Working Paper no. **172**

Skills, preferences and rights: evolutionary complementarities in labour organisation

Stefano Dughera
University of Paris-Nanterre, University of Torino

December, 2019

Laboratorio R. Revelli, *Collegio Carlo Alberto*
Piazza Vincenzo Arbarello, 8 – 10122 Torino, Italy
Tel. +39 011 670.50.60
www.laboratoriorevelli.it - labor@laboratoriorevelli.it

Skills, preferences and rights:

evolutionary complementarities in labour organisation

STEFANO DUGHERA*

Abstract: The paper contributes to the literature on organisational change by analysing two competing paradigms of work organisation, where a "hierarchical" regime characterised by concentration of decision-making power is juxtaposed to a "network-like" regime where workers are entitled to modulate their productive activity via the delegation of decision rights. It does so by presenting an evolutionary game-theoretic model where heterogenous workers are matched with heterogenous organisations, within a framework where the existence of strategic complementarities between organisations and employees determine the latter's motivation and well-being, the efficiency of production and the stability of equilibria. Explicit conditions under which the system may remain stuck into what we call "an evolutionary trap" are derived, as to explain the observed persistence of sub-optimal equilibria in organisational behaviour and account for many of the empirical puzzles which seem to characterise nowadays' Western economies.

KEYWORDS: Motivation · capabilities· decision rights· evolutionary games

JEL CLASSIFICATIONS : C73 · L23 · M54 · J24

* Department of Economics and Statistics "Cognetti De Martiis", Università degli studi di Torino, Lungo Dora Siena, 100 A, 10153 Torino TO, s.dughera@unito.it.

1. Introduction

The organisation of labour underwent tremendous transformations in the past four-to-five decades (Lindbeck/Snower, 2000; Caroli et al., 2001). Starting from the mid-80s, Taylor's (1911) principles of work organisation[1] have been continuously challenged by the emergence and hybridization of alternative organisational forms (Aoki, 1995), whose unifying trait—among those which conversely distinguish each arrangement from one another—can be found in the steady increase of *decision rights* that organisations allocate to low-levels workers and, consequently, by high levels of on-the-job learning[2]. In this period, the choice to empower employees with control over their work methods—within the broader strategy of introducing high involvement practices at the plant-level—followed from the need of reaping productivity gains within a framework of increasing complexity and instability[3].

After this period of expansion though, the trend towards autonomy seems to have halted, if not reverted at all (Green et al., 2016; Holm/Lorenz, 2015). The fact is particularly puzzling considering that the literature on organisational change first theorised and then empirically proved that decentralised form of work organisation increase both productivity (Eurofound,

---

[1] Braverman (1974) summarises these principles as follows: (*i*) dissociation of the labour 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.

[2] Many other elements are, of course, involved in the renovation, from the way in which organisations allocate tasks—multiskilling vs specialization (Lindbeck/Snower, 2000)—to the information-processing procedures they adopt—horizontal vs vertical (Aoki, 1986). Model addressing the amply investigated complementarity between these other elements and job discretion include, but are not limited to, Morita (2005) and Dessein and Santos (2006).

[3] Two other sources of exogenous pressure are also worth recalling. From a "domestic" viewpoint, a significant discontent towards Taylor's paradigm begun to spread among Western workers starting from the late 50s. The loathing against a division of labour which was increasingly perceived as "authoritarian", "alienating" and "paternalistic" (Boltanski/Chiappello, 2005: 167-200) grew so intensively to culminate in a real "challenge to authority" (especially in Italy and France) which arose serious concerns in the entrepreneurial population (OECD, 1971). Reorganising firms thus, was not just a matter of productive efficiency, but it also addressed a "political" dilemma which was menacing to jeopardise profitability tout court. Simultaneously, the introduction of high involvement practices was also being stimulated by the comparison with the Japanese organisational mode, which has been the object of massive reference and explicit transplantation during the entire de-layering process. Interestingly, rather than transferring the Japanese practices as they were, Western organisations adapted the latter to their needs and business culture, thus stimulating a feedback mechanism which prompted their Japanese competitors to re-transfer some of their modified procedures in their setting (see Aoki, 1995). Doeringer et al. (2003) empirically surveyed the adoption of high-performance management in the West to conclude that this was severely restrained by the organisations' concern to maintain control over their workforce.

2011; European Commission, 2009) and innovation (Arundel et al, 2007)[4], especially when they are employed in occupations where the use of non-routine or generic knowledge—comprising social and influence skills and problem-solving capabilities in general—significantly affects the efficiency of production (Green et al., 2016). Holman and Rafferty (2018), for instance, find that job discretion spreads out more rapidly within non-routine tasks, while the evidence presented in Green (2012) shows that rising employee involvement account for many of the increases in the use of generic skills up to 2006[5]. As a working hypothesis then, it seems reasonable to conjecture that the diffusion of decentralised forms of work organisation may prompt workers to invest in the development of non-routine skills and, vice versa, that increases in the level of generic human capital may incentivise organisations to delegate decision rights, or, put differently, that there exists a *strategic complementarity* between non-routine knowledge and work decentralisation. How do we explain then, the decline in job discretion within environments where non-routine occupations and skills seem to be steadily increasing?

