflect this value to a considerable extent (Diamond 1967). It is this combination of difficult geographical conditions and religious fervor which assured the relative homogeneity of these colonies. Interestingly, New England colonies also had explicit cultural homogenization policies.

While the Southern colonies were not particularly concerned with enforcing homogeneity, as their agricultural economy was organized in relatively independent plantations and was not hindered by diversity, the main New England economic unit was the town (Meinig 1986: pp. 103–104; Innes 1995: pp. 209–210). These towns were very strongly concerned with public order. While the provincial government made decisions on legislation and public policy affecting the entire colony, towns were responsible for their execution—e.g. public education, land grants to promote commercial development, laws governing religious practice and morality (Innes 1995: pp. 216–220; see also Taylor 2001: 170–171). As we would expect from the calculus of consent (Theorem 3, Fig. 4), the high homogeneity led to relatively inclusive political decision-making. Indeed, town meetings were open to nearly all adult men, where they could raise any issues for discussion and debate.

Because the main collective problem in New England colonies was a town's public order, Puritan colonies adopted a variety of strict, exclusionary policies designed to keep out a variety of people: e.g. non-Puritans, poor, aristocratic, indolent, uneducated (Fischer 1989: pp. 811–812). Moreover, Puritan colonial leaders, such as John Winthrop and others, looked for immigrants possessing specific qualities and skills, and tried to assess their work ethic (Innes 1995: pp. 85–86; pp. 95–99). Such policies led to a significant Puritan homogeneity (Meinig 1986: pp. 222–226).

Furthermore, the Puritan emphasis on the role of the family in maintaining social order (Fischer 1989: pp. 72–75) led them to adopt a series of institutions and policies governing marriage and family life designed to strengthen the nuclear family. These included prohibiting domestic abuse/violence, adopting relatively egalitarian laws between spouses, liberalizing divorce, protecting single and married women's property rights and rights of contract (Fischer 1989: pp. 83–86). Puritan New

England had a very high marriage rate, as well as one of the most balanced gender ratios compared to other British American colonies. Single men were considered the biggest threat to public order, and colonies tried to address the issue. Perhaps the most interesting policy designed to mitigate the potential conflicts and disorder that might arise from a population with an "excess" of young single men, was adopted by the Massachusetts Bay Colony which mandated that all single adult men be taken in by a family in town, and live under the rules set by the head of the household (Fischer 1989: p. 73; Archer 1990: pp. 487–488). The effect of this was to further decrease the heterogeneity introduced by migration, by forcing the single men immigrants to be socialized in the ways of the colony.

As we have seen, the calculus of consent logic creates serious constraints if one would have attempted to recreate a European style, mercantilist and centralized institutions in the colonies. We can see this as creating a filter favoring more liberal ideologies. The Puritans beliefs indeed seem pre-adapted to thrive in the new conditions. Although they probably did not have a clear institutional blueprint in mind prior to their migration, they were already suspicious of arbitrary government and unconstrained executive power, partly from contemporary events—English Civil War—as well as religious reasons. Puritanism promoted anti-authoritarian, anti-monarchical beliefs and attitudes, and was relatively egalitarian. Based on this background, it is less surprising that Puritans developed a distinct constitutionalism based on contract theory, common law, and religious doctrine (Innes 1995: pp. 193–197, pp. 201–204).

