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Governance structures, cultural distance, and socialization dynamics: further challenges for the modern corporation

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Abstract

This paper relates cultural distance and governance structures. We suggest a model of cultural evolution that captures the idiosyncratic socialization dynamics taking place in groups of communicating and interacting agents. Based on these processes, cultural distance within and between groups or organizational units develops. Transaction cost theorists associate higher cultural distance with higher transaction costs. Therefore, one problem of economic organization is assessing alternative governance structures in terms of the socialization dynamics they enable that entail different intraorganizational transaction costs. Socialization governance structures that can be used to affect cultural distance among employees include shared social experiences in groups, the assignment of influential role models, group sizes, the recruitment of employees presocialized in certain ways, the recognition of specific cultural dimensions such as “individualism” or “collectivism”, and the implementation of cooperative cultures in business units. These yield organizations differential capacities to adapt internal structures in transaction cost-minimizing ways.

Keywords Cultural distance · Governance structures · Corporate culture · Cultural evolution · Firm performance

JEL Classification D21 · D23 · L25 · M14 · C61

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1 Introduction

Disparate cultural endowments of firm members or units, i.e., different languages, values, frames of reference, beliefs, norms, etc., as well as differences in more organization-specific traits, such as organizational stories, shared experiences, rituals, symbols, and solutions to problems, pose a challenge to every organization. For example, employees responsible for encoding and decoding of knowledge in transactions not sharing implicit assumptions and interpretations cause additional costs in the intraorganizational transfer of knowledge. Consequently, the collaboration of employees who have different cultural backgrounds imposes higher internal transaction costs on an organization. These would be absent were cultures homogeneous (Lazear 1999; Kuran and Sandholm 2008). We argue that firms can react to this challenge by choosing suited socialization governance structures that close cultural distance (CD) between individuals or organizational entities. These include shared social experiences in groups, the assignment of influential role models, group sizes, the recruitment of employees presocialized in a certain way, the recognition of specific cultural dimensions such as “individualism” or “collectivism”, and the implementation of, for example, cooperative cultures in business units.

Internal transaction costs caused by CD among employees or units explain important organizational phenomena, such as their general performance and adaptability, characteristics of corporate cultures, foreign investment strategies, headquarter-subsidiaries relations, recruitment policies, or make-or-buy decisions (e.g., Kogut and Singh 1988; Shenkar 2001; Hutzschenreuter et al. 2011; Oldenski 2012). CD has been used as a key variable in many areas of organizational behavior and firms have been interpreted as multi-cultural teams (e.g., Kogut and Zander 1993, Rob and Zemsky 2002; Buckley and Carter 2004). While disjoint skill sets of members of a multi-cultural group potentially yield diversity gains, communication and transfer problems due to CD entail higher costs of transacting (e.g., Lazear 1999).¹ Lower CD in homogenous group cultures or between separate groups economizes on these costs and enables the combination of disjoint skills more efficiently. Hence, transaction cost theorists associate higher CD with higher efforts of transaction due to communication and information costs or less efficient transfer of knowledge, competencies, and skills (e.g., Weber et al. 1996; Nahapiet and Ghoshal 1998; Hennart 2003; Keller and Yeaple 2013).²

As a new avenue to this organizational problem, our paper relates CD, as a further attribute of transactions, and governance structures. Standing in the tradition of Oliver E. Williamson (1979, 1981, 2005; also Commons 1934; Coase 1937), we suggest an additional problem of economic organization: assessing alternative

¹ There is supporting evidence from psychology that diversity in values and attitudes has negative effects on group performance, whereas informational diversity is positively related to it. For details and further references see van Knippenberg & Schippers (2007).

² CD between agents or populations also constitutes a barrier to economic development in general by causing higher costs of adoption and imitation of new technologies. For econometric evidence for this observation, see Spolaore & Wacziarg (2013).

governance structures in terms of the socialization dynamics they enable, which entail different intraorganizational transaction costs due to CD. These impacts of CD on transaction costs are not covered by established attributes of transactions: they are neither caused by uncertainty or disturbances and adaptive needs due to incomplete contracts nor by asset-specificity.³ Also, the consideration of a transaction's frequency of arms-length market interactions - without shared organizational socialization of the parties involved - does not address CD among partners. We assume that transactions in organizations can be assigned to and organized within governance structures that allow transaction cost economizing socialization processes.

Our argument is based on a model of cultural evolution that captures socialization processes and convergence as well as divergence in CD within and between groups or organizational units (drawing on ideas from DeGroot 1974; Feldman and Cavalli-Sforza 1975; Boyd and Richerson 1985; Friedkin and Johnsen 1997). As a measure of intra- and intergroup CD, we capture the variance in cultural trait values of agents.⁴ Moreover, we integrate learning processes in groups of varying size into a specific cultural transmission table as the central element of our model. It then describes the idiosyncratic learning and socialization dynamics taking place in groups of communicating and interacting agents. Thereby, the model explains important aspects of governance structures and related transaction costs. It allows us to derive some general principles of socialization governance in organizations.

What is more, we examine socialization governance structures by incorporating behavioral-related variables of organizational development in our model of cultural evolution, such as imitation, a role model bias, and cultural dimensions that affect learning in groups. Given this perspective, our work is also a contribution to social interaction theory as a field of economic theory (e.g., Schelling 1972; Kirman 1993; Ellison and Fudenberg 1995; Brock and Durlauf 2007). Moreover, sociology investigates the important role of socialization in the evolution of cultures (e.g., French 1956; Parsons 1967; Bandura 1977). In line with these contributions, our model assumes an agent's cultural trait to be dependent on the cultural traits exhibited by other actors. Humans' constrained psychological resources are fundamental to cultural evolution: learning from others, i.e., relying on purely social influences, are a means by which agents finesse the bounds of rationality (e.g., Bernheim 1994; Manski 2000; DeMarzo et al. 2003; Richerson and Boyd 2005). Cultural traits are transmitted by processes of cultural learning that require extended series of personal interaction (also Bisin and Verdier 2000). Socialization processes within groups are based on such mechanisms of cultural transmission. Their implications matter a lot to organizations and their efforts to craft governance structures that mitigate the problem of CD.

³ However, in the case of incomplete contracts, parties' differing cultural norms may account for some emerging, unanticipated problems in the course of the contractual relationship.

⁴ A cultural trait is defined as an idea, norm, belief, attitude, habit, or value that is acquired by social learning and that influences an individual's behavior (e.g., Henrich et al. 2008). Cultural traits have long been used in anthropology as units of transmission that reflect behavioral characteristics of individuals or groups (e.g., O'Brian et al. 2010).

A central lesson of our study of socialization dynamics in organizations is that they lead to varying CD between agents or groups and thus different internal transaction costs. Therefore, one strategy of firms to deal with the problem of CD as an attribute of intraorganizational transactions is to devise governance structures supportive of socialization dynamics that close CD within and between groups or organizational units. Key features of socialization governance should vary along intraorganizational constellations of CD. Interpreting governance structures in this way infuses further operational content to this concept. A comparative analysis of organizational structures in terms of their transaction costs due to CD becomes feasible as well as a corresponding predictive theory of economic organization.

The paper is organized as follows. Section 2 specifies a model of the evolution of CD within and between groups or organizational units. In Section 3, implications of socialization processes for intra- and intergroup CD are developed and several principles of governance of socialization in organizations are derived. These guide organizations in their endeavor to minimize transaction costs due to CD. Section 4 concludes.

2 A model of intra- and intergroup socialization

In order to capture intra- and intergroup socialization dynamics within different governance structures, our Markov-type model combines ideas originating from several fields: while cultural evolution theory provides insights into the effects of various learning biases on cultural transmission, opinion formation models and further contributions from mathematical sociology informed the setup of the formal framework that depicts these cultural forces.⁵ Models of this kind including social interactions, boundedly rational agents, and rules of thumb have also been used in economics (e.g., Ellison and Fudenberg 1995). Furthermore, as a new measure of intraorganizational CD, the model traces the development of the variance in cultural trait values within and between groups of communicating and interacting agents.

We restrict our analysis of socialization dynamics to the level of small groups or organizational units. These entities represent the building blocks of larger organizations.⁶ Let there be $i = 1, \dots, N \geq 3$ members of such a unit. For notational

⁵ See, e.g., Feldman and Cavalli-Sforza 1975; Boyd and Richerson 1985; DeGroot 1974; Friedkin and Johnsen 1997, and Krasnoshchekov 1998.

