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REGULAR ARTICLE

# Skills, preferences and rights: evolutionary complementarities in labor organization

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**Abstract**
In this paper, we model the interaction between types of workers and organizations through evolutionary game theory. In particular, we compare two paradigms of work organization: in the "hierarchical" regime, it is the organization itself that makes all relevant decisions, leaving little autonomy to its employees. Conversely, modern "networks" empower their workforce with the right to take initiatives, modulate routines and use their general knowledge in an instrumental way. In our framework, the choice to decentralize decisions is driven by the interplay between three elements: the complexity of production, the employees' work preferences and skills and the labor-discipline implications of different organizational modes. By analyzing a series of match-specific effects, we derive parametrizations for which centralization dominates delegation and vice-versa. Explicit conditions under which the system remains stuck in Pareto-inferior situations are also obtained. Finally, we interpret our results to draw comments on the current contraction of job-discretion in OECD countries.

**Keywords** Skills · Organizational preferences · Work organization · Decision rights · Evolutionary games

**JEL classifications** C73 · L23 · M54 · J24

## 1 Introduction

The organization of labor underwent tremendous transformations in the past decades (Aoki 1995). Starting from the 80s, new work practices such as multitasking (Lindbeck and Snower 2000), horizontal communication (Aoki 1986) and autonomous teamworking (Kozlowski and Bell 2003) begun to spread, either in isolation or in

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clusters (Morita 2005). The steady increase of workplace autonomy (Caroli et al. 2001) is perhaps the most distinctive trait of this process of organizational change. Commonly provided explanations to this phenomenon include the increase in technological complexity and market instability (ivi), the influence of the Japanese organizational mode (Doeringer et al. 2003) and the workers' dissatisfaction with Taylor's (1911) principles of work organization[1] (O.E.C.D. 1972; Boltanski and Chiappello 2005: 167–200).

After this period of expansion, the trend towards autonomy came to a halt (Greenan et al. 2013; Green et al. 2016; Holm and Lorenz 2015). This fact is surprising, given that decentralized decision-making fares better in terms of productivity (Eurofound 2011; European Commission 2009) and innovation (Arundel and Lorenz 2007; Holm and Lorenz 2015). In addition, Aghion et al. (2016) show that organizations relying on job-discretion navigate economic downturns better than their centralized competitors.

The contraction of autonomy becomes even fuzzier once skills are allowed into the picture. As a matter of fact, the literature highlights a positive relation between the delegation of decision rights and the use of generic skills, such as social or influence skills or general problem-solving capabilities (Green et al. 2016). Holman and Rafferty (2018), for instance, find that job-discretion spreads out more rapidly within non-routine tasks, while Green (2012) shows that rising employee involvement accounts for many of the increases in the use of generic skills up to 2006. More broadly, many record an increase in the share of non-routine occupations (Reijnders 2018; Cortes 2017), while others notice that social skills attract a premium in the labor market (Green et al. 2016; Deming 2017). This seems to suggest a *strategic complementarity* between non-routine knowledge and delegation. How do we explain the decline of job-discretion within countries where non-routine occupations and skills are steadily increasing?

As of now, the literature relates this contraction to the deterioration of the economic environment (Holm and Lorenz 2015; Green et al. 2016), which worsened during the crises of 1990–1991 and 2007–2008. During periods of economic stagnation, both managers and entrepreneurs focus on short-term survival, and thus choose the organizational form that allows the greatest control over the knowledge-base of the firm.

In this paper, we explore theoretically the conditions that incentivise the delegation of decision rights in organizations. To do so, we develop a simple evolutionary game-theoretic model where individuals from two heterogenous populations (of workers and firms) randomly interact in production. In our framework, the choice to decentralize is driven by the interplay between three elements: the complexity of production, the employees' work preferences and skills and the labor-discipline implications of different organizational modes. By analyzing a series of match-specific effects emerging from the interaction between types of workers and organizations, we derive parametrizations for which centralization dominates delegation and vice-versa. Hereafter, we define a given effect as "match-specific" when it results from the idiosyncratic interaction between a given type of worker and a given type of organization.

The paper highlights two different explanations for the persistence of Pareto-inferior equilibria in organizational behavior. We conceptualize these scenarios as "evolutionary

[1] Braverman (1974) summarizes the philosophy of Taylorsim as follows: (*i*) dissociation of the labor process from the skills of the workers; (*ii*) separation of conception from execution, (*iii*) exploitation of this cognitive monopoly to control the mode of execution.

traps". The former applies to situations characterized by high levels of intraorganizational conflict, where organizations have no clear incentive to choose either of the organizational forms and thus randomize between the two. The latter pertains to cases where the system gravitates to stable-low path due to adverse initial conditions or poor equilibrium selection. This is similar to the poverty trap studied in growth theory (Carrera 2018) or the social poverty trap studied by Antoci et al. (2007).

The remainder of the paper is organised as follows. Section 2 presents the theoretical framework and reviews the literatures to which it relates. In section 3, we discuss the model's assumptions, while the topological and welfare properties are analyzed in section 4 and 5, respectively. Section 5 presents conditions for evolutionary traps to emerge. Section 6 concludes.

## 2 Theoretical framework

### 2.1 Related literature: Decision rights and organizational performance

The allocation of decision rights has major effects on organizational performance, and it has been studied by various strands of economic research. Team-theorists have long analyzed costly communication to compare the efficiency of centralized and decentralized structures of decision-making. A seminal reference in the field is Bolton and Dewatripont (1994). In another influential paper, Aoki (1986) suggests a complementarity between types of knowledge and organizational forms. More precisely, he postulates that organizations that concentrate decision rights place relative emphasis on codified knowledge, while those that delegate relies more on tacit skills and collective learning-by-doing. In the former, efficiency depends on the procedures that are formalized in what Nelson and Winter (1982: 99) call "the memory of an organization"; in the latter, on forms of know-how that are embodied in the workers' skills.

In frameworks of this sort, centralized organizations require employees to apply their specific knowledge to the procedures they *ex-ante* design. While deviations from these paths are not allowed, complying with daily duties is all that workers are asked to do. By contrast, employees working in decentralized organizations must perform their task-specific routines and additionally use their general knowledge to adapt to local circumstances. Hence, if general capabilities are unevenly distributed in the workers' population, the match-quality between types of organizations and employees significantly affects organizational performance.

Another stream of team-theoretic research focuses on the trade-off between adaptivity—fostered through decentralization—and coordination—fostered through centralization (Dessein and Santos 2006; Dewatripont 2006; Alonso et al. 2008; Rantakari 2008). This literature is indebted to previous works on the correlation between communication technology, human capital and decentralization—see Acemoglu et al. (2007) for a development. One of the key results of this research is that organizations that face high levels of technological complexity or market instability rely more on adaptivity than on coordination. Hence, workplace autonomy should diffuse in sectors that are close to the technological frontier. Both Acemoglu et al. (ivi) and Christie et al. (2003) find empirical support to this prediction.

Finally, agency-theorists study the effect of delegation on mechanism design and organizational compliance—see Mookherjee (2006) for a review. The main intuition is that delegation implies loss of control. This may induce agents the temptation to shirk, or, more simply, to undertake actions that differ from those that maximise their principals' objectives. The seminal reference in this case is Aghion and Tirole (1997).[2]

### 2.2 Related literature: Decision rights and workers' well-being

In the neighboring sciences, delegation has been studied from different perspectives. Both educational and personnel psychology focus on the correlation between autonomy in decision-making and individual behavior. The working hypothesis is that individuals react differently when empowered with decision rights. Put simply, while some may welcome autonomy as an opportunity to self-fulfil and get rid of hierarchical control, others may suffer from psychological distress, such as anxiety and fear of failure. Marton and Säljö (1976) use a qualitative study to assess students' approaches to learning and identify two types of learners, conceptualized as "deep" and "surface" learners. In their study, deep learners are characterized by an effort to understand the meaning of their assignment, while surface learners appear to be content with mastering the minimum knowledge to complete the task.