4.2 The Chesapeake Bay colonies: indentured servitude, slavery, and large-scale policing

The Chesapeake Bay region was the first area to be settled by the English, with the establishment of the Virginia colony in 1583. At first, the English strategy was similar to the Spanish one: seek a quick payoff of gold and treasure by sending adventurous young men to use military force and subdue natives. This drew risk-seeking adventurous young men with few connections, and who dreamed of immediate gratification, gold and treasure, with little work or waiting. But this strategy quickly failed, since this region had few precious metals or treasures, and eventually turned to plantations as longer term investments (Taylor 2001: p. 118). The fertile land and warm, humid climate did prove capable of yielding bountiful harvests of valuable crops, particularly tobacco. However, compared to the rainy, temperate, and milder climate of Britain, the mercurial climate of the Chesapeake colonies (Virginia and Maryland) was incredibly harsh: long hot summers left laborers exhausted and sick from heat stroke, and the cold, wet winters also proved lethal at times. Endemic diseases were transmitted through infected water supplies and the mosquitoes that bred in the abundant stagnant waters (Fischer 1989: pp. 247–252). In the Chesapeake, the life expectancy of male immigrants was in the early to mid-forties, and for females in the late thirties—in the first year alone, the mortality rate among immigrants could be as high as one-in-four (Taylor 2001: pp. 129–131, pp. 142–144; Innes 1995: p. 23).

Given these harsh conditions, stronger incentives were needed to attract workers. The migration to Virginia was financed by a particular institutional innovation: indentured servitude (Bailyn 1986: pp. 166–167). Under this system, an individual who wanted to emigrate to America, but could not afford the trip, could contract with an intermediary to finance their travel to America, in exchange for a bond to their labor for a fixed period of time, usually between 3 and 7 years, with 4 years being the most common. In a sense, individuals bought a voyage to America by selling themselves into slavery for a number of years. Indentured servitude proved to be an enormously successful institution in terms of the number of emigrants who participated, although not exactly popular in terms of their expressed opinions. It thrived for well over a century, including after the voyage to America became more easily affordable due to rising incomes as a result of economic growth in Britain.

Indentured servants—usually young men and skilled workers—dominated the pattern of emigration to certain regions. According to Taylor (2001: p. 142), "at least three-quarters of the emigrants to the Chesapeake during the seventeenth century" were English indentured servants, "about 90,000 of the 120,000 total". Life during indentured servitude was often grueling and harsh; disease, hard labor, brutal working conditions and environments, and even cruel treatment by their masters claimed the lives of a significant fraction of indentured servants (Taylor 2001: pp. 142–144; Innes 1995: p. 23; Bailyn 1986: pp. 166–189). But, if they survived their term of indentured servitude, the emigrants were granted their freedom and "freedom dues", usually a set of new clothes, tools, some money wages, and sometimes a modest parcel of land (Taylor 2001: pp. 142–143). To a poor British male, this would have been a rather significant payoff opening up a range of opportunities that would have been otherwise unattainable in Britain, especially the prospect of owning land. Indentured servitude thus selected for risk-loving individuals, but with very low discount rates, rather than just impatient adventurers.

Moreover, because the workers had to be attracted to the colonies, a credible commitment to the post-servitude rights had to exist. This need for credible commitments lead to stronger institutions for protecting property and contracts. As Congleton (2011: p. 526) noted,

> To attract labor and capital to their colonies, landowners needed to assure labor, small business-men, and other investors that they would be better off in their particular colony than at home. In early-seventeenth-century America, this required establishing a reliable, credible method of enforcing land titles and contracts and for assuring that new laws would not be adopted that would undermine those titles and contracts.

Apart from the indentured servants, the Chesapeake colonies agricultural economy was increasingly based on slaves brought from Africa (Fogel and Engerman 1974). Between the 16th and 19th centuries about 9.5 million Africans were forcibly transported over the Atlantic, of which 6% to the Southern US colonies. The slave population in the US colonies also increased significantly due to births, unlike the Caribbean colonies where death rates were exciding birthrates. "[T]he United States became the leading slave power of the Western world not because it participated heavily in the slave trade, but because of the unusually high rate of natural increase

of its slave population." (Fogel and Engerman 1974: p. 29) By the second half of the 18th century, the slave population in the Southern colonies reached about 30–40% (growing from less than 10% in the 1680s) (Fogel and Engerman 1974: p. 21). By contrast, slaves in the Northern US colonies have always been less than 5% of the population.