⁶ Empirical evidence entertains this idea of small groups as elementary organizational building blocks: in a study of 182 work groups in a global organization, Cummings and Cross (2003) find an average work group size of 8.1 members. Similarly, Henttonen et al. (2013) analyzed a random sample of Finnish work organizations that exhibit an average team size of seven. Oh et al. (2004) scrutinized work groups in several organizations in Korea featuring an average size of six members (for further empirical evidence see Henttonen 2010). Moreover, in a theoretical model, Kumpula et al. (2007) show how communities emerge in a weighted complex social network. In an empirically calibrated scenario, they find community sizes consistent with our assumption (also Kossinets and Watts 2006). An average network size among employees of about 10 members is supported by Lluent (2021), who reports data on 1249 french firms. Finally, empirical research suggests a similar range for the average span of control (e.g., Davison 2003).

convenience, we focus on the evolution of a single trait. The analysis can easily be extended to the case of multiple traits, as long as they evolve independently. The value of the cultural trait of individual i at time t is considered continuous in nature and is denoted by $x_{i,t} \in \mathbb{R}$. The vector x_t captures the state of the group, i.e., $x_t = (x_{1,t}, \dots, x_{N,t})'$. Let \bar{x}_t denote the group mean value of the cultural trait at time t . A cultural trait of an individual i is assumed to depend on the values of the same trait in all N members of the group and these members' weights, w_{ik} , in socialization. Each coefficient w_{ik} measures the dependence of the trait of the i th employee on the trait exhibited by the k th group member. Hence, employee i 's value of a cultural trait develops according to

$$x_{i,t+1} = \sum_{k=1}^N w_{ik} x_{k,t}. \quad (1)$$

Cultural transmission within a group can then be represented by a right stochastic $N \times N$ matrix $W = (w_{ik})$. It has as its elements the proportional contributions of each individual to their own and other group members' trait values, i.e., $0 \leq w_{ik} \leq 1, \forall i, k$ and $\sum_{k=1}^N w_{ik} = 1, \forall i$. For a single cultural trait, the change in a group's state is modeled as:

$$x_{t+1} = Wx_t + \epsilon_t, \quad (2)$$

where $\epsilon_t = (\epsilon_1, \epsilon_2, \dots, \epsilon_N)'$ is a random component for each agent that represents *individual learning* (with mean zero and variance σ^2).⁷ We assume ϵ_i and ϵ_k to be independent across employees. Thus, the cultural trait of the i th employee at $t+1$ can be considered as the weighted influences of the traits of all group members at t including herself and the individual learning term ϵ_i .⁸ Means and variances of cultural traits within and between groups of N individuals will be subject to change in the course of ongoing socialization processes. From Eq. 2 we have

$$E(x_{t+1}) = W^{t+1}x_0 \quad (3)$$

so that the expected value of x_{t+1} is determined by its initial values and the spectral properties of W .

Regarding our measures of cultural distance, within-group CD is measured by the intragroup variance in cultural trait values at time t and is denoted by VAR_t^{WIG} (for a formal definition, see below). Employees constituting an organizational unit have different cultural backgrounds and have experienced idiosyncratic individual learning and socialization histories prior to and after entering the organization. Therefore, we expect a considerable degree of initial intragroup variance in cultural trait values. Within-group CD will then change in the course of time depending on individual learning and socialization dynamics. CD between

⁷ Due to this random term, CD between agents will never completely vanish.

⁸ We abstract from internal communication structures and assume all unit members to participate in intragroup social interaction.

organizational units is denoted by VAR_i^{BTG} and captured by the variance in the difference of groups' mean values of a cultural trait (also defined below).

We now successively introduce several structural assumptions on the weights w_{ik} that constitute the cultural transmission matrix W . As a reference point, consider the case where W equals the identity matrix of size N . This corresponds to isolated learning processes absent any influences of the cultural environment. Individual trait values evolve independently. Weights are only affected by individual learning captured by ϵ_i (see Eq. 2). Next, we integrate cultural learning biases into W 's elements. Biases are viewed as frugal, boundedly rational heuristics. Copying the cultural traits shown by other members of one's reference group is such a simple, general rule (e.g., Kirman 1993). We therefore incorporate socialization in a group by accounting for its members' mutual influences within the updating process of cultural trait values. This is done by a parameter $p \in [0, 1]$, where p measures the weight an individual puts on her own trait value. Accordingly, $(1-p)$ measures the aggregate weight of other group members' trait values on the individual's one. If group members are homogeneous in their mutual influence, then each member's weight on the trait value of another member is given by $(1-p)/(N-1)$. This yields the following transmission matrix,

$$W^S = \begin{pmatrix} p & \frac{1-p}{N-1} & \cdots & \frac{1-p}{N-1} \\ \frac{1-p}{N-1} & p & \cdots & \frac{1-p}{N-1} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1-p}{N-1} & \frac{1-p}{N-1} & \cdots & p \end{pmatrix}. \quad (4)$$

If p takes on a relatively high value, then the diagonal elements of W^S imply that each individual strongly determines her own trait value, while other group members have a relatively small effect. Otherwise, if p is low, the group has a stronger influence on the value of a single individual's cultural trait, i.e., conformity and compliance are relatively strong (e.g., Bernheim 1994; Cialdini and Goldstein 2004). Hofstede (1989) offers empirical support for the existence of this bias in socialization: one cultural dimension in his cross-cultural comparisons is "individualism", the degree to which people act as self-determined individuals rather than collectivistic as members of a cohesive group (also Nisbett et al. 2001). Similarly, Greif (1994) differentiates between collectivist and individualist cultures to explain behavioral and institutional differences between societies (also Gorodnichenko and Roland 2011).

Moreover, group members often differ as to their intragroup influence. A particular learning bias relevant in this context is based on prominent or prestigious role models in an individual's social environment. Single individuals, including ordinary managers, (corporate) entrepreneurs, or business leaders, often play outstanding roles in the socialization of employees (e.g., Schein 1992; Van den Steen 2010). Indeed, evidence from social psychology and anthropology suggests that human agents are prone to adopt cultural traits that are shown by role models (Harrington 1999; Henrich and Gil-White 2001; Labov 2006; Atkisson et al. 2012). Therefore, a cognitive disposition to imitate prominent agents takes effect in socialization.

We incorporate such a role model bias into W^δ . Let individual $i=1$ be this model. We parameterize the additional influence of this agent by a parameter $r \in [0, 1]$. Different values of r reflect the fact that individuals differ in their ability or effort to exert influence in the socialization of other agents.⁹ This can be due to differences in charismatic potential, prestige, authority, social skills, personal work ethic, or different levels of engagement in active leadership, such as face-to-face communication with employees (e.g., Milgram 1974; Langlois 1998; Witt 1998; Acemoglu and Jackson 2015). Therefore, r represents - within boundaries - another tool for the governance of group-bound socialization open to managerial decision making.

We assume that the role model's impact decreases with increasing group size, i.e., the effective additional weight by which her trait value influences the cultural trait values of all other group members is described by $r/(N-1)$. Thus, the weights in the first column of W^δ increase by $r/(N-1)$ for each group member, except for the model herself. This reduces the relative influence of all other agents by $\frac{r}{(N-1)^2}$, such that the weights in each row add up to one. This gives us the following transmission matrix on which our further analysis rests:¹⁰

$$W = \begin{pmatrix} p & \frac{1-p}{N-1} & \dots & \frac{1-p}{N-1} \\ \frac{1-p}{N-1} + \frac{r}{N-1} & p - \frac{r}{(N-1)^2} & \dots & \frac{1-p}{N-1} - \frac{r}{(N-1)^2} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1-p}{N-1} + \frac{r}{N-1} & \frac{1-p}{N-1} - \frac{r}{(N-1)^2} & \dots & p - \frac{r}{(N-1)^2} \end{pmatrix}. \quad (5)$$

W also captures the effects of changing group size, N , which allows us to derive implications for developing organizations or units of different sizes as to socialization dynamics in Section 3. As shown in this context, group size affects many aspects of group-bound socialization and the development of CD.