As of now and with reference to the European case, the literature advanced a preliminary though promising conjecture which relates this contraction to the exogenous deterioration of the outside economic environment (Holm/Lorenz, 2018; Green et al., 2016), which worsened during the crisis of 1991 and then—much more gravely—during the recession initiated in between 2007 and 2008. In this view, periods of economic stagnation stimulate the adoption of

[4] As regards the effect of new work practices on workers' well-being, a consensus is yet to emerge, both at the theoretical and at the empirical level. As of now, there are two contrasting interpretations. On the one side, there are the advocates of the "empowerment thesis", who maintain that workers benefit from autonomy as they enjoy higher levels of job satisfaction and own-skills exploitation (Handel and Levine, 2004; Askenazy and Caroli, 2006, Antonioli et al., 2009). On the other side, that are those supporting the "intensification thesis", who claim that job discretion entails substantial costs to workers, due to the reduction in working dead-times and to the exposure to greater degrees of psychological and physical pressures (Gallie, 2005; Green, 2004; Brenner et al., 2004).

[5] In addition, a great deal of research has highlighted a significant growth in the share of non-routine occupations over the last decades—see, e.g., Goos et al. (2014), Reijnders et al. (2018) and Cortes (2017)—while others have found that social skills attract a premium in the labour market—see, e.g., Green et al. (2016) for the UK and Deming (2017) for the US. While this evidence does not draw any explicit link between job-discretion and generic skills use, it however shows correlated phenomena which depict a favorable environment for both to proliferate.

work practices that are more command-oriented, as managers enhances their control over the knowledge-base of the firm—and thus, on its personnel—to focus on short-term survival. This is consistent with the evidence—but in contrast with the prescriptive business cycle management literature—according to which organisations cut down on investments while dealing with waves of economic downturn (Marginson/McAaulay, 2008), with all the negative repercussions that this entails for productivity and growth[6,7].

All in all, we believe that this evidence is convincing enough to inquire into the *evolutionary trap* which seems to be restraining the performance of those countries where job-discretion is now declining. In this paper, we explore theoretically the conditions which incentivise the adoption of work practices based on the diffusion of decision rights. 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 decentralise decisions is driven by the interplay between three elements: the first is of "environmental" nature and relates to the complexity (and thus, to the routinizability) of the labour process, the second refers to employees' work attitudes and skills and the third to the governance implications of different organisational structures.

The paper highlights two different explanations for the persistence of Pareto-inferior equilibria in organisational behaviour. The former applies to situations characterized by high levels of intraorganisational conflict[8]. Partial delegation, in this framework, emerges as a quasi-stable—but Pareto-inferior—outcome in response to the worker's defective behaviour. The latter pertains to cases where the system gravitates to stable-low path due to adverse initial

[6] Holm and Lorentz (2018: 1179-1180) indicate the decline of job discretion as « 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 capable of sustainable economic growth with more and better jobs and greater social cohesion" ».

[7] To the best of our knowledge, Aghion et al. (2016) is the only study which analyses empirically which organisational form is best-equipped to survive to periods of economic instability. Notably, the study suggests that decentralised organisations navigate economic downturns better than their more centralised competitors.

[8] For a definition and associated discussion, see Nelson and Winter (1982: 111). For a classical treatment of the role of the shirking problem in organisations see Shapiro and Stiglitz (1984) and Bowles (1985).

conditions or poor equilibrium selection. This is very much like the classical poverty trap studied in growth theory[9].

The remainder of the paper is organised as follows. Section 2 briefly presents the theoretical framework and reviews the associated literature. In section 3, we discuss the model's assumptions and study its Nash-equilibria, the topological and welfare properties of which are analysed in section 4 and 5 respectively[10]. Section 6 concludes.

2. Related literature and theoretical framework

The choice of delegating or centralise decisions continuously attracted the attention of economists, both theoretically and empirically[11]. Seminal references in the field include, but are not limited to, Williamson (1976)—who highlighted the limits to hierarchical control due to bounded rationality—Jensen and Meckling (1990)—who were among the first to recognise that the right to decide is best allocated towards the knowledge which is most valuable to any specific decisions—and Aghion and Tirole (1997)—who investigated the pitfalls of delegation in terms of a real versus formal authority dilemma. The concerns expressed by these authors—among the others—reveal the existence of two separate problems at the heart of the matter, either of which relates to a specific strand of research.

From a team-theoretic perspective, the key point of delegation concerns the comparative informational efficiency of different communication structures (see e.g., Aoki, 1986). This, in turn, calls for a consideration of the amply investigated trade-off between adaptivity—enhanced through decentralisation—and coordination—enhanced through centralisation (see e.g. Dessein/Santos, 2006). A key theoretical prediction of this literature is that delegative organisations should optimally proliferate in sectors which are close to the technological

---

[9] For an evolutionary analyses of poverty traps, see the model in Carrera (2018). For other evolutionary models inquiring into the existence of "social poverty traps" in social capital accumulation and social interactions see Antoci et al. (2007) and Antoci et al.(2018b)

[10] The organisation of the model is borrowed for Antoci et al. (2018a).