Felstead et al. (2015: 297) provide with a connection between this and the literature on delegation. By analyzing how person and job characteristics correlate with job satisfaction, they find that learning alignments between workers' dispositions and organizational requirements have a positive effect on workers' well-being. As such, they suggest that «new ways of working that give employees more autonomy in carrying out their work […] may be welcomed by those who have a readiness […] to learn, but resisted by those who do not». In this framework, individuals of the deep-learning type will be happier in decentralized organizations, while surface learners will be happier in centralized organizations. That delegation associates with high levels of employee learning is intuitive. Holm and Lorenz (2015) identify a particular form of work organization—which they call "discretionary learning"—in which delegation and deep-learning clearly complement each other.

Empirically, the effect of delegation on workers' well-being is still an open issue. Greenan et al. (2013) suggest that the decrease in the quality of working life in Europe over the decade 1995–2005 is related to the contraction of job-discretion. Similarly, Calapez et al. (2014) find that Scandinavian countries fare better in terms of job-satisfaction because workplace autonomy is above the rest of the EU for all groups of workers. This view is also supported by the advocates of the "empowerment effect", which claims that workplace autonomy improves intrinsic motivation and self-fulfilment (Handel and Levine 2004; Askenazy and Caroli 2006; Antonioli et al. 2009). Conversely, it is opposed by those who endorse the "sociotechnic" view, who maintain that complex organizations offering simple jobs have been transforming into simple organizations offering complex jobs (Dankbaar et al. 1997). In this view, workplace autonomy is positively correlated with more challenging and demanding

[2] For a paper analyzing the shirking-problem under centralization and delegation respectively, see Godlücke and Kranz (2012). For a classic treatment of the shirking-problem, see Shapiro and Stiglitz (1984) or Bowles (1985).

tasks. Empirical support to this conceptualization is given, for instance, by Brenner et al. (2004), who find a positive relationship between cumulative trauma disorders and the use of quality circles and just-in-time production. We shall refer to this mechanism as the "challenge effect".[3] The results from Felstead et al. (2015) partially reconcile these views by suggesting that the relative magnitude of these two effects may depend on the fit between individuals' and organizations' characteristics.[4]

Personnel psychologists and management scholars have long insisted on the importance of getting the right fit between individual and job characteristics (Kristof-Brown et al. 2005). Myriad studies show that worker well-being is positively correlated with labor productivity and organizational performance—see, for instance, DeNeve et al. (2019) and Bryson et al. (2017). This may either occur because higher satisfaction associates with higher morale, or because employees are more confident in performing tasks they feel compatible with their abilities. Support to these hypotheses comes from human relation theory (Strauss 1968) and from the literature on confidence management (Bénabou and Tirole 2003).

## 2.3 Contribution

Our paper relates to the above literatures in various ways. By focusing on the co-evolution of organizational forms and worker types, it highlights a series of match-specific effects. In our framework, an effect is defined as match-specific when it results from the idiosyncratic interaction between a given type of worker and a given type of organization.

First, it expands on Aoki's (1986) idea and inquiries into the complementarity between types of knowledge and organizations. To do so, it distinguishes between the specific ability to perform a task and the generic ability to communicate with others, take general decisions and adapt to local circumstances. In our framework, all types of organizations require the use of the former, while decentralized organizations require both.

To draw a link between this and the research on adaptivity, it further postulates that the productivity of generic knowledge increase with the complexity of production. As such, it describes scenarios in which centralization dominates decentralization and vice-versa.

Third, by drawing from the fields of educational and personnel psychology, it tries to fill a gap in the agency-theory of delegation. Agency-theorists have indeed abstracted from behavioral heterogeneity and addressed intraorganizational conflict as a general

[3] In a neighboring stream of research that investigates the evolution of work pressure in Europe Green/McIntosh, 2001; Gallie 2005; Green 2004), the introduction of high involvement practices have been sometimes found responsible for the reduction of working dead-times and for the increase in the physical and psychological pressure to which employees are exposed. In this view, workplace autonomy «is perceived as a strategy for co-opting workers into a managerial perspective in order to preserve hierarchical authority without bureaucratic control» (Antonioli et al. 2009) and it is invoked as the primary cause of work intensification in Europe. In this literature, however, these new work practices have been conceptualized as Neo-Taylorist, so that they are better understood as an extension of the classical hierarchical mode of coordinating employees rather than as an alternative to it. Hence, the "challenge effect" discussed in this paper should not be confused with the "intensification effect" highlighted in this literature.

[4] Personnel and industrial psychologists have also analyzed the correlation between autonomy *in teams* and job-satisfaction. For a review, see Van Mierlo et al. (2006).

issue. In our framework, the shirking-problem is match-specific: if there is a good fit between workers' dispositions and organizational requirements, workers provide labor services; if the fit is bad, they conversely try to shirk. The success of these shirking attempts, however, depends on the organization-specific effectiveness of the monitoring technology.

Finally, our study postulates that different skills associate with different preferences over work organization. In our framework, the "readiness to learn" investigated by Marton and Säljö (1976) and by Felstead et al. (2015) complements the ability to communicate, take general decisions and adapt to local circumstances. The idea is simple. If individuals have an appetite for learning—and thus, for delegation (ivi)—they must either possess or be willing to develop high levels of learning capabilities. In other words, if individuals welcome the opportunity to take autonomous decisions, they likely feel confident about their ability to solve the associated problems. That self-confidence and performance are positively correlated is something that has been already put forward by the literature on confidence management (Bénabou and Tirole 2003).

In sum, we have three types of match-specific effects: a cognitive effect, arising from the interaction between types of knowledge and allocations of decision rights; a technological effect, arising from the interaction between the cognitive effect and the environment in which it occurs; and a labor-discipline effect, arising from the interaction between workers' preferences, decision rights and monitoring effectiveness.

To our knowledge, our contribution is the first that uses an evolutionary game-theoretic model to study the delegation of decision rights in organizations. Standard modelling in the field includes principal-agent models (Mookherjee 2006) and team-theoretic models (Aoki 1986; Dessein and Santos 2006; Dewatripont 2006; Alonso et al. 2008; Rantakari 2008). In addition, while economists have mainly addressed the effects of delegation by focusing on firm performance only, we also consider its impact on job-satisfaction. As such, we provide with a bridge between the economic theory of delegation and complementary theories in the neighboring sciences.

## 3 The model

### 3.1 Skills, preferences and rights

Consider a model economy where large populations of organizations and workers (of mass 1) are randomly coupled to engage in production. Organizations are of two types: networks, denoted by $N$, and hierarchies, denoted by $H$, respectively occurring in the population with frequencies $0 \leq x \leq 1$ and $(1-x)$. Workers, in turn, are also of two types: knowledge-workers, denoted by $K$, and production-workers, denoted by $P$, respectively occurring in the population with frequencies $0 \leq y \leq 1$ and $(1-y)$.

In traditional hierarchies, it is the organization itself that makes all relevant decisions, leaving little autonomy to its employees. Conversely, modern networks empower their workforce with the right to take initiatives, modulate routines and use their general knowledge in an instrumental way. The first mode of coordination can be referred to as "centralized"; the second as "decentralized".