The governance of socialization in organizations is complicated by the fact that employees have been presocialized in their prior social environments, for example, their national cultures (e.g., Ralston et al. 1997; Gorodnichenko and Roland 2011). People's behavior is strongly affected by their previous experiences in the family, school, and society as a whole. Hence, initial cultural trait values and the relative strength of learning biases are expected to vary among individuals due to prior socialization. These aspects of individuals' cultural backgrounds affect later intra-organizational socialization dynamics. Moreover, biases and cultural dimensions also differ across organizations endowed with different corporate cultures and may be subject to change as time elapses: while strong firm cultures emphasize collective goals, interaction, and identification (low p values), in other organizations agents

⁹ Research in social psychology provides evidence that fundamental personality traits coined early in life strongly predict stable distributions of individual differences in behavior later in life (e.g., Fleeson 2001; Fleeson and Gallagher 2009).

¹⁰ For any given $N \geq 3$, W is a right stochastic matrix if and only if $(p, r) \in [0, 1]^2$ such that $\frac{r}{(N-1)^2} \leq p \leq 1 - \frac{r}{N-1}$.

may focus more on their personal, individual agendas (high p values).¹¹ As shown below, when governing socialization processes in and between groups, organizations should consider employees' prior socialization histories in recruitment and a business unit's idiosyncratic culture for these take effect on agents' susceptibility to certain modes of socialization, i.e., p represents a means of socialization governance by organizations.

3 Principles of socialization governance in organizations

Our model of cultural evolution enables us to derive original insights for organization theory concerning different governance structures, socialization processes therein, and related transaction costs due to CD. In this context, socialization governance structures are characterized by varying constellations of the parameter set (p, r, N) . Our contribution to the economics of governance concerns the implementation of organizational structures that economize on internal transaction costs by facilitating socialization processes that reduce CD between agents or groups. Based on our formal analysis, we offer principles of the governance of socialization that capture the problem of the development of intra- and intergroup CD. We show that concrete lessons for organization theory reside in our analysis and derive refutable implications, inviting empirical testing.

3.1 Convergence and stabilization of cultural trait values within groups

Based on the cultural transmission table, W^S , which does not include an extraordinarily influential role model or business leader, Proposition 1 below presents a general finding of socialization governance: group-bound joint socialization leads to a reduction of intragroup variance in cultural trait values, VAR_t^{WIG} , irrespective of individual learning processes.

Let $V_t = E[(x_t - \bar{x}_t)'(x_t - \bar{x}_t)]$ denote the $N \times N$ variance-covariance matrix of the individuals in the group. Then, the intragroup variance at time t , measuring CD within the group, is given by the sum of the diagonal elements of V_t divided by $N-1$, i.e.,

$$VAR_t^{WIG} = \frac{1}{N-1} tr(V_t). \quad (6)$$

If no cultural transmission between group members takes place, i.e., $p=1$, then W^S equals the identity matrix and each agent's cultural trait value follows a random walk driven by uncorrelated individual learning. In this case, intragroup variance increases. However, in the presence of joint socialization based on mutual cultural learning, i.e., $p < 1$, the long-run intragroup variance is given by:

¹¹ Mesoudi et al. (2015) show that social learning strategies in humans are culturally variable: for example, members of Asian cultures exhibited a shift from pronounced social to more asocial learning due to exposure to Western culture.

$$VAR^{WIG,S} = \lim_{t \rightarrow \infty} VAR_t^{WIG,S} = \sigma^2 \left(1 + \frac{\lambda^2}{1 - \lambda^2} \right), \quad (7)$$

where λ refers to the $(N-1)$ -fold non-unit eigenvalue of W^S , given by.¹²

For p approaching unity, the situation of absent cultural learning can be interpreted as the limit case of Eq. 7. While governance structures with $p=1$ imply agents who fully determine their own cultural trait value, those with $p=0$ lead to individuals who are exclusively subject to group influences. Hence, our first proposition says:

Proposition 1 $VAR^{WIG,S} < \infty, \forall p \in [0, 1)$ and $VAR^{WIG,S} \xrightarrow{p \rightarrow 1} \infty$, i.e., socialization reduces intragroup variance in trait values.

Proof All proofs are given in the Appendix.

Communication and interaction among members tend to decrease intragroup CD. In fact, evidence from social psychology strongly supports the existence of such general convergence processes in groups as to the variance in behaviors, norms, attitudes, etc. (e.g., Festinger 1950; Levine and Moreland 1998). Hence, we claim that homogenization effects of shared socialization lower intraorganizational transaction costs via reducing intragroup CD. The first principle of governance of socialization in organizations says:

Principle 1a Governance structures that allow shared socialization experiences among members of an organizational unit lower CD among individual employees and thus economize on internal transaction costs.

For example, according to Alba (1990), an “American culture” emerged from the convergence of dozens of “immigrant cultures” in the course of actively promoted “Americanization”, a particular form of socialization. Mas and Moretti (2009) show that work ethos is a cultural trait whose variance and convergence among group members depend on the influence of employees’ social environment within organizations and role models therein (see below). Moreover, following (Pettigrew and Tropp 2000), mixing between individuals with different cultural endowments and subsequent prolonged communication and interaction breaks down stereotypes and encourages deeper mutual understanding, a process expected to lower CD between agents. Hence, a distinctive advantage of the governance structure of the firm is that it provides a framework for group-bound socialization reducing CD among employees and thus internal transaction costs – a benefit not feasible via market contracting. This is, we claim, another reason why firms exist as a form of economic organization (also Coase 1937; Alchian and Demsetz 1972; Hodgson 2004; Cordes et al. 2011).

Business leaders play an outstanding role in socializing employees by providing influential models in cultural learning within groups (e.g., Schein 1992). We

¹² $VAR_t^{WIG,S} = \sigma^2 \left(1 + \lambda^2 \frac{1 - \lambda^{2t}}{1 - \lambda^2} \right) + \sigma_0^2 \lambda^{2(t+1)}$, where σ_0^2 measures the unbiased initial group variance.

account for the effects of a manager's or business leader's higher weight in socialization (measured by the relative size of r) by analyzing the properties of our cultural transmission matrix, W (Eq. 5). We find that intragroup variance, VAR_t^{WIG} , converges and stabilizes at a finite value and – under certain conditions – also decreases in the course of socialization.

To establish this result, the following Lemma provides a compact expression for VAR_t^{WIG} . Let $\sigma_1^2 = \frac{1}{N}(x_{1,0} - \bar{x}_{-1,0})^2$ and $\sigma_{-1}^2 = \frac{1}{N-1} \sum_{k=2}^N (x_{k,0} - \bar{x}_{-1,0})^2$, where the former measures the initial distance of the model's trait to the average of all other group members, $\bar{x}_{-1,0}$, and the latter the unbiased initial trait variance for all non-role models.

Lemma 1 $VAR_t^{WIG} = \sigma^2 \left(1 + \frac{\lambda_2^2}{N-1} \frac{1-\lambda_2^{2t}}{1-\lambda_2^2} + \frac{(N-2)\lambda_{N-2}^2}{N-1} \frac{1-\lambda_{N-2}^{2t}}{1-\lambda_{N-2}^2} \right) + \sigma_1^2 \lambda_2^{2(t+1)} + \sigma_{-1}^2 \lambda_{N-2}^{2(t+1)}$,

where $\lambda_2 = \frac{Np-1}{N-1} - \frac{r}{N-1}$ and $\lambda_{N-2} = \frac{Np-1}{N-1}$ are the non-unit eigenvalues of W .

An immediate consequence of Lemma 1 is that the long-run intragroup variance stabilizes at a finite value given by

$$VAR^{WIG} = \lim_{t \rightarrow \infty} VAR_t^{WIG} = \sigma^2 \left(1 + \frac{1}{N-1} \frac{\lambda_2^2}{1-\lambda_2^2} + \frac{N-2}{N-1} \frac{\lambda_{N-2}^2}{1-\lambda_{N-2}^2} \right). \quad (8)$$

Lemma 1 highlights two major forces. First, the last two terms in the expression for VAR_t^{WIG} give the initial difference in trait values that monotonically decreases and vanishes in the long run due to shared socialisation. Second, the first term captures the increasing but converging variation in trait values stemming from ongoing uncorrelated individual learning. Consequently, whether VAR_t^{WIG} decreases or increases at time t depends on the relative size of these two forces. Given the expression for the intragroup variance provided by Lemma 1 above, Proposition 2 states the condition under which VAR_t^{WIG} decreases between two consecutive time steps when a role model takes effect in cultural transmission:

Proposition 2 $VAR_t^{WIG} - VAR_{t-1}^{WIG} < 0$ if and only if $\lambda_2^{2t} \left(\frac{\sigma^2}{N-1} - \sigma_1^2(1-\lambda_2^2) \right) + \lambda_{N-2}^{2t} \left((N-2) \frac{\sigma^2}{N-1} - \sigma_{-1}^2(1-\lambda_{N-2}^2) \right) < 0$.