As a result of these policies to attract or forcefully bring in people, the Chesapeake colonies ended up less homogeneous than the New England ones. As a consequence, the relatively more homogeneous towns of New England were more democratic compared to the Southern ones. We can see this from the calculus of consent Theorem 3 (illustrated in Fig. 4). When heterogeneity is higher, as in the Southern colonies, the efficient level of consensus is lower (Fig. 4a), i.e. less inclusive politics. By contrast, when homogeneity is higher, as in the New England colonies, the efficient level of consensus increases (Fig. 4b), i.e. a more representative form of government is optimal. This, in a nutshell, explains the broad differences between the Northern and Southern colonies.

But the *nature* of the collective problems that communities try to solve can also have a big impact upon the scale of government. The New England towns were concerned with a wider range of public issues than the Southern colonies in which individuals had larger scale farms. We can illustrate this with respect to the scale of police forces in the North and South. As we saw earlier, New England colonies had a wide range of policies aimed at "public order" and cultural homogeneity. By contrast, in the South, the range of types of public issues was smaller, but the geographical scale was larger.

As a result of their agricultural slave-based economy, the main public problem in the South, from the point of view of the dominant white population with political representation, was the fact that slaves often tried to escape. Slaves escaping from one plantation created a relatively large inter-jurisdictional externality to the other plantations, as escaping slaves often tried to ferment revolts. As a result, in the early 18th century the "Slave Patrol" was formed (Reichel 1992), tasked with catching and returning runaway slaves to their owners, deterring slave revolts by a variety of terror tactics, and summarily punishing slaves who violated plantation rules. The Slave Patrol was initially a private police force emerging in a bottom-up fashion, and later gaining state support.

By comparison, the emergent police forces created in the North were much more local and were created to solve public order issues inside growing towns. There were few inter-jurisdictional externalities that required police attention. In the North constables provided ordinary policing services—execute court orders and warrants, arrest lawbreakers, and general peacekeeping (Fischer 1989: 190–191). The constable was elected and paid by the community he served, of which he was himself a member. His authority and power was closely tied to the preferences and support of the people he served.

This difference of scale of the police institutions is indeed predicted by the calculus of consent account of inter-jurisdictional externalities (Theorem 1, illustrated in Fig. 2). The Southern colonies correspond to the situation in Fig. 2a (high spillover effects) while the Northern colonies to Fig. 2b (low spillover effects). As predicted, the scale of police was large in the South and small in the North.

Finally, some similarities actually hide significant differences. Although both the New England and Chesapeake colonies had greater economic freedom for white men than mercantilist Europe, they did so for different reasons. New England small-scale town economies were preempting the emergence of a rent-seeking society, while the Southern colonies had to create strong and credible protections for property and contracts in order to be able to attract indentured servants as workers.

5 Conclusion and further implications

The calculus of consent analytical framework can be used for two complementary purposes. It can be applied *within* a given jurisdiction to identify the efficient level of consensus for various issues. And it can be applied *across* jurisdictions to identify the efficient level of centralization or decentralization of different issues. We have explored several important predictions: (1) The model predicts that the efficient organization in the colonies, particularly New England, was more inclusive than in Europe. This is partly because the migrants to New England self-selected into small, relatively homogeneous communities. (2) The relatively small geographic area and large population in Britain and Europe meant the spillover effects from one region to another were relatively high compared to British America, which leads the model to predict a more centralized state in Europe compared to North America. (3) Differences between the Chesapeake and New England colonies can also be explained as emerging from their different levels of homogeneity and from the different nature of their economies (agricultural vs. towns). (4) Some similarities between the colonies turn out to have different underlining causes.

The purpose of this paper was to show that such important patterns can be explained with a very simple model—the calculus of consent model describing the formation of institutions for collective choice as resulting from the trade-off between decision-making costs and external costs. The historical reality is of course much more complicated, and includes numerous nuances and details which cannot be captured by such a simple model. Nonetheless, it is remarkable that some very important comparative patterns—about democratic representation, the extent of market regulation, and the extent of political centralization—can be predicted and explained.

The same calculus of consent model can be used to shed light on a number of other puzzles in a similar fashion. Let us end by briefly mentioning two other phenomena, which might be further expanded by future studies.