Workers enter the work relation with different preferences and skills. While both types of workers have the same level of task-specific knowledge, we assume that *K*-workers are also capable of using a positive level of generic skills, such as social or influence skills and general problem-solving capabilities. To keep the model open to different interpretations, we do not specify if this distinction arises from the *ex-ante* possession of different abilities or from different work-attitudes. In other words, workers may either vary in their general knowledge or in their *willingness* to use their general knowledge. In what follows, we shall refer to either of these perspectives interchangeably.

Drawing a link between preferences and skills, we assume that different human capitals associate with different preferences over work organization. More precisely, we assume that *K*-workers enjoy using their general knowledge and thus welcome the opportunity of taking decisions. As such, they experience a utility gain when empowered with decision rights. Conversely, *P*-workers prefer to work in less stressful environments, where routines are well-defined and the array of cognitive interpretations is minimised. This suggests a *strategic complementarity* between types of workers and organizations. See Felstead et al. (2015) for empirical support.

### 3.1.1 Workers

To model preferences over work organization, we assume that workers enjoy higher (resp., lower) payoffs when matched with an organization that fits (resp., misfits) with their organizational inclinations. More formally, we assume that *K*-workers have a psychological benefit $a > 0$ when matched with a *N*-organization and a psychological harm $-a$ when matched with a *H*-organization. Similarly, *P*-workers have a psychological benefit $b > 0$ when matched with a *H*-organization and a psychological harm $-b$ when matched with a *N*-organization. Besides capturing the workers' preferences over labor organization, $a$ and $b$ measure *how strongly* workers are affected by these preferences. The higher their values, the stronger the complementarity between types of workers and organizations. In what follows, we shall refer to this as generating an "alignment effect" between workers' dispositions and organizational requirements.

In addition to these subjective benefits and costs, there are also objective costs of working. We denote by $c^N > 0$ and $c^H > 0$ the effort-costs in networks and hierarchies respectively. Further, we assume $c^N > c^H$. This is to model the idea that increasing autonomy may raise the cost of action. Advocates of the sociotechnic view have indeed claimed that new work practices increases job complexity, and thus correlate with more challenging and demanding tasks (Dankbaar et al. 1997).

Considering both the objective and the subjective effects, the effort-cost of a *K*-worker employed in an *N*-organization is given by $-c^N + a$, while the effort-cost of a *K*-worker employed in an *H*-organization is given by $-c^H - a$. Similarly, the effort-cost of a *P*-worker employed in an *N*-organization is given by $-c^N - b$, while the effort-cost of a *P*-worker employed in an *H*-organization is given by $-c^H + b$.

Finally, we introduce an agency element in the model by assuming that misfits between workers and firms increase the level of intraorganizational conflict. More specifically, we assume that mismatched workers provide with lower efforts, though they do so decreasingly with the effectiveness of the monitoring technology. In formal terms, we assume that *K*-workers employed in *H*-organizations "discount" their effort level by a factor $0 \leq p^H \leq 1$, where $p^H$ measures the monitoring effectiveness in hierarchies. Thus, the expected cost of a $K$-worker employed in an $H$-organization is given by $-(c^H + a)p^H$.

Similarly, we assume that $P$-workers employed in $N$-organizations "discount" their effort level by a factor $0 \leq p^N \leq 1$, where $p^N$ measures the monitoring effectiveness in networks. The expected cost of a $P$-worker employed in an $N$-organization thus, is given by $-(c^N + b)p^N$. If $p^i = 1$, $i = H, N$, workers never shirk. If $p^i = 0$, $i = H, N$, workers always shirk.

The intuition is simple, though somewhat different from the classical shirking models à-la Shapiro and Stiglitz (1984) or à-la Bowles (1985). In these models, workers are fired when caught shirking, so that there exists a threshold value in the detection probability that compels the entire workforce to comply. Here, we assume that workers are capable of adjusting their commitment in response to variations in the detection probability. As such, they increase their effort when monitoring improves and decreases it when it deteriorates. In what follows, we shall refer to this as the "conflict effect".

Given the above assumptions, the workers' payoff matrix is given by (1), where workers are row players and organizations are column players. As anticipated, workers' payoffs depend on three elements: on the organization-specific costs of effort $c^N$ and $c^H$; on the workers' organizational preferences $a$ and $b$; and on the effectiveness of the monitoring technologies $p^N$ and $p^H$.

$$\begin{array}{lll} & \boldsymbol{N} & \boldsymbol{H} \\ \boldsymbol{K} & w - c^N + a & w - \left(c^H + a\right)p^H \\ \boldsymbol{P} & w - \left(c^N + b\right)p^N & w - c^H + b \end{array} \tag{1}$$

### 3.1.2 Workers: Remarks

From matrix (1), it is easy to check that the payoff of a $K$-workers employed in a $N$-organization is higher than the payoff of a $P$-workers employed in a $N$-organization if and only if the monitoring effectiveness in networks is above a critical threshold. When this is not the case, $P$-workers more than compensate their organization-specific disutility by reducing their effort. The same line of reasoning applies to $H$-organizations. When $p^H$ is below a critical threshold, the payoff of a $K$-workers employed in a $H$-organization is higher than the payoff of a $P$-workers employed in a $H$-organization, as $K$-workers more than compensate their organization-specific disutility by lowering their effort. In these cases, the "conflict effect" dominates the "alignment effect" and the complementarity between $K$-workers (resp., $P$-workers) and $N$-organizations (resp., $H$-organizations) is somehow reverted.

By subtracting the first entry of the second row of matrix (1) from the first entry of the first row of matrix (1), we calculate the payoff-difference between playing $K$ against $N$ and playing $P$ against $N$, which is given by:

$$\left(c^N + b\right)p^N - c^N + a \tag{2}$$

Similarly, by subtracting the second entry of the first row of matrix (1) from the second entry of the second row of matrix (1), we calculate the payoff-difference between playing $P$ against $H$ and playing $K$ against $H$, which is given by:

$$\left(c^H + a\right)p^H - c^H + b \tag{3}$$

Imposing (2) >0 and solving for $p^N$, we derive the threshold level of $p^N$ for which playing $K$ against $N$ dominates playing $P$ against $N$, which is given by:

$$p^N > \frac{c^N - a}{c^N + b} \tag{4}$$

Since $p^N$ is a strictly positive parameter, condition (4) is always satisfied when $a > c^N$, regardless of the level of $p^N$. In words, playing $K$ against $N$ always dominates playing $P$ against $N$ when $K$-workers' have strong preferences over work organization.

Similarly, imposing (3) >0 and solving for $p^H$, we derive the threshold level of $p^H$ for which playing $P$ against $H$ dominates playing $K$ against $H$, which is given by:

$$p^H > \frac{c^H - b}{c^H + a} \tag{5}$$

As above, since $p^H$ is a strictly positive parameter, condition (5) is always satisfied when $b > c^H$, regardless of the level of $p^H$. In words, playing $P$ against $H$ always dominates playing $K$ against $H$ when $P$-workers' have strong preferences over work organization.

When conditions (4) (resp., condition (5)) is satisfied, the effectiveness of the monitoring technology in networks (resp., hierarchies) is sufficiently high for the "alignment effect" to dominate the "conflict effect". Conversely, when conditions (4) (resp., condition (5)) is not satisfied, the effectiveness of the monitoring technology in networks (resp., hierarchies) is sufficiently low for the "conflict effect" to dominate the "alignment effect".

### 3.1.3 Organizations

Productivity gains are obtained differently in the two organizational forms, given the interplay between their mode of coordination and the workers' skills. While hierarchies command their employees to follow step-by-step procedures, networks allow theirs to modulate routines through the use of their general knowledge. As such, they enjoy higher payoff when matched with $K$-individuals. In addition, recall that the productivity of a $P$-worker (resp., $K$-worker) employed in an $N$-organization (resp., $H$-organization) decreases with the effectiveness of the monitoring technology, as lower efforts translates in lower productivity. This suggests that the above complementarity runs both ways, from workers to organizations and from organizations to workers.