Based on Proposition 2, the following Corollary provides sufficient conditions for VAR_t^{WIG} to monotonically decrease or increase in the presence of a role model:

Corollary 1

1. If the variance introduced by individual learning, as measured by σ^2 , is sufficiently small (large), VAR_t^{WIG} decreases (increases) monotonically.
2. For any given level of variance in individual learning, σ^2 : if the initial intragroup variance among non-role models and the initial cultural distance of the model to the group's average trait value are sufficiently high, VAR_t^{WIG} decreases monotonically.

The Corollary of Proposition 2 delivers a sufficient condition for monotonically decreasing intragroup variance, VAR_t^{WIG} , if we allow for a role model with given r to take effect in socialization: since strong individual learning forces can offset the harmonizing effect of communication and interaction among employees in groups hosting a model, the variance in individual learning, σ^2 , must not exceed a certain threshold to let intragroup CD decline.¹³ Consequently, as long as organizations and business leaders avoid (weak) corporate cultures with high levels of idiosyncratic individual learning, which indicates low group cohesion and strong focus on personal (potentially opportunistic) agendas, intragroup CD decreases due to shared socialization. This is consistent with empirical evidence from social psychology as to the harmonizing effects of group-bound communication including role models (e.g., Atkisson et al. 2012). This leads to Principle 1b:

Principle 1b Governance structures that allow shared socialization in units including a role model facilitate a reduction of intragroup CD and thus internal transaction costs if individual learning among group members is not too strong. The latter would indicate low group cohesion.

The Corollary also states that if intragroup variance among peers and CD of the model to the group's average trait value are sufficiently high, then VAR_t^{WIG} decreases irrespective of the strength of individual learning forces. As initial intragroup variance in traits reflects accumulated prior individual and cultural learning, this is likely to be the case in, for example, cross-cultural mergers. On all accounts, group-bound socialization then benefits the integrated organization in terms of internal transaction costs.

3.2 Divergence of cultural trait values between groups

We now scrutinize the development of the variance in trait values in distinct (sub-) groups. The model shows that each group of interacting and communicating agents will develop an idiosyncratic cultural endowment in the course of time. As a consequence, the variance in the difference of groups' mean values of cultural traits, VAR_t^{BTG} , increases as a linear function of time. Accordingly, CD between groups or organizational units necessarily grows proportionately to time if the groups' members do not (or rarely) interact with members of the other groups.

We capture this argument formally in Proposition 3.

Proposition 3 VAR_t^{BTG} increases (asymptotically) as a linear function of time.

Idiosyncratic socialization processes between separate groups have concrete implications for CD within organizations. Even if two groups consist of members

¹³ Individual learning occurs at the cultural, not the skill level, where it may be beneficial (see Lazear 1999).

that have all been socialized in the same culture and have acquired the same initial cultural endowment, subsequent intragroup learning dynamics will increase intergroup CD. This is due to two effects: (1) individual learning introduces variation to a group's cultural trait (as captured by the random component ϵ) and (2) the cultural transmission matrices capturing the respective groups' inner socialization dynamics will never be exactly identical. There will always be some variance in, for example, the influence of role models in socialization because of differences in personal characteristics, such as charismatic potential or prestige. In distinct groups, these changes in trait values are not "averaged out" but rather accumulated over time. From this follows a cultural divergence principle in socialization governance:

Principle 2 Idiosyncratic socialization processes within organizational units necessarily lead to an increase in intergroup CD and thus higher costs of transacting between them.

Organizational governance structures have to cope with this permanent challenge of rising intergroup CD. Given our first principle of socialization governance, we expect shared socialization experiences to alleviate the problem of rising CD between organizational units. Hence, socialization governance structures that enable systematic exchange among groups and that establish ongoing intergroup communication lower intraorganizational transaction costs.

We also expect increasing intergroup CD in the case of a group partitioned into subgroups whose respective members confine themselves – at least to a great extent – to communicating with one another: variance in trait values within subgroups will then converge (Principle 1a), while CD between subgroups will grow (Principle 2).¹⁴ If contributions of all subgroups are required for attaining unit goals, this process of divergence of CD between subgroups is likely to impair organizational performance via increased internal transaction costs.¹⁵ Business leaders may, therefore, deliberately devise socialization governance structures that avoid the emergence of isolated subgroups within business units. The development of distinct dialects for subgroups of a population provides an empirical example for increasing intergroup CD and concomitant convergence of CD within groups: (Labov and Harris 1986) show that Black English of different metropolitan areas has converged, while it diverged at the same time from (White) Standard American English. The authors take this observation as an indicator of growing CD between these groups due to a low level of social interaction among them. The cultural divergence principle may also underlie appearing growth crises in organizations that have been split up in several non-communicating subgroups with increasing firm size.

¹⁴ The cultural transmission matrix allows for the existence of more or less isolated subgroups.

¹⁵ This problem is also eminent in the case of an organization's self-contained units (e.g., subsidiaries), whose cultural endowments diverge in the course of time absent communication across unit boundaries. Via increased intergroup CD, this process raises internal transaction costs of collaboration involving these units.

3.3 Business leaders as role models in group-bound socialization

Next, we analyze how governance structures characterized by role models with a varying influence in group-bound socialization affect the development of intragroup variance in cultural trait values, VAR^{WIG} , and, therefore, an organization's internal transaction costs. The model's weight in intragroup cultural transmission is subject to change: a business leader may increase (decrease) her influence, measured by r , by augmenting (reducing) the time spent for face-to-face communication and engagement in active leadership. r also increases (decreases) when a new role model endowed with higher (lower) charismatic potential or greater (lesser) social skills is assigned to a group.

Since many aspects of socialization governance - including those involving a role model - hinge on our cultural dimensions of "individualism" and "collectivism", we (1) formally discriminate between these dimensions and (2) briefly provide some intuition on the empirical occurrence of group cultures characterized by different manifestations of "individualism" and "collectivism". We state that $VAR^{WIG,S}$ is minimal for $\lambda = 0$ (see Eq. 7). This is the case if and only if $p = 1/N$, i.e., if each group member puts the same weight on all fellow employees' trait values including herself. Intuitively, if every member has the same weight in socialization, individual learning is optimally diversified and $VAR^{WIG,S}$ equals the individual learning variance, σ^2 . Relative to this benchmark, we refer to cultural environments in groups with $p > 1/N$ as *individualistic*, while settings with $p < 1/N$ are considered *collectivistic*. Moreover, we capture the *degree of individualism* by $\frac{p}{1/N} = Np$. Thus, individualistic (collectivistic) environments are characterized by a degree of individualism above (below) one.

We expect to empirically observe various types of organizational group cultures characterized by different levels of "individualism" and "collectivism". For instance, while clan- or family-like organizational structures are rather collectivistic emphasizing close communication, market-oriented structures that focus on external economic performance indicators foster an individualistic culture with members concerned with fulfilling their personal tasks. Similarly, firms with clear lines of authority, hierarchy, and centralized decisions would instill an individualistic stance among employees, while a creative workplace setting would necessitate exchange in a more collectivistic cultural environment.¹⁶ Other determinants of unit culture are an industry's life cycle or the organization's age: entrepreneurial ventures whose employees share a "vision" exhibit high group cohesion (Witt 1998). Moreover, to cope with the challenges posed by a nascent, turbulent business environment, members are required to intensively communicate and interact, i.e., to engage in mutual learning (see Cordes 2008). In these particular settings, we expect more collectivistic group cultures. On the other hand, organizations active in mature business environments may rely on more formal means of management, hierarchical structures, and standardized production (see Cr  mer 1993; Thompson 1967). In this situation,

¹⁶ Here, we draw on the "competing value framework" for the classification of organizational cultures (see Quinn and Rohrbaugh 1981; Quinn 1988; Cameron and Quinn 2011).

employees drawing on routines in day-to-day operations feel less committed to collective goals and focus more on their personal agendas. As a consequence, group cultures would be more individualistic. Moreover, one might expect differences in work group cultures within a firm: while an R&D unit doing sophisticated collaboration in the context of creative problem-solving may have a strong collectivistic unit culture, workers on the shop floor may individualistically focus on their piecework wage and engage little in firm-related group exchange.