5.1 The American revolution

Historians continue to ask why the American Revolution ever occurred, given that the explicit differences and grievances between the British and American colonists can appear relatively small. For example, North (1990:101–103) places the development of the US on a continuous evolutionary path that preserved the tradition of English constitutionalism through "consistent ideological modeling," and later led to

the creation of the Federal Constitution. He argues that the outbreak of the Revolutionary War was the result of differences in the subjective perceptions of the British and the American colonists, but does not explain *why* their subjective mental models diverged. Similarly, de Figueiredo et al. (2006) use a game theoretic model of self-confirming equilibrium to explain how the mental models of the British and Americans diverged at distinct points in English political history, and eventually led to "surprise" conflict and war. Although North (1990) and de Figueiredo et al. (2006) both explicitly emphasize the role of ideas in these events, they focus almost entirely on the political aspects, and arguably reduce the whole subject to a matter of politics.

By contrast, in our account, this difference of perception is determined by the underlying difference in the decision-making costs and the political external costs. These costs differed so dramatically in the American British colonies, as compared to Europe, that they made the European institutional system fundamentally unfit for the new conditions. Furthermore, the attempt to govern the colonies from across the ocean faced major technological difficulties, i.e. the decision-making costs were prohibitive. Under such conditions, it is less surprising that the United States became independent from Britain or that South American colonies became independent from Spain and Portugal, as it is the fact that Canada and Australia didn't (this is perhaps explained by the smaller population and the fact that they were actually given de facto independence across most issues). Congleton (2011: p. 531) argues that "the North American colonies remained independently organized and governed, rather than centrally administered under the tight control of England's king … partly [as] a matter of luck". By contrast, in our view luck had little importance. This was a direct consequence of the high costs involved.

5.2 The institutional evolution of United States compared to Europe

We can also note that the same logic also explains the later history of United States. As technology diminished decision costs across jurisdictions, centralization gradually followed, in line with Theorem 2 (Fig. 3a). The growing population, combined with travel and communication technologies, lead to higher inter-jurisdictional spillover effects favoring, in line with Theorem 1 (Fig. 2), more centralization (more issues being left in the responsibility of the federal government and fewer to state and local governments). Moreover, in line with Theorems 2 and 3 (Figs. 3, 4), as the initial homogeneity of the small communities made room for higher levels of heterogeneity in larger cities, a decline of the multitude of mutual aid associations followed, replaced by centralized welfare state institutions (Beito 1992).

Furthermore, the larger size of the US, making decision-making costlier, has also led to a more extensive scope of markets as compared to European countries. In line with Theorem 2 (Fig. 3), the cost of market failures has to be higher in the US than in Europe to justify government control. And, last but not least, less democratic, independent regulatory agencies (IRAs) have played a much bigger role in the governance of public issues in the United States as compared to Europe (Gilardi 2004), IRAs corresponding to the case where various public issues are decided by a smaller deciding group than democratic legislatures. This is again predicted by Theorem 2 (Fig. 3).

This obviously just scratches the surface, and a full examination of such issues is outside the scope of this paper. But it is worth noting that the calculus of consent logic seems to provide a quick explanation of a rather wide variety of institutional developments. This makes the calculus of consent stand out among many other economic history and institutional theories—rather than providing an explanation just for one particular event, it has a very broad applicability across history. The limits of this theory, and its inherent approximation, are due to the extent to which we can reasonably assume that real-world institutional design and political exchanges occur under a "veil of uncertainty". When this approximation fails, we need to shift our attention toward theories of conflict.

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Appendix

The simplest case of decreasing external costs and increasing decision-making costs is when the *marginal* costs, $\delta E/\delta n$ and $\delta D/\delta n$, are proportional to the current *levels* of the costs, E and D:

$$\begin{cases} \delta E(n) = -\frac{1}{h} E(n)\delta n \\ \delta D(n) = \frac{1}{g} D(n)\delta n \end{cases}$$

h and g are positive. This means: (a) in terms of external costs, we have diminishing returns from increasing the deciding group; and (b) in terms of decision-making costs, in line with Olson's (1965) logic of collective action, the bigger the group, the less likely it is that one can personally affect the decision of the group, and, hence, it is increasingly more difficult to motivate people to become involved in the decision making process or to seek a convergence to complete consensus.