To model the idea that networks outperform hierarchies in complex environments, and vice-versa, we let the productivity of general skills in networks increase with the complexity of production, while we let the productivity of specific skills in hierarchies to increase with the simplicity of production. The intuition is simple. By allowing employees to tailor their actions to local information, networks miss the gains from Smithian dexterity, and they do so increasingly when production becomes simpler. Similarly, by demanding workers follow step-by-step procedures, hierarchies miss the gains from adaptivity, and they do so increasingly when production becomes more complex. This is in line with the results from team-theory, which postulates a trade-off between adaptivity—fostered through decentralization—and coordination— fostered through centralization (Dessein and Santos 2006; Dewatripont 2006; Alonso et al. 2008; Rantakari 2008).[5]

In formal terms, we assume that the productivity of a $K$-worker employed in a $N$-organization is given by $s + g(1 - r)$, where $s > 0$ and $g > 0$ measures the productivity of specific and generic skills, respectively, and $0 \le r \le 1$ proxies the routinizability of production. In our framework, routinizability is an inverse index of productive complexity, as complex processes are assumed to be less routinizable and vice-versa. When $r = 1$, the process' complexity reaches a minimum, and the productivity of generic skills are nil; when $r = 0$, the process' complexity reaches a maximum, and so do the productivity of generic skills.

The productivity of a $P$-worker employed in a $N$-organization is given by $sp^N$, where $0 \le p^N \le 1$ measures the monitoring effectiveness in networks. In this case, there are two sources of incompatibility between workers of type $P$ and organizations of type $N$. One is of cognitive nature, and relates to the fact that $P$-workers are assumed to be either incapable or unwilling to use their general skills. The other is of disciplinary nature, and relates to the assumption that $P$-workers attempt to reduce their effort when employed in hierarchies.

Finally, the productivity of a $P$-worker employed in a $H$-organization is given by $s(1 + r)$, where the term $sr$ captures the gains from Smithian dexterity achieved through routinization. Similarly, the productivity of a $K$-worker employed in a $H$-organization is given by $s(1 + r)p^H$, where $0 \le p^H \le 1$ measures the monitoring effectiveness in hierarchies. Here, the incompatibility between workers of type $K$ and organizations of type $H$ is only of disciplinary nature. When $p^H = 1$ in fact, hierarchies get the same payoff whomever they hire and are thus insensitive to the random-matching procedure. This suggests a sort of "organizational resilience" of the hierarchical form.

$$\begin{array}{lll} & \boldsymbol{K} & \boldsymbol{P} \\ \boldsymbol{N} & s+g(1-r)-w & sp^N-w \\ \boldsymbol{H} & s(1+r)p^H-w & s(1+r)-w \end{array} \tag{6}$$

Given the above assumptions, the organizations' payoff matrix is given by (6), where organizations are row players and workers are column players. As anticipated, organizations' payoffs depend on three elements: on the productivity gains of specific and general skills, given by $s$ and $g$ respectively; on the routinizability of production $r$; and on the effectiveness of the monitoring technologies $p^N$ and $p^H$.

### 3.1.4 Organizations: Remarks

From matrix (6), it is easy to check that the payoffs of a $H$-organization hiring a $P$-worker are always higher or equal to that of a $N$-organization hiring a $P$-worker, since

[5] See Acemoglu et al. (2007) and Christie et al. (2003) for empirical support.

$s(1+r) \geq sp^N$ always. Conversely, the payoffs of a $N$-organization hiring a $K$-worker are higher than those of a $H$-organization hiring a $K$-worker if the complexity of production is above a critical threshold, or, which is the same, if routinizability is below a critical threshold. This follows from the fact that the productivity of general skills in networks are increasing in $r$, while the productivity of specific skills in hierarchies are decreasing in $r$. Recall that $0 \leq r \leq 1$ proxies the routinizability of production, which is assumed to be inversely related to its complexity. If $r$ is above the critical level, routinizability is high and complexity is low, and the productivity of generic skills less than compensate the losses from Smithian dexterity. In this case, playing $N$ is always dominated by playing $H$, that is, $H$ is the organizations' dominant strategy.

By subtracting the first entry of the second row of matrix (8) from the first entry of the first row of matrix (8), we calculate the payoff-difference between playing $N$ against $K$ and playing $H$ against $K$, which is given by:

$$s\left[1-(1+r)p^H\right] + g(1-r) \tag{7}$$

Imposing (7) > 0 and solving for $r$, we derive the threshold level of $r$ for which playing $N$ against $K$ dominates playing $H$ against $K$, which is given by:

$$r < \frac{g + s(1-p^H)}{g + sp^H} \tag{8}$$

Interestingly, when the effectiveness of the monitoring technology in hierarchies is low (formally, <1/2), playing $H$ against $K$ is always dominated by playing $N$ against $K$, regardless of the level of technological complexity.[6] In this case, the choice of the organizational form is not driven by efficiency considerations, but rather, by the inability of hierarchies of promoting what Nelson and Winter (1982: 110) call «a comprehensive truce in intraorganizational conflict». With condition (8), we have completed the static specification of the economy at any moment in time. The next step is to describe how the populations' composition may evolve over time under alternative parametrizations.

## 4 Dynamics

### 4.1 Replicator equations and strategy adoption

We model the diffusion of the $N$ and $K$ strategies in their respective populations via the standard replicator-dynamics derived by Taylor and Jonker (Jonker and Taylor 1978). The replicator-dynamics is a learning-by-imitation model that postulates that players are boundedly rational, they learn from each other, and they tend to adopt the strategy that performs better than the other. In this framework, relatively successful behaviors are replicated, while unsuccessful behaviors are abandoned.

[6] In formal terms, this occurs because $\frac{g+s(1-p^H)}{g+sp^H} > 1$ when $p^H < 1/2$, and since $r < 1$ by assumption, $r < \frac{g+s(1-p^H)}{g+sp^H}\Big|_{p^H<1/2}$ always.

The reason for assuming that both organizations and workers are boundedly rational is twofold. First, since the worker's level of generic skills cannot to be derived from their resumés or from their occupational history, organizations cannot infer the workers' types when selecting their personnel. In the same vein, as the features of work organization reveal through day-to-day interaction, workers cannot infer the organizational form when signing a labor contract. Hence, the random marching framework.

Recalling that the real variables $0 \leq x \leq 1$ and $(1-x)$ represent the shares of networks and hierarchies in the organizations' populations, we calculate the expected utilities to the $K$ and $P$ strategies from matrix (1), which are given, respectively, by:

$$U^K = \left(w - c^N + a\right)x + \left[w - \left(c^H + a\right)p^H\right](1-x)$$

$$U^P = \left[w - \left(c^N + b\right)p^N\right]x + \left(w - c^H + b\right)(1-x)$$

The utility differential of the two strategies writes:

$$U^K - U^P = c^H - b - \left(c^H + a\right)p^H + \left[-c^N + a - c^H + b + \left(c^H + a\right)p^H + \left(c^N + b\right)p^N\right]x$$

From which it is easy to derive the nullcline along which $U^K - U^P = 0$, the equation of which is given by:

$$x = \frac{-c^H + b + (c^H + a)p^H}{-c^N + a - c^H + b + (c^H + a)p^H + (c^N + b)p^N} \tag{9}$$