Returning to a role model's influence in group-bound socialization, the following proposition describes the impact of varying values for r on the limit of intragroup variance in trait values.

Proposition 4 VAR^{WIG} decreases in r if and only if $Np > 1 + r$.

Proposition 4 shows the implications of role models' changing influence in socialization for intraorganizational CD: in any individualistic group culture ($p > 1/N$), the assignment of a model decreases VAR^{WIG} if r is not too large. Moreover, in cultural environments with a degree of individualism so that $Np > 1 + r$ holds, (marginally) strengthening a model's influence in socialization always reduces intragroup CD. Consequently, role models can serve as a means to strengthen cohesion in groups composed of otherwise individualistically minded individuals. Such a stronger group culture induced by business leaders leads to collective goals becoming more important relative to employees' personal agendas. This is expected to improve on firm performance and to establish a more participative, cooperative corporate culture. To reproduce this general aspect of group-bound socialization involving a role model with varying r , note that in the absence of a model, individual learning is evenly balanced across group members if $p = 1/N$. In individualistic cultures, employees put too much weight on their own cultural trait value and too little on those of their peers to enable a reduction of CD within the group.¹⁷ The role model's rising influence then shifts some of the weight group members put on their own trait toward her weight in socialization. As a consequence, employees are more likely to subordinate their personal – potentially opportunistic – agendas and subscribe to the group's and model's collective goals, beliefs, and values. Organization members then exhibit a higher degree of identification with the organization (see Akerlof and Kranton 2005). Hence, in the case of individualistic group cultures, assigning a more influential role model or increasing an existing one's engagement in active leadership, i.e., creating governance structures characterized by a certain constellation of the parameter set (p, r) , ameliorates the negative transactional effects of CD within a business unit. These findings lead to a principle concerning the effects of role models' changing weight in governing socialization:

¹⁷ A pronounced cultural dimension of "individualism" in prior socialization may have led to agents less amenable to the influence of their social environment.

Principle 3a In socialization governance structures characterized by individualistic group cultures, a role model's augmented influence strengthens group coherence by lowering intragroup CD, thereby economizing on transaction costs.

However, in collectivistic cultural environments ($p < 1/N$), the role model's growing influence amplifies the pronounced influence of peers so that intragroup variance and CD rise in r . A relatively low value of p among group members may imply individuals presocialized in a collectivistic cultural environment. Similarly, new recruits that rely on copying the cultural traits of peers as a frugal heuristic to identify locally adapted norms, values, attitudes, etc. in complex cultural environments would entail low values for p . Finally, the latter can also indicate an organizational unit endowed with a strong participative culture in which every member is motivated to codetermine the group's productivity. In all cases, groups would profit from a business leader avoiding a too strong influence in cultural transmission but acting as an "equal among equals". Consequently, as to the assignment and influence of role models, the choice of modes of socialization governance depends on cultural dimensions, employees' cultural backgrounds, and a firm's culture: models' final effect on intragroup variance in trait values is mediated by a group's culture.

3.4 Socialization in growing organizational units

Since group size, N , affects many aspects of group-bound socialization (e.g., Olson 1994; Spoor and Kelly 2004; Cordes et al. 2008), it represents an important component of socialization governance structures' set of parameters (p, r, N). We now turn to an analysis of its interplay with our forces of cultural transmission.

Let $P(N)$ denote the set of parameters (p, r) for which VAR^{WIG} decreases in r . Furthermore, let $Q(N)$ denote the set of parameters (p, r) ensuring that W is a right stochastic matrix (see footnote 10). We are interested in the share of parameters in $Q(N)$ that allows VAR^{WIG} to decrease in r . Then, the relative size of $P(N)$ yields a measure of the mass of cultural environments in which a role model's growing influence in socialization reduces intragroup CD. Thus, the share of parameters (p, r) causing VAR^{WIG} to decrease in r is given by $\frac{\int_{[0,1] \times [0,1]} \mathbb{1}_{P(N)} d(r, p)}{\int_{[0,1] \times [0,1]} \mathbb{1}_{Q(N)} d(r, p)}$, where $\mathbb{1}$ denotes the indicator function. We state the following result:

Proposition 5 The share of parameters (p, r) for which VAR^{WIG} decreases in r increases in N .

Proposition 5 shows that the scope for individuals talented to serve as influential role models reducing intragroup CD is growing with the size of the organizational unit. The share of socialization governance structures characterized by constellations of (p, r) that facilitate a reduction of intragroup CD via an assignment of a more influential model or an existing one's higher engagement in active leadership increases with unit size, N . Consider an individualistic cultural environment ($p > 1/N$). In the absence of a role model, growth in group size increases CD due to individual learning experiences being less uniformly distributed across group members. This grants role models a higher leverage in

socialization to lower CD by shifting influence in cultural transmission away from ordinary group members toward the role model. Therefore, the share of governance structures (p, r) in which VAR^{WIG} decreases with a business leader's increasing influence grows with the size of the organizational unit. Agents who can take advantage of this widening scope for models in socialization by raising their influence may be characterized by an extraordinary amount of charisma, persuasiveness, greater skills in active leadership, or may enjoy a high level of prestige in their group. The implications of Proposition 5 lead to another principle in socialization governance:

Principle 3b The share of socialization governance structures enabling a role model to reduce intragroup CD and internal transaction costs by augmenting her influence in group-bound socialization increases in the organizational unit's size.

This principle of socialization governance is especially relevant for organizations that aim at maintaining a strong, participative corporate culture within their growing units. A concomitant task for these firms is to hire talented agents that may serve as role models or to identify them among their own employees. The latter option appears particularly attractive since these agents experienced prior socialization within the organization and its idiosyncratic cultural endowment (for empirical studies supporting this view, see Gittel 2003; Higgins 2005).

Another implication of growing unit size emerges for role models with a fixed weight in organizational socialization: in cultural environments in which VAR^{WIG} decreases in a role model's given weight r (see Proposition 2), increasing group size N counters this force by reducing the model's effective influence, $r/(N-1)$, in cultural transmission. This lowers her dampening impact on VAR^{WIG} . Formally, to show whether a growing unit size amplifies or attenuates the role model's impact, we look at the effect of N on the marginal impact of the role model's weight, r , on the intragroup variance, VAR^{WIG} . For this purpose, we take the derivative of $\frac{\partial VAR^{WIG}}{\partial r}$ w.r.t. to N . We find multiple effects of a growing N . First, it changes the net impact of the role model via $r/(N-1)$. Second, for a fixed p , it yields a relatively more individualistic group culture. In order to isolate these effects, we keep the degree of individualism constant, i.e., we consider a change in N for a fixed $\frac{p}{1/N} = pN$. It turns out that the change of the impact of r holding the degree of individualism constant is positive, which implies that the role model's variance-reducing impact is attenuated by growing unit size.¹⁸

¹⁸ Let $D_r(N, p, r)$ denote the partial derivative of VAR^{WIG} w.r.t. r . We look at the total derivative of $D_r(N, p, r)$ for a fixed r , i.e., $dr = 0$:

$$\begin{aligned} \frac{\partial D_r(N, p, r)}{\partial N} dN + \frac{\partial D_r(N, p, r)}{\partial p} dp &= \frac{\partial D_r(N, p, r)}{\partial N} dN + \frac{\partial D_r(N, p, r)}{\partial p} \left(-\frac{p}{N} dN \right) \\ &= \left(\frac{1}{(N(1-p)+r)^3} + \frac{1}{(2-N(1+p)+r)^3} \right) dN. \end{aligned}$$

Note that the first equality follows from holding pN constant, which implies $dp = -\frac{p}{N}dN$. Moreover, under the assumption that $D_r(N, p, r) < 0$, the coefficient in the last term is strictly positive.