Under this assumption, we find the following mathematical forms for the external costs and for the decision-making costs:

$$E(n) = E_0 \exp\left(-\frac{n}{h}\right)$$

$$D(n) = D_0 \exp\left(\frac{n}{g}\right)$$

where h and g are two measures of homogeneity, and E_0 and D_0 are the costs under pure authoritarian rule (i.e. when $n \to 0$). The model is entirely agnostic with

respect to why homogeneity may change, e.g. due to changes of the group size or just of the internal composition, and, hence, can be applied to a wide range of cases.

The equilibrium decision rule, minimizing total cost, $E + D$, is:

$$n^* = -\frac{gh}{g+h}\log\left(\frac{D_0 h}{E_0 g}\right)$$

Proof of Theorem 1

$$\frac{dn^*}{dE(n^*)} = \frac{\partial n^*}{\partial E_0}\frac{1}{\left(\frac{dE}{dE_0}\right)_{n^*}} + \frac{\partial n^*}{\partial h}\frac{1}{\left(\frac{dE}{dh}\right)_{n^*}} = \frac{gh^2}{(g+h)n^* E} > 0$$

□

Proof of Theorem 2

$$\frac{dn^*}{dD(n^*)} = \frac{\partial n^*}{\partial D_0}\frac{1}{\left(\frac{dD}{dD_0}\right)_{n^*}} + \frac{\partial n^*}{\partial g}\frac{1}{\left(\frac{dD}{dg}\right)_{n^*}} = -\frac{g^2 h}{(g+h)n^* D} < 0$$

□

Constants h and g are not independent. As discussed in the main text, homogeneity manifests itself both in the realm of external costs and in the realm of decision-making costs. Let $g = \alpha h$, where α is a positive scaling constant accounting for the possibly different strength with which homogeneity impacts external and decision-making costs. Consequently,

$$n^* = -\frac{\alpha}{1+\alpha} h \log\left(\frac{D_0}{\alpha E_0}\right)$$

Lemma 1 *The external costs curve always starts above the decision-making curve.*

Proof The level of consensus is always positive, $n^* > 0$, which implies that $E_0 > D_0$. □

Lemma 2 *The scaling parameter α is always greater than* $\frac{D_0}{E_0}$.

Proof $n^* = 0 \Rightarrow \forall h, \alpha = \frac{D_0}{E_0}$ The level of consensus is always positive, $n^* > 0$, which implies that $\alpha > \frac{D_0}{E_0}$. This is illustrated in Fig. 5.□

Proof of Theorem 3

$$\frac{\partial n^*}{\partial h} = -\frac{\alpha}{1+\alpha}\log\left(\frac{D_0}{\alpha E_0}\right) > 0$$

□

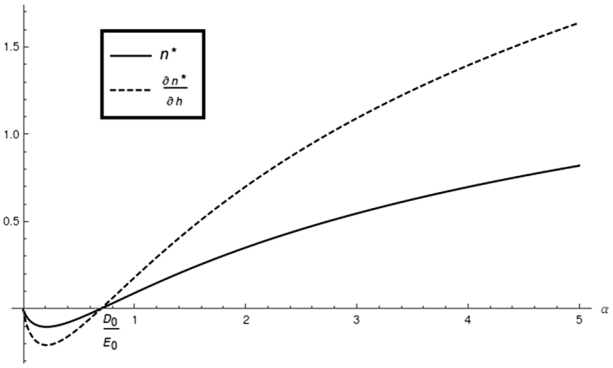

Fig. 5 Graphical illustration of Theorem 3

This is always positive because of the Lemmas 1 and 2. Hence, as homogeneity increases, the efficient level of consensus also increases. As shown by Fig. 5, the sensitivity of the efficient level of consensus with respect to homogeneity increases as a function of the scaling factor α.

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