Recalling that the real variables $0 \leq y \leq 1$ and $(1-y)$ represent the shares of $K$ and $P$-players in the workers' populations respectively, we calculate the expected profits to the $N$ and $H$ strategies from matrix (6), which are given, respectively, by:

$$\Pi^N = [s + g(1-r) - w]y + \left(sp^N - w\right)(1-y)$$

$$\Pi^H = \left[s(1+r)p^H - w\right]y + [s(1+r) - w](1-y)$$

The profit differentials of the two strategies writes:

$$\Pi^N - \Pi^H = s\left(p^N - 1 - r\right) + \left\{s\left[1 - p^N + (1+r)\left(1 - p^H\right)\right] + g(1-r)\right\}y$$

From which it is easy to derive the nullcline along which $\Pi^N - \Pi^H = 0$, the equation of which is given by:

$$y = \frac{s(1 + r - p^N)}{s[1 - p^N + (1+r)(1 - p^H)] + g(1-r)} \tag{10}$$

Finally, the system's dynamics are given by:

$$\left\{ \dot{x} = x(1-x)\beta_1\left(\Pi^N - \Pi^H\right)\dot{y} = y(1-y)\beta_2\left(U^K - U^P\right) \right. \quad (11)$$

Where $\dot{x}$ and $\dot{y}$ are the time derivatives of $x$ and $y$ respectively and $1 \leq \beta_i \leq 0$, $i = 1, 2$ represent the shares of organizations and workers willing to switch their strategies by best-responding to payoff difference in the past. The $\beta_i$, $i = 1, 2$ parameters can be interpreted in two ways. First, they may capture switching costs between types of organizations and workers. Changing the organizational form may require specific investments in, say, personnel training and selection. In the same vein, it may be costly for individuals to change their organizational preferences or to acquire new skills, both in material and psychological terms. Second, $\beta_i$, $i = 1, 2$ may measure the resilience of cultural beliefs in both individual and organizational behavior. When managers are more of a command-and-control type, for instance, they may be unwilling to abandon the hierarchical form. Similar reasonings apply to workers.

The $x(1-x)$ and $y(1-y)$ terms on the r.h.s. of dynamics (11) represent the initial variance in the populations' composition. Observe that $x(1-x)$ and $y(1-y)$ reach a maximum for $x = 1/2$ and $y = 1/2$. Ceteris paribus, evenly divided populations will maximize the rate of change in $x$ and $y$. As usual with replicator dynamics, the time derivatives depend positively on payoff differences, so that a strategy will spread (resp., shrink) when the expected payoffs to that strategy are higher (resp., lower) than the expected payoffs to its alternative.

## 4.2 Taxonomy of dynamics regimes

Dynamics (11) is defined in the unit square $Q = [0, 1]^2$. As usual with replicator dynamics, all edges of the square are invariant[7] and the four vertices (0, 0), (0, 1), (1, 0) and (1, 1) where both populations are homogenous—they are both composed of one type only—are always stationary states. The game admits another stationary point in the interior of $Q$, which correspond to the intersections, when existing, of the nullclines defined by (9) and (10). In this equilibrium, $U^K - U^P = 0$ and $\Pi^N - \Pi^H = 0$. The coordinates of this point are given by:

$$(x^*, y^*) = \left( \frac{-c^H + b + (c^H + a)p^H}{-c^N + a - c^H + b + (c^H + a)p^H + (c^N + b)p^N}, \frac{s(1 + r - p^N)}{s[1 - p^N + (1 + r)(1 - p^H)] + g(1 - r)} \right)$$

At this state, organizations play strategy with frequency $x^*$ and strategy with frequency $1 - x^*$ and workers play strategy $K$ with frequency $y^*$ and strategy $P$ with frequency $1 - y^*$. Given the random matching, when both types of organizations and workers coexist in equilibrium, the latter are randomly split across the former. Further, by imposing $0 < x^* < 1$ and $0 < y^* < 1$, we see that $(x^*, y^*)$ may exist either when conditions (4), (5) and (8) simultaneously hold, or when conditions (8) is satisfied

[7] Meaning that all trajectories starting from an initial pair $(x_0, y_0) = (1, \hat{y})$, $(x_0, y_0) = (0, \hat{y})$, $(x_0, y_0) = (\hat{x}, 0)$ and $(x_0, y_0) = (\hat{x}, 1)$ will lie on the side with $x = 1$, $x = 0$, $y = 0$ and $y = 1$ respectively, where $0 \leq \hat{x} \leq 1$ and $0 \leq \hat{y} \leq 1$.

but (4) and (5) are not. Hence, a necessary condition for $(x^*, y^*)$ to exist is that productive complexity must be high.

To analyze the system's topological properties, we first calculate the Jacobian matrix, which is given by:

$$J = \begin{bmatrix} (1-2x)\left(\Pi^N - \Pi^H\right) & x(1-x)A \\ y(1-y)B & (1-2y)\left(U^K - U^P\right) \end{bmatrix}$$

As is well-known, the behavior of the system near an equilibrium point is related to the eigenvalues of the Jacobian matrix at that point. In $J$, we have defined $A \equiv s[1 - p^N + (1 + r)(1 - p^H)] + g(1 - r)$ and $B \equiv -c^N + a - c^H + b + (c^H + a)p^H + (c^N + b)p^N$. To avoid notational clutter, we have omitted $\beta_1$ and $\beta_2$, as they have no qualitative role in affecting the system's evolution Although they may either increase or decrease the rate of change, in fact, they cannot alter its qualitative course. By evaluating $J$ at each stationary point, we derive the topological properties of dynamics (11), which are summarized in the following Proposition:

**PROPOSITION 1** —*the stationary point* $(1, 0)$ *is never attractive. In particular, it is a source when condition* (4) *is satisfied and a saddle when is not. The* $(x^*, y^*)$ *stationary point exists if and only if no point is globally attractive. In addition:*

(i) *The* $(0, 0)$ *equilibrium is globally attractive when conditions* (5) *and* (8) *are satisfied but condition* (4) *is not; when conditions* (5) *and* (4) *are satisfied but condition* (8) *is not; and when condition* (5) *is satisfied and conditions* (4) *and* (8) *are not—see Fig. 1a.*[8]
(ii) *The* $(0, 1)$ *equilibrium is globally attractive when condition* (5) *and* (8) *are not satisfied—see Fig. 1b.*[9]
(iii) *The* $(1, 1)$ *equilibrium is globally attractive when condition* (5) *is not satisfied and conditions* (4) *and* (8) *are simultaneously satisfied—see Fig. 1c.*
(iv) *The* $(0, 0)$ *and* $(1, 1)$ *equilibria are locally attractive when conditions* (4), (5) *and* (8) *simultaneously hold. In this case, the* $(x^*, y^*)$ *equilibrium exists and it is a saddle point—see* fig. 2a.
(v) *The* $(x^*, y^*)$ *equilibrium is Lyapunov-stable when condition* (8) *is satisfied, while conditions* (4) *and* (5) *are not. In this case, all trajectories starting from initial pairs* $(x_0, x_0) \neq (x^*, y^*)$ *are close curves surrounding it in countercyclical oscillations, while all remaining critical points are saddles—see* fig. 2b.

Proposition 1 resumes the dynamic regimes that may be observed under dynamics (11). The first three regimes can be classified as monostable, as they depict situations in

[8] In particular, Fig. 1a visualizes the third of the cases listed in point (i) of Proposition 1, that is, when condition (5) is satisfied but conditions (4) and (8) are not.
[9] Fig. 1b visualizes the case where condition (4) is not satisfied either, as can be seen from the fact that (1, 0) is a saddle.