As a result, in governance structures (p, r, N) with a given influence of the role model, a fixed p , and growing group size, the model suffers from a “dilution effect” in group-bound socialization. This effect implies that with a fixed weight r , the role model’s variance-reducing impact decreases with group size. The intensity of communication and the frequency of face-to-face contacts between a business leader and a single group member necessarily dwindle with growing unit size, if effective leadership effort is not - or cannot - be adapted. Hence, a model’s capacity to influence group members and maintain a strong group culture is subject to constraints imposed by an organizational unit’s size and the model’s talent in leadership. This leads to a “dilution principle” in socialization governance:

Principle 3c In governance structures including a role model with a constant weight in cultural transmission, increasing size of the organizational unit lowers her effectiveness as a socialization governance response to reduce intragroup CD and corresponding transaction costs.

An appropriate socialization governance response to this challenge would be the pairing of rather small groups with a business leader. This avoids the ‘dilution effect’ and enables social interaction at high levels of intensity (e.g., Levine and Moreland 1990; Forsyth 2006). Such modes of model-based socialization governance have been successfully employed by firms and are expected to reliably reduce intraorganizational CD. Baxter Inc., to provide an example, adhered to strong socialization processes of this kind: small groups of newly recruited employees were paired with a senior manager to enable a phase during which the firm’s idiosyncratic, participative culture was passed on to the organization’s new members (see Higgins 2005).

Another interesting feature of the “dilution principle” in socialization governance concerns dynamic governance structure: the size-contingent constraints on the influence of business leaders who are not able to adapt their influence in socialization constitute potential limits to firm growth or subunit size. These are, therefore, reasons for systematically appearing growth crises in organizational development (e.g., Greiner 1998; Cordes et al. 2010) or poor performance of subunits (e.g., Wagner 1995) due to increasing CD. For instance, Southwest Airlines relied on their two charismatic founders to serve as role models in the socialization of employees and the implementation of the firm’s cooperative culture (see Gittel 2003). First, as organizational size increased, this mode of socialization governance was maintained by the founders’ boosted active leadership and their charismatic potentials they could tap (see Principle 3c). Then, as organizational growth continued while the the role models’ influence could not be raised further, it started to fail inducing a growth crisis. The “dilution principle” impaired model-based socialization causing the corporation’s culture to deteriorate.

3.5 Cultural dimensions and intragroup cultural distance

Since the development of intragroup variance in traits varies with group culture captured by the dimensions of “individualism” and “collectivism”, we analyze its effects on CD within groups in governance structures with different constellations of (r, p, N) .

Proposition 6 gives the precise conditions.

Proposition 6

1. In a collectivistic cultural environment ($p < \frac{1}{N}$), VAR^{WIG} decreases in p .
2. In an individualistic cultural environment ($p \geq \frac{1}{N}$), we differentiate two cases: (a) if $Np \geq 1 + r$, VAR^{WIG} increases in p . (b) If $Np < 1 + r$, VAR^{WIG} decreases in p if and only if $\frac{\lambda_2}{(1-\lambda_2^2)^2} + (N-2)\frac{\lambda_{N-2}}{(1-\lambda_{N-2}^2)^2} < 0$.

Proposition 6 shows how the development of VAR^{WIG} is affected by the varying relative strength of the cultural dimensions “individualism” and “collectivism”, as measured by p . In the case of a collectivistic group culture characterized by low p values ($p < \frac{1}{N}$), VAR^{WIG} decreases in p , i.e., an increase in the weight each employee puts on her own trait in socialization decreases intragroup variance. This is due to the fact that a share of the model’s and peer employees’ weights in cultural transmission is shifted toward individual group members, thereby balancing better intragroup individual learning. This implies that a reduction of the influence of the group and more “self-reliant” agents lower intragroup CD. We state:

Principle 4a In socialization governance structures composed of collectivistic group cultures, a rising level of individualism reduces CD and intraorganizational transaction costs.

Principle 4a bears transaction cost-relevant implications for a firm’s socialization governance: organizational units characterized by cultures with high levels of conformity and compliance (an “esprit de corps”) or groups of employees presocialized in pronounced collectivistic environments before recruitment profit - up to a limit - from a corporate culture emphasizing a higher degree of individual autonomy. We expect such collectivistic firm cultures in industries characterized by fierce competition with great adaptive needs (see Cordes et al. 2008) or within firms with strong organizational routines (e.g., Higgins 2005).

In organizational governance structures with individualistic cultural environments indicated by relatively high values of p ($p > \frac{1}{N}$), we differentiate two cases: (1) as long as the degree of individualism fulfills the condition $Np \geq 1 + r$, intragroup variance in cultural trait values grows with a rising level of individualism. (2) Below this threshold, i.e., if $Np < 1 + r$, VAR^{WIG} only decreases in p if a certain condition is met, otherwise it also increases in p . An analysis of the parameter space revealed that for most constellations intragroup variance in cultural traits increases with a rising level of individualism in already individualistic group cultures. This situation

is given in organizational units whose members exhibit a relatively high level of “individualism” due to prior socialization or weak firm culture. A further increase in this dimension then makes agents even less susceptible to group-bound socialization and collective organizational goals. Members would focus more on their personal - potentially opportunistic - agendas, i.e., their own cultural traits, augmenting intragroup CD. Furthermore, since the likelihood that $p > \frac{1}{N}$ holds increases, *ceteris paribus*, with growing group size, larger organizational units are especially prone to this problem of growing individualism. Given these insights, the next principle of socialization governance in organizations is this:

Principle 4b When individualism among employees increases in governance structures already endowed with individualistic group cultures, CD between employees and transaction costs tend to grow. Larger organizational units are especially prone to this problem.

This is in line with evidence from social psychology showing that members of larger or more anonymous groups tend to feel less attached to other members and participate less in collective activities (e.g., Kerr 1989; Levine & Moreland 1998; Forsyth 2006) - potential manifestations of increased intragroup CD.

Moreover, resulting from Proposition 6 (2), governance structures composed of employees with an individualistic stance ($p > \frac{1}{N}$) gain from more team-oriented cultures for a lower p decreases intragroup CD in most cases. We therefore also state:

Principle 4c In governance structures characterized by individualistic group cultures, a transition toward socialization governance that facilitates more intense group-bound interaction and thus a rising level of collectivism lowers intragroup CD and transaction costs.

Hence, in these cases, firms can cope with intraorganizational CD and corresponding transaction costs by deliberately implementing governance structures with more collectivistic, participative group cultures, in which members’ cultural traits are more susceptible to peer employees’ influence. The assignment of influential role models represents a way to achieve this (see above). A corporation may also take recourse to the recruitment of employees presocialized in collectivistic environments, either in a societal context, in another organization, or in the own firm. Moreover, there are reasons for organizations to keep unit sizes small and group cultures strong in transaction cost-minimizing socialization governance. This is especially important when recruiting individualistically presocialized employees. Google Inc. represents an example of a firm that takes great effort to implement a strong corporate culture. Deliberately crafted, intense intraorganizational socialization processes are combined with flat hierarchies and high levels of discretion that facilitate strong participation of employees. Thereby, newly recruited members learn about the organization’s collective goals and become highly motivated to adopt these (see Finkle 2012). Furthermore, when asked in an interview how to maintain Google’s corporate culture while the organization is growing, the firm’s founders argued for

the existence of a “natural size for human organizations” and that creating (sub-) groups of this size “...can retain a lot of that culture” (Lashinsky 2008).

4 Conclusions

In this paper, we have claimed that cultural distance (CD) is an important attribute of transactions. Adding to Williamson’s problem of economic organization, we suggested that the governance of socialization processes has the potential to economize on intraorganizational transaction costs by lowering CD between employees or groups. We have been discussing socialization processes based on a model of cultural evolution that explains the development of CD within and between groups or organizational units. Specific socialization dynamics in these entities are, we have argued, a determinant of CD and related transaction costs in corporations. Some general principles of the governance of socialization in organizations have been suggested. Given these principles, organizations can implement alternative modes of socialization governance to reduce internal transaction costs in businesses where CD is relevant.

Socialization processes as modes of governance are means to deal with CD among employees. They are considered a key purpose of organizations. Characteristics that define an organization’s socialization governance structure include shared or divided social experiences in (sub-)groups, intergroup exchange, the assignment and influence of role models, the adjustment of group size to facilitate socialization in small units, the recruitment of employees presocialized in particular ways, the recognition of specific cultural dimensions taking effect in group-bound social interaction, and the implementation of cooperative cultures in business units. The alternative modes of governance resulting from these characteristics are defined by the particular socialization dynamics they facilitate. They yield differential capacities of organizations to adapt internal structures in transaction cost-minimizing ways.