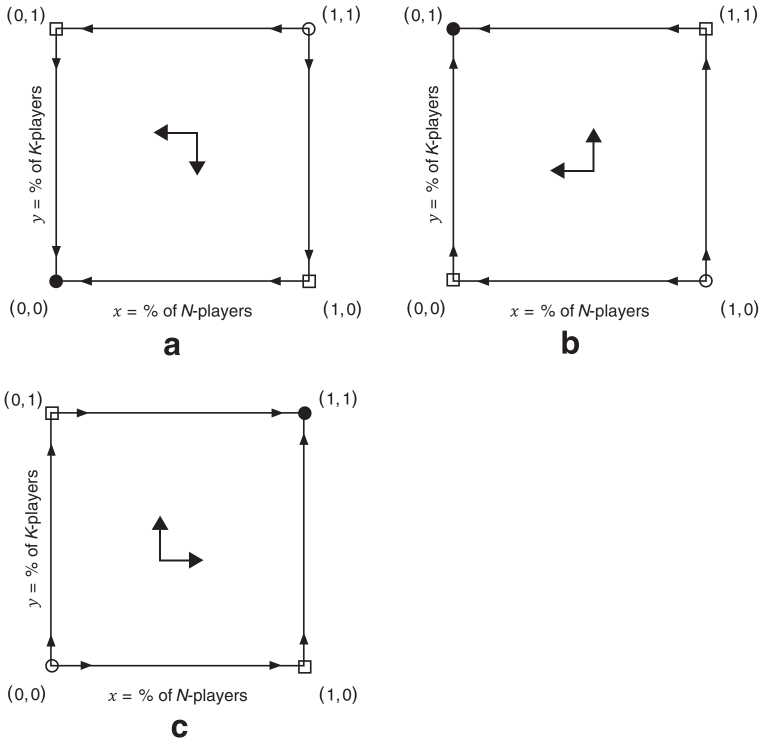


**Fig. 1** Phase portraits of replicator dynamics ( ) when the mixed strategy Nash equilibrium does not exist. Filled dots represent attractors; empty dots represent repellors (sources); empty squares represent saddle points.

which the game admits a single attractor. In all these cases, the system will eventually gravitate towards the global attractor regardless of initial conditions.

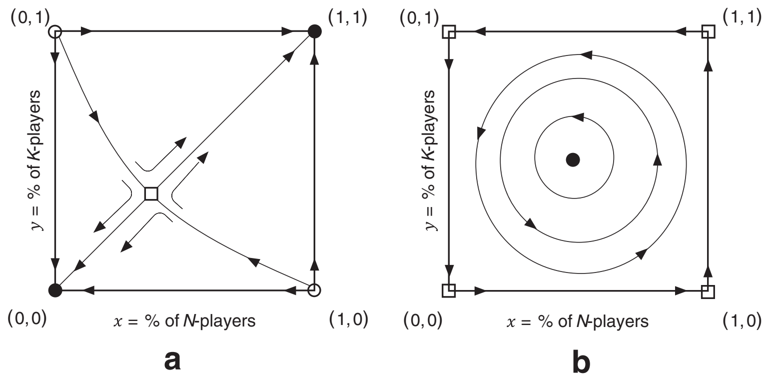


**Fig. 2** Phase portraits of replicator dynamics (11) when the mixed strategy Nash equilibrium exists. Filled dots represent attractors; empty dots represent repellors (sources); empty squares represent saddle points. In fig. 2a, the curve that connects the (0, 1) and (1, 0) sources is the stable manifold of the $(x^*, y^*)$ equilibrium, and it divides the basins of attraction of the (1, 1) equilibrium—represented by the area above the stable manifold—and of the (0, 0) equilibrium—represented by the area below the stable manifold

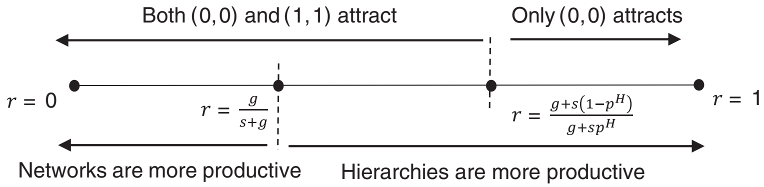


**Fig. 3** Complexity, productivity and stability

In the first of these cases, the (0, 0) equilibrium globally attracts under three alternative parametrizations. In the first and third parametrizations, condition (5) is satisfied but condition (4) is not, so that the monitoring effectiveness in hierarchies is high and the monitoring effectiveness in networks is low. As such, *P*-workers enjoy higher payoffs than *K*-workers in both hierarchies and networks and *P* is the workers' dominant strategy. When all workers are *P*-players, hierarchies have no incentives to switch to the *N*-form, as playing *N* against *P* is always dominated by playing *H* against *P*, regardless of the level of productive complexity. In the second parametrization, condition (8) is not satisfied, meaning that productive complexity is low. In this case, the productivity of general skills are low and playing *H* is the organizations' dominant strategy.

In the third of these cases, where (1, 1) is the global attractor and condition (4) is satisfied,

The second case, where (0, 1) is the global attractor, is a peculiar one. In this scenario, all organizations adopt the *H*-strategy and all workers adopt the *K*-strategy. This is due to the fact that condition (8) in not satisfied, so that productive complexity is low and playing *N* is always dominated by playing *H*. However, since condition (5) is also not satisfied, the monitoring effectiveness in hierarchies is low and playing *K* dominates playing *P*. Hence, the populations' composition in equilibrium.

In the third of these cases, where (1, 1) is the global attractor and condition (4) is satisfied, the monitoring effectiveness in networks is sufficiently high for *K*-workers to enjoy higher payoffs than *P*-workers, which ensures that the former have no incentives to switch to the *P*-strategy. Moreover, since condition (8) is also satisfied and productive complexity is high, the productivity of generic-skills are sufficiently high for *K*-workers to perform better than *P*-workers in networks. As such, the latter have no incentives to switch to the *H*-form. Finally, since condition (5) is not satisfied, playing *K* against *H* dominates playing *P* against *H*, so that *N* is the organizations' dominant strategy.

More interesting are the scenarios described in points (iv) and (v) of Proposition 1. In the first, the (0, 0) and (1, 1) equilibria simultaneously attract and the corresponding dynamic regime can be referred to as bistable. This occurs when conditions (4) and (5) simultaneously hold. In this case, both $p^N$ and $p^H$ are high and the "alignment effect" dominates the "conflict" effect in both organizations. In addition, since condition (8) is also satisfied in this regime, productive complexity is high and so are the productivity of generic skills, so that playing *N* against *K* dominates playing *H* against *K*.

The second of these regimes also requires a high level of productive complexity. Differently from the previous scenario however, conditions (4) and (5) do not hold. In this case, both $p^N$ and $p^H$ are low and the "conflict effect" dominates the "alignment effect" in both organizations. As job-satisfaction is higher for the mismatched than for the well-matched employees, all $K$-workers (resp., $P$-workers) employed in $N$-organizations (resp., $H$-organizations) have an incentive to switch their strategy. However, since playing $N$ against $K$ is more rewarding than playing $H$ against $K$ due to the high levels of productive complexity, organizations have no clear incentives for choosing either of the two organizational forms and thus randomize between $N$ and $H$. This scenario generates the cyclical or oscillatory behavior depicted in fig. 2b. There, the $(x^*, y^*)$ equilibrium is a center—i.e., is Lyapunov stable—and all deviations from $(x^*, y^*)$ are neither self-correcting nor self-enhancing.

Both the bistable and the cyclical regimes imply scenarios in which the system may remain stuck in an *evolutionary trap*. This occurs in situation when a critical state Pareto-dominates the others but the system converges to a low-level equilibrium. In the next section, we derive conditions for this to happen and discuss the implications on both productivity and job-satisfaction.

# 5 Evolutionary traps

## 5.1 Welfare

We study the welfare properties of the model in the most relevant regimes, that is, when the mixed-strategy Nash equilibrium exists and the system exhibits bistable or cyclical behavior. To measure job-satisfaction, we compare the workers' expected utilities $U^W$ at the relevant equilibria. The workers' expected utility are given by[10]:

$$U^W_{(1,1)} = w - c^N + a$$

$$U^W_{(0,0)} = w - c^H + b$$

$$U^W_{(x^*,y^*)} = \left[w - \left(c^N + b\right)p^N\right]x^* + \left(w - c^H + b\right)\left(1 - x^*\right)$$

Accordingly, we write the utility differentials as:

$$U^W_{(1,1)} - U^W_{(0,0)} = c^H - c^N + a - b \tag{12}$$

$$U^W_{(1,1)} - U^W_{(x^*,y^*)} = c^H - c^N + a - b - \left[c^H - b - \left(c^N + b\right)p^N\right]x^* \tag{13}$$

$$U^W_{(0,0)} - U^W_{(x^*,y^*)} = -\left[c^H - b - \left(c^N + b\right)p^N\right]x^* \tag{14}$$

[10] Observe that we have calculated $\Pi^W_{(x^*,y^*)}$ from the second row of matrix (1). By construction however, the expected payoffs to the $K$ and $P$ strategies are equal in the $(x^*, y^*)$ equilibrium, so we may have interchangeably calculated $\Pi^W_{(x^*,y^*)}$ from the first row of matrix (1).

Similarly, we measure productivity by comparing the organizations' expected profits $\Pi^O$ at the relevant equilibria. The organizations' expected profits are given by:

$$\Pi^O_{(1,1)}=s+g(1-r)-w$$

$$\Pi^O_{(0,0)}=s(1+r)-w$$

$$\Pi^O_{(x^*,y^*)}=\left[s(1+r)p^H-w\right]y^*+\left[s(1+r)-w\right]\left(1-y^*\right)$$

Accordingly, we write the profit differentials as

$$\Pi^O_{(1,1)}-\Pi^O_{(0,0)}=g-r(s+g) \quad (15)$$

$$\Pi^O_{(1,1)}-\Pi^O_{(x^*,y^*)}=g-r(s+g)+s(1+r)\left(1-p^H\right)y^* \quad (16)$$

$$\Pi^O_{(0,0)}-\Pi^O_{(x^*,y^*)}=s(1+r)\left(1-p^H\right)y^* \quad (17)$$

Comparing equations (12), (13) and (14) and equations (15), (16)and (17), we derive the welfare properties of the model, which are summarized in the following Proposition:

**PROPOSITION 2** —*The* $(x^*, y^*)$ *equilibrium is never Pareto-efficient, since* $\Pi^O_{(0,0)} > \Pi^O_{(x^*,y^*)}$ *always. Conversely, the* $(1, 1)$ *equilibrium is Pareto-efficient iff:*

$$-c^N+a>-c^H+b \text{ and } r<\frac{g}{s+g} \quad (18)$$

*while the* $(0, 0)$ *equilibrium is Pareto-efficient iff:*

$$-c^H+b>-c^N+a \text{ and } r>\frac{g}{s+g} \quad (19)$$

[11] As above, we have calculated $\Pi^O_{(x^*,y^*)}$ from the second row of matrix (6). By construction, the expected payoffs to the $N$ and $H$ strategies are equal in the $(x^*, y^*)$ equilibrium, so we may have interchangeably calculated $\Pi^O_{(x^*,y^*)}$ from the first row of matrix (6).

### 5.2 Results and discussion

From Proposition 2, five remarks are worth drawing. First, since the $(x^*, y^*)$ equilibrium is never Pareto-efficient, when the system exhibits cyclical behavior, it is always stuck in an evolutionary trap. In what follows, we shall refer to this as the "shirking trap", as it generates from a situation where the "conflict effect" dominates the "alignment effect" in both organizations. This is due to the interplay between ineffective monitoring and organizational preferences. In our framework, employees have inclinations over work organizations, and thus reduce their effort when organizationally mismatched. The success of these shirking attempts, however, depends on the effectiveness of the monitoring technology. If the latter is loose, shirkers have higher payoffs than compliers. In this case, the learning-by-imitation mechanism underlying the replicator dynamics predicts that shirking will become endemic, as compliers will imitate defectors by best-responding to payoff difference in the past. This entails that those who are organizationally well-matched will decide to cheat on the organization with which they are complementary when the latter fail to impede unsatisfied workers from shirking. In this case, the positive effect arising from the alignments between organizational requirements and workers' dispositions disappears. Hence, the first message of our study is that keeping labor discipline not only discourages shirking as an isolated phenomenon, but also prevents the latter from escalating. Mass behavior effects are not novel in behavioral sciences—see, for instance, Schelling (1978). When intra-group comparison is high, feelings of envy and procedural injustice likely spread and undermine positive intentions and intrinsic motivation. Chang and Lai (1999) provide with a social custom view on worker effort and show that conformity to social norms—work morale—is characterized by snowball behavior. Our result corroborates this view. In addition, it also suggests that the organizations' inability to keep labor discipline may frustrate other investments, such as those to improve the fit between individual and job characteristics.

Second, when the system exhibits bistable behavior and conditions (18) or (19) are satisfied, it may converge to a low-level equilibrium because of adverse initial conditions or poor equilibrium selection. In what follows, we shall refer to this as the "path-dependency trap". This is like the classical poverty trap studied in growth theory (Carrera 2018) or the social poverty trap studied by Antoci et al. (2007). In frameworks characterized by strategic complementarities, coordination failures due to bounded rationality may block players in Pareto-inefficient states. Consider the case where (0, 0) and (1, 1) locally attract but one of the two Pareto-dominates the other. If the shares of workers and organizations that choose the superior strategies are low, the system will eventually converge to the low-level equilibrium. This occurs when the initial shares $(x_0, y_0)$ lie within the basin of attraction of the Pareto-inferior equilibrium. More precisely, it occurs when the system's dynamics displays bistable behavior, condition (18)—resp., condition (19)—holds and $(x_0, y_0)$ is below (resp., above) the stable manifold of the $(x^*, y^*)$ equilibrium—see fig. 2a.

Third, when $-c^N + a > -c^H + b$ but $r > g/(s + g)$ or when $-c^H + b > -c^N + a$ but $r < g/(s + g)$, no equilibrium Pareto-dominates the others, as either of the two populations would be better off in another critical state. This also applies to situations that are not explicitly accounted for by Proposition 2. In particular, by comparing equations (12), (13) and (14), we see that the game admits parametrizations where workers enjoy higher payoffs in the $(x^*, y^*)$ stationary state than in the $(0, 0)$ or in the $(1, 1)$ equilibria. This is due to the distortion of intraorganizational conflict, as shirkers enjoy high utility-levels because of the low effectiveness of the monitoring technology.[12] In all these cases, the system exhibits examples of what may be called "non-symbiotic" evolution.

Fourth, by combining the results from conditions (8), (18) and (19), we see that the complexity of production plays a key role in our model, as variations in $r$ affects both the welfare and the topological properties of the system. Hence, our model generates different predictions if applied to countries, sectors or industries characterized by different levels of productive complexity. To check this argument, recall that condition (8) is always satisfied in both the bistable and the cyclical regimes, so that $r < [g + s(1 - p^H)]/(g + sp^H)$. In addition, observe that $g/(s + g) < [g + s(1 - p^H)]/(g + sp^H)$ always. With these facts in mind, it is easy to check that:

(i) When $r > \frac{g+s(1-p^H)}{g+sp^H}$, the $(0, 0)$ equilibrium is the global attractor of the system. In this scenario, hierarchies are more productive than networks;
(ii) When $\frac{g}{s+g} < r < \frac{g+s(1-p^H)}{g+sp^H}$, both the $(0, 0)$ and $(1, 1)$ equilibria are local attractors. In this scenario, hierarchies are more productive than networks;
(iii) When $r < \frac{g}{s+g}$, both the $(0, 0)$ and $(1, 1)$ equilibria are local attractors. In this scenario, networks are more productive than hierarchies;

We visualize this relationships in the following figure.