It is the governance form of the firm that enables intraorganizational socialization processes that potentially lower intra- and intergroup CD and that are not feasible via market contracting. This provides another motive for choosing the organizational form of the firm. Organizations have the capacity to capture transactional benefits arising from the governance of socialization experiences, i.e., a further challenge for the modern corporation is to align governance structures with socialization dynamics.

Appendix

Proofs

Proof of Proposition 1 Plugging in $\lambda = \frac{Np-1}{N-1}$ into Eq. 7 and taking the limit w.r.t. p yields the claim.

Proof of Lemma 1 Following Feldman and Cavalli-Sforza's (1975) analysis of the properties of within-group variance, we know that

$$V_{t+1} = \tilde{P}W^{t+1}V_0W'^{t+1}\tilde{P} + \sigma^2\tilde{P} + \sigma^2\tilde{P}\sum_{k=1}^t W^k W'^k \tilde{P}. \quad (\text{A.1})$$

where $\tilde{P} = I - P$, and P is a matrix whose rows all equal $(1/N, \dots, 1/N)$.

$$\begin{aligned} \text{VAR}_t^{\text{WIG}} &= \frac{\text{tr}(\tilde{P}W^{t+1}V_0W'^{t+1}\tilde{P} + \sigma^2\tilde{P} + \sigma^2\tilde{P}\sum_{k=1}^t W^k W'^k \tilde{P})}{N-1} \\ &= \sigma^2 + \frac{\text{tr}(\tilde{P}W^{t+1}V_0W'^{t+1}\tilde{P})}{N-1} + \frac{\text{tr}(\sigma^2\tilde{P}\sum_{k=1}^t W^k W'^k \tilde{P})}{N-1} \\ &= \sigma^2 + \frac{\text{tr}(\tilde{P}W^{t+1}V_0W'^{t+1}\tilde{P})}{N-1} + \sum_{k=1}^t \frac{\text{tr}(\sigma^2\tilde{P}W^k W'^k \tilde{P})}{N-1} \end{aligned} \quad (\text{A.2})$$

The last term can be simplified: with eigenvalues $\lambda_1 = 1, \lambda_2 = \frac{Np-1}{N-1} - \frac{r}{N-1}$ and $\lambda_3 = \dots = \lambda_N = \frac{Np-1}{N-1} \equiv \lambda_{N-2}$, it follows that

$$\text{tr}(\sigma^2\tilde{P}W^k W'^k \tilde{P}) = \sigma^2(\lambda_2^{2k} + (N-2)\lambda_{N-2}^{2k}). \quad (\text{A.3})$$

Equation (A.3) derives from $W^k = (Q\Lambda Q^{-1})^k = Q\Lambda^k Q^{-1}$, and, accordingly $W'^k = (Q\Lambda^k Q^{-1})'$, where the columns of Q correspond to the set of eigenvectors of W . More precisely, let $Q = (v'_1, v'_2, \dots, v'_N)$ with v_i being the eigenvector associated with λ_i . Eigenvectors are given by $v_1 = (1, \dots, 1)$; $v_2 = (-\frac{(N-1)(1-p)}{1-p+r}, 1, \dots, 1)$; $v_k = -e_2 + e_k$, $k = 3, \dots, N$.

Hence,

$$\begin{aligned} \sum_{k=1}^t \frac{\text{tr}(\sigma^2\tilde{P}W^k W'^k \tilde{P})}{N-1} &= \frac{\sigma^2}{N-1} \sum_{k=1}^t (\lambda_2^{2k} + (N-2)\lambda_{N-2}^{2k}) \\ &= \frac{\sigma^2}{N-1} \left(\lambda_2^2 \frac{1-\lambda_2^{2t}}{1-\lambda_2^2} + \lambda_{N-2}^2 \frac{1-\lambda_{N-2}^{2t}}{1-\lambda_{N-2}^2} \right) \end{aligned} \quad (\text{A.4})$$

For the middle term, we have:

$$\frac{\text{tr}(\tilde{P}W^{t+1}V_0W'^{t+1}\tilde{P})}{N-1} = \frac{1}{N}(x_1 - \bar{x}_{-1})^2 \lambda_2^{2t} + \frac{1}{N-1} \sum_{k>1} (x_k - \bar{x}_{-1})^2 \lambda_{N-2}^{2t}. \quad (\text{A.5})$$

The first term in parenthesis on the right-hand side of Eq. A.5 is the initial variance between the role model's trait value and the average of all other employees. It is decreasing geometrically. The second term describes the initial variance among all ordinary employees excluding the role model. Combining Eq. A.4 and A.5 yields the claim.

Proof of Proposition 2 Given the expression for $\text{VAR}_t^{\text{WIG}}$ by Lemma 1 we have:

$$\begin{aligned} & \text{VAR}_t^{\text{WIG}} - \text{VAR}_{t-1}^{\text{WIG}} < 0 \Leftrightarrow \\ & \sigma_1^2 \lambda_2^{2t} (\lambda_2^2 - 1) + \sigma_{-1}^2 \lambda_{N-2}^{2t} (\lambda_{N-2}^2 - 1) + \frac{\sigma^2}{N-1} (\lambda_2^{2t} + (N-2) \lambda_{N-2}^{2t}) < 0 \Leftrightarrow \quad (\text{A.6}) \\ & \lambda_2^{2t} \left(\frac{\sigma^2}{N-1} - \sigma_1^2 (1 - \lambda_2^2) \right) + \lambda_{N-2}^{2t} \left((N-2) \frac{\sigma^2}{N-1} - \sigma_{-1}^2 (1 - \lambda_{N-2}^2) \right) < 0. \end{aligned}$$

Proof of Corollary 1

1. For $\sigma \rightarrow 0$: $\text{VAR}_t^{\text{WIG}} - \text{VAR}_{t-1}^{\text{WIG}} < 0, \forall t$, whereas $\sigma \rightarrow \infty$: $\text{VAR}_t^{\text{WIG}} - \text{VAR}_{t-1}^{\text{WIG}} > 0, \forall t$
2. Note that $\frac{\sigma^2}{N-1} - \sigma_1^2 (1 - \lambda_2^2) < 0 \Leftrightarrow \frac{\sigma^2}{(N-1)(1-\lambda_2^2)} < \sigma_1^2$ and $(N-2) \frac{\sigma^2}{N-1} - \sigma_{-1}^2 (1 - \lambda_{N-2}^2) < 0 \Leftrightarrow \frac{(N-2)\sigma^2}{(N-1)(1-\lambda_{N-2}^2)} < \sigma_{-1}^2$.

Proof of Proposition 3 Let $y_{t+1} = W_y y_t + \epsilon_{y,t}$ and $z_{t+1} = W_z z_t + \epsilon_{z,t}$ denote the transition processes for this trait within the two groups, where ϵ_y and ϵ_z are independent.

Thus, $\text{VAR}_t^{\text{BTG}} = E[(\bar{y}_t - \bar{z}_t)^2]$. Recall that $y_{t+1} = W_y^{t+1} y_0 + \sum_{k=0}^t W_y^k \epsilon_{y,t-k}$. Hence, $\bar{y}_{t+1} = \overline{W_y^{t+1} x_0} + \sum_{k=0}^t \overline{W_y^k \epsilon_{y,t-k}}$.

$$\overline{W_y^{t+1} x_0} = \overline{Q_y \Lambda_y^{t+1} Q_y x_0} = \sum_{i=1}^{N_y} \phi_{y,i}^{t+1} y_i, \quad (\text{A.7})$$

where

$$\begin{aligned} \phi_{y,1}^{t+1} &= -\frac{(N_y-1)(N_y-(N_y-1+b_y)\lambda_2^{t+1})}{N_y(N_y-1)(b_y-1)} \xrightarrow{t \rightarrow \infty} \frac{1}{1-b_y} \\ \phi_{y,i \geq 2}^{t+1} &= \frac{N_y b_y - (N_y-1+b_y)\lambda_2^{t+1}}{N_y(N_y-1)(b_y-1)} \xrightarrow{t \rightarrow \infty} \frac{b_y}{(N_y-1)(b_y-1)}, \end{aligned} \quad (\text{A.8})$$

where $b_y = \frac{r_y - \frac{N_y}{\alpha_y - (1-p_y)}}{r_y - \frac{N_y}{\alpha_y} + \frac{1-p_y}{N_y-1}}$. Expressions for $\overline{W_y^k \epsilon_{y,t-k}}$, $\overline{W_y^{t+1} y_0}$, and $\overline{W_z^k \epsilon_{z,t-k}}$ can be derived analogously.