The fact that the $(1, 1)$ equilibrium attracts in the interval $g/(s + g) < r < [g + s(1 - p^H)]/(g + sp^H)$ despite being Pareto-inefficient is related to the low effectiveness of the monitoring technology in hierarchies. Indeed, despite networks are less productive than hierarchies in this interval, playing $N$ against $K$ dominates playing $H$ against $K$ because of the low value of $p^H$. Hence, our model suggests that intraorganizational conflict may distort the choice of the organizational form, as efficiency considerations on worker productivity may be biased by agency considerations on worker effort. This is consistent with the results of McElheran (2014), who show that delegation patterns are largely but not entirely consistent with standard predictions from team-theory, and call for a consideration of agency costs as well. In addition, the fact that $(1, 1)$ attracts when productive complexity is high is consistent with the team-theoretic research on adaptivity (Dessein and Santos 2006; Dewatripont 2006; Alonso et al. 2008; Rantakari 2008), which postulates that job-discretion should diffuse close to the technological frontier.

Finally, since we have assumed that $c^N > c^H$ to model the idea that workplace autonomy increases the cost of effort, a necessary condition for (18) to hold is that $a > b$. In words, the psychological utility that $K$-workers receive from working in $N$-organizations must be higher than the psychological utility that $P$-workers receive from working in $H$-organizations. Put differently, the $K$-workers' organizational preferences must be stronger than the $P$-workers'. This is consistent with the idea that workplace

[12] The possible Pareto-rankings of the relevant equilibria are multiple. However, the only cases that are Pareto-efficient for both populations are those reported in Proposition 2. The complete list of Pareto-rankings, along with the associated parametrisations, are given in the Appendix, which is available from the author upon request.

autonomy, albeit more demanding in terms of effort-costs, may improve intrinsic motivation and self-fulfilment. In the literature, this has been identified as the "empowerment effect" (Handel and Levine 2004; Askenazy and Caroli 2006; Antonioli et al. 2009). Our model suggest that if the "empowerment effect" dominates the "challenge effect", workers are better off in networks than in hierarchies.

## 6 Concluding remarks

The paper presents an evolutionary-game theoretic model to study the delegation of decision rights in organizations. To do so, it investigates the hypothesis that decentralized systems of workers' coordination coevolve with non-routine skills under the pressure of technological complexity. By analyzing three types of match-specific effects emerging from the idiosyncratic interaction between types of workers and organizations, it derives different levels of job-related well-being and organizational productivity and further identifies two types of evolutionary traps. In the former, which we have called the "shirking trap", organizations have no clear incentive to choose either of the organizational forms because of the distortion of intraorganizational conflict. The latter, which we have called the "path-dependency trap", is similar to other Pareto-inferior situations analyzed in the literature (Carrera 2018; Antoci et al. 2007) and emerges in contexts characterized by strategic complementarities.

More interesting for our purposes is the case that fits better with the available empirical evidence. As recalled at the beginning of this paper, workplace autonomy is losing momentum in the OECD countries (Green et al. 2016), with negative repercussion on workers' well-being (Greenan et al. 2013) and organizational performance (Holm and Lorenz 2015). Holm and Lorenz (ivi: 1180) argue that the decline in job-discretion «was a constraint on the transition to the knowledge-based economy in Europe, and was a largely unappreciated factor contributing to the disappointing performance in terms of achieving the Lisbon Agenda's overall goal of making Europe the most competitive and dynamic knowledge-based economy in the world». In this view, Western economies appear to be stuck into what we call the "path dependency trap", with firms disinvesting in job-discretion and workers enjoying decreasing level of job-satisfaction. In the context of our model, this indicates that conditions (4), (5) and (8) hold and the dynamics exhibits bistable behavior, that condition (18) holds and $(1, 1)$ Pareto-dominates $(0, 0)$ and that the system is converging to a low-equilibrium, namely, $(0, 0)$.

In providing with an explanation to this phenomenon, we expand on Holm and Lorenz (2015) and Green et al. (2016), who argue that the diffusion of hierarchical forms of work organization is countercyclical. During periods of economic stagnation, both trust and expectations deteriorate and managers enhance their control over the firm. In our framework, the learning-by-imitation mechanism underlying the replicator dynamics predicts that this affect how the workers' organizational preferences will evolve over time. Indeed, when hierarchies become dominant, employees will invest in the $P$-profile. The long-run implication of this mechanism of preference formation is that they will be discouraged from using their general knowledge at work. Should employers decide to re-invest in job-discretion and thus require their workforce to use their generic skills, workers will perceive that the implicit contract with their employers is breached and will thus engage in counterproductive work behaviors. As such, our model postulates that the contraction of job-discretion has a negative long-run effect on workers' dispositions.

Similar forms or cultural resilience may also influence the workers' behavior. If work morale is predominately low in, say, a country, workers of that country are less likely to invest in the *K*-strategy, as own-skill usage and proactivity are at odds with antagonistic work behaviors. Intuitively, workers of low morale may find it more appealing to follow step-by-step procedures than being asked to use their knowledge to find solutions to production problems themselves. This, in turn, will produce a similar effect to that analyzed above. Consider an organization that had initially picked the *N*-strategy. When it starts noticing that employees are unwilling to use their general knowledge at work, it will switch to the hierarchical form.

Countervailing cultural trends of this sort, of course, is not an easy task. On the one hand, as recalled by Green et al. (2016), job-design is largely a private matter between employers and employees. On the other hand, both skills and preferences take time to respond to economic incentives. As a preliminary hypothesis, we postulate that nurturing trust is vital to escaping the "path-dependency" trap. Providing employers and employees with a cooperative environment to interact may indeed discourage managerial shortermism and workers' hostility. In the same vein, helping organizations to design their environments to improve the fit between workers' dispositions and organizational requirements may have a positive effect on labor productivity.

Workers' organizations may play a key role in this mechanism. Indeed, they may either build a cooperative system of industrial relations or ask to get involved in job-design. The former channel is quite standard. The latter, in turn, indicates a novel direction for unions and work councils to express the workers' voice within organizations. Antonioli et al. (2009) find a robust linkage between working conditions, innovative work practices and cooperative industrial relations. This loosely suggests a complementarity between cooperative industrial relations and the diffusion of workplace autonomy.

Governments themselves may have a role in affecting job-design. As suggested by Green et al. (2016), they may encourage business leaders to invest in workplace autonomy by introducing organizational innovations in the public and semi-public sector. In this way, they may lead private organizations through best-practice and inspiration. As Scandinavian countries further demonstrate, governments can also advice firms on how to improve routine-design. In this view, forms of partnerships, dialogue and consultancy between industrial confederations, academic institutions and public commissions may create a positive environment for workplace autonomy to diffuse. In the long run, however, it is the quality of the public discourse that has the greater effect on matters of this sort. Hence, governments may attract public attention on how the unsatisfying performance of OECD countries correlates with the decline of job-discretion. Finally, ad hoc fiscal incentives may encourage firms to invest in organizational innovations.

To conclude with a skeptical note, all the policies mentioned above require time and political stability to be effective. The recent uprise of global populisms and neo-protectionism, along with the uncertainty deriving from Brexit, are likely to boost rather than inhibits the decline of job-discretion, with all the negative repercussions that this entails for both productivity and job-satisfaction.

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## Compliance with ethical standards

**Conflict of interest** none.

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