$$E[(\bar{y}_t - \bar{z}_t)^2] = E \left[\left(\overline{W_y^t x_0} + \sum_{k=0}^{t-1} \overline{W_y^k \epsilon_{y,t-k}} - \overline{W_z^t z_0} - \sum_{k=0}^{t-1} \overline{W_z^k \epsilon_{z,t-k}} \right)^2 \right] \quad (\text{A.9})$$

$$\begin{aligned} & \stackrel{E[\epsilon_{y,t-k}]=0}{=} \left(\overline{W_y^t x_0} - \overline{W_z^t z_0} \right)^2 + E \left[\left(\sum_{k=0}^{t-1} \overline{W_y^k \epsilon_{y,t-k}} - \sum_{k=0}^{t-1} \overline{W_z^k \epsilon_{z,t-k}} \right)^2 \right] \end{aligned} \quad (\text{A.10})$$

$$\stackrel{\epsilon_y, \epsilon_z}{=} \stackrel{\text{indep.}}{=} \left(\overline{W_y^t x_0} - \overline{W_z^t z_0} \right)^2 + E \left[\left(\sum_{k=0}^{t-1} \overline{W_y^k \epsilon_{y,t-k}} \right)^2 \right] + E \left[\left(\sum_{k=0}^{t-1} \overline{W_z^k \epsilon_{z,t-k}} \right)^2 \right] \quad (\text{A.11})$$

$$\stackrel{\epsilon_{y,t}, \epsilon_{y,t'}, \epsilon_{z,t'}}{=} \stackrel{\epsilon_{z,s} \text{ indep.}}{=} \left(\overline{W_y^t x_0} - \overline{W_z^t z_0} \right)^2 + \sum_{k=0}^{t-1} E \left[\left(\overline{W_y^k \epsilon_{y,t-k}} \right)^2 \right] + \sum_{k=0}^{t-1} E \left[\left(\overline{W_z^k \epsilon_{z,t-k}} \right)^2 \right] \quad (\text{A.12})$$

Plugging in Eq. A.8 and its analogs into Eq. A.12 gives us:

$$\begin{aligned} & \left(\overline{W_y^t x_0} - \overline{W_z^t z_0} \right)^2 + \sum_{k=0}^{t-1} E \left[\left(\sum_{i=1}^{N_y} \phi_{y,i}^k \epsilon_{y,i,t-k} \right)^2 \right] + \sum_{k=0}^{t-1} E \left[\left(\sum_{i=1}^{N_z} \phi_{z,i}^k \epsilon_{z,i,t-k} \right)^2 \right] \\ & \stackrel{\substack{\epsilon_{y,i,t}, \epsilon_{y,i,s}, \epsilon_{z,i,t}, \epsilon_{z,i,s} \\ \text{independent}}}{=} \left(\overline{W_y^t x_0} - \overline{W_z^t z_0} \right)^2 + \sum_{k=0}^{t-1} \sigma_y^2 \sum_{i=1}^{N_y} (\phi_{y,i}^k)^2 + \sum_{k=0}^{t-1} \sigma_z^2 \sum_{i=1}^{N_z} (\phi_{z,i}^k)^2. \end{aligned} \quad (\text{A.13})$$

Note that $\sum_{i=1}^{N_y} (\phi_{y,i}^k)^2$ and $\sum_{i=1}^{N_z} (\phi_{z,i}^k)^2$ converge. Therefore, asymptotically, the variance in the difference of two different groups' mean values of a cultural trait increases linearly in time. \square

Proof of Proposition 4 According to Eq. 8, $\text{VAR}_t^{\text{WIG}}$ converges and stabilizes at a finite value. We now study the impact of r on this limit. Recall, $\text{VAR}^{\text{WIG}} = \sigma^2 \left(1 + \frac{1}{N-1} \frac{\lambda_2^2}{1-\lambda_2^2} \right) + \left(1 - \frac{1}{N-1} \right) \frac{\lambda_{N-2}^2}{1-\lambda_{N-2}^2}$. Note that for the derivative of VAR^{WIG} with respect to r we have:

$$\begin{aligned} \frac{\partial \text{VAR}^{\text{WIG}}}{\partial r} &= - \frac{2(N-1)(Np-1-r)}{(N^2(1-p^2)-r(2+r)-2N(1-p(1+r)))^2} \\ &\leq 0 \Leftrightarrow p \geq \frac{1}{N} + \frac{r}{N} \end{aligned} \quad (\text{A.14})$$

Thus, VAR^{WIG} decreases in r if and only if $p > \frac{1+r}{N}$. \square

Proof of Proposition 5 Let us first consider the set $P(N)$, i.e., the set of parameters (r, p) such that W is a right-stochastic matrix. The restrictions on the weights w_{ik} for a given $N \geq 3$ reduce to $P(N) = \{(r, p) \in [0, 1]^2 \mid \frac{r}{(N-1)^2} \leq p \leq 1 - \frac{r}{N-1}\}$. The requirement of a role-model's weight r to reduce CD introduces the additional restriction that $p > \frac{1+r}{N}$ (see Proposition 4). For $N \geq 4$ we have $Q(N) = \{(r, p) \in [0, 1]^2 \mid \frac{1+r}{N} < p \leq 1 - \frac{r}{N-1}\}$. In this case, the ratio $\frac{\int_{[0,1] \times [0,1]} \mathbb{1}_{Q(N)} d(r, p)}{\int_{[0,1] \times [0,1]} \mathbb{1}_{P(N)} d(r, p)}$ equals $\frac{(N-1)(2N(N-3)+3)}{N(2N(N-3)+3)+N(N-1)}$ which increases in N and equals $\frac{33}{56}$ for $N=4$. For $N=3$ we have $Q(N) = \{(r, p) \in [0, 1]^2 \mid r < \frac{4}{5}, \frac{1+r}{3} < p \leq 1 - \frac{r}{2}\}$. In this case, the ratio takes on the value of $\frac{32}{75}$. Thus, the share of parameters (r, p) such that VAR^{WIG} decreases in r is increasing in N . \square

Proof of Proposition 6 $\text{VAR}_t^{\text{WIG}}$ converges and stabilizes at a finite value, and we now study the impact of p on this limit: $\text{VAR}^{\text{WIG}} = \sigma^2 \left(1 + \frac{1}{N-1} \frac{\lambda_2^2}{1-\lambda_2^2} + \left(1 - \frac{1}{N-1} \right) \frac{\lambda_{N-2}^2}{1-\lambda_{N-2}^2} \right)$. Thus, the effect of the parameter p on VAR^{WIG} is determined by its influence on the eigenvalues. Note that both eigenvalues increase in p . However, the impact depends on the signs of λ_2 and λ_{N-2} . We distinguish three cases:

1. If $p < \frac{1}{N}$, then $\lambda_2 < \lambda_{N-2} < 0$. In this case, both eigenvalues increase in p while $\frac{\lambda_2^2}{1-\lambda_2^2}$ and $\frac{\lambda_{N-2}^2}{1-\lambda_{N-2}^2}$ decrease. Hence, VAR^{WIG} decreases.

2. If, on the other hand, $p \geq \frac{1}{N}$ and $0 \leq \lambda_2 < \lambda_{N-2}$, then both eigenvalues increase in p and also $\frac{\lambda_2^2}{1-\lambda_2^2}$ and $\frac{\lambda_{N-2}^2}{1-\lambda_{N-2}^2}$. Hence, VAR^{WIG} increases.
3. Finally, if, $p \geq \frac{1}{N}$ and $\lambda_2 < 0 \leq \lambda_{N-2}$, then both eigenvalues increase in p while $\frac{\lambda_2^2}{1-\lambda_2^2}$ decreases and $\frac{\lambda_{N-2}^2}{1-\lambda_{N-2}^2}$ increases. Thus, the effect on VAR^{WIG} depends on the strengths of the two opposing effects.

Note that $\lambda_2 = 0 \Leftrightarrow p = p_r$ (see Proposition 4), which defines the critical value for p .

Taking the derivative of VAR^{WIG} w.r.t. p yields the last claim.

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Declarations

Conflict of Interests The authors have no competing interests to declare that are relevant to the content of this article.

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