[11] For a review of the empirical literature, see Gibbons and Roberts (2012).

frontier and, more generally, within environments characterised by high levels of complexity and/or instability[12].

From the viewpoint of contract-theory, on the other hand, the key point is to understand how delegation affect the design of optimal incentives, and thus call for the consideration of different agency costs—for a review, see Mookherjee (2006).

Our paper contributes to this literature in several ways. First, it draws a clear-cut link between worker's autonomy and the use or development of generic-skills, thus suggesting the existence of a *strategic complementarity* between the two. While this is something that already found preliminary support in the relevant empirical literature, to the best of our knowledge, ours is the first contribution which tackles the issue theoretically[13]. Second, by drawing from the framework presented in Felstead et al. (2015), it allows for the possibility that learning dispositions may be more or less well-matched to the learning requirements of different organisations and this, in turn, permits our model to derive conditions supporting both the "intensification" and the "empowerment" thesis, as both have found empirical endorsement in the empirical literature—see footnote 4. Finally, it tries to keep an eye on the governance of organisations by taking the position that misfits between the learning dispositions and requirements may result in an outburst of intraorganisational conflict.

3 The model

[12] Both Acemoglu et al. (2007) and Christie et al. (2003) find empirical support to this prediction, while McElheran (2014) more generally demonstrated that delegation patterns are largely consistent with all predictions from team-theory, though some of her findings—like the negative correlation between delegation and firm size—suggest that agency costs also play a role in determining the organisational form. Interestingly, her study shows that delegation is a matter of degree, as actual firms are neither entirely centralised nor decentralised. This is also consistent with the rich findings of Katayama et al. (2018), who use a latent-class model to identify four different authority/communication structures.

[13] Incidentally, this also provides with a rationale to criticise a knowledge-hierarchical approach *à-la* Garicano (2000), where the agents of an organisation are given the authority to decide according to an exact correspondence between their skills and the problems to be solved in production. While this correspondence may exist when dealing with well-identifiable pieces of expertise—regardless of their level of specific complexity—this is more arguable when dealing with more opaque skills that are not that easy to identify, such as social or influence skills and the likes.

3.1 Assumptions and payoffs

Consider a model economy where large populations of organisations and workers (of mass 1) are randomly coupled to engage in production. Organisations are of two types: networks (N)—who diffuse decision rights— and hierarchies (H)—who concentrate decision rights—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 (K) and production-workers (P), respectively occurring in the population with frequencies $0 \leq y \leq 1$ and $(1 - y)$.

We assume that the ability to carry out a specific task or set of tasks ($s > 0$) is evenly distributed across the population. This may be viewed as indicating that workers have the same educational level and/or formal training. In addition, we assume that K-workers are also endowed with non-routine or generic skills ($g > 0$), or, for what matters, that they are willing to exploit them on the job. This assumption allows our model to apply "orthogonally" to the occupational spectrum, or better, to apply homogenously at every level of specific human capital. Indeed, we are not distinguishing between high and low skills—and thus comparing jobs which are located at different layers of the occupational ladder—but rather, between the ability (or willingness) to use non-specific skills and the inability (or unwillingness) to do so[14]. To keep the model open to different interpretations, we do not specify the nature of this distinction, as this may arise from the *ex-ante* possession of different skills (workers vary in their general knowledge), from different work-attitudes[15] (workers vary in their *willingness* to use their general knowledge) or from different ways in which abilities grow through learning-by-doing. Hereafter then, we shall refer to either of these three perspectives interchangeably.

[14] As previously anticipated, we adopt a broad understanding of "general knowledge", as we allow the latter to include the capability to adapt one's action to local information, to engage in exercises of social intelligence, to think creative and out of the box and the likes.

[15] With this respect, Williamson et al. (1975: 266) draw an insightful distinction between "perfunctory" and "consummate" cooperation: « consummate cooperation is an affirmative job attitude-to include the use of judgment, filling gaps, and taking initiative in an instrumental way. Perfunctory cooperation, by contrast, involves job performance of a minimally acceptable sort ».

Observe that the assumption that workers are equivalent in terms of educational attainments—and, complementarily, that non-routine skills are largely unrelated to the latter—forcedly implies that organisations cannot ascertain their type during the matching procedure. In addition, we also introduce the reasonable restriction that workers are unable to foresee the degree of organisational flexibility while entering into an employment relation—hence, the random-matching framework[16].

Productivity gains are obtained differently in the two organisational forms, according to the interplay between their modes of coordination and the degree of environmental complexity. More specifically, we assume that hierarchies concentrate decision rights and provide workers with standardized procedures to carry out tasks (centralised coordination), while networks provide employees with the flexibility to exploit their general knowledge and tailor their actions to local information (decentralised coordination). In the latter environment then, workers are exposed to greater learning possibilities, which may raise their effort cost but also provides them with greater job-satisfaction.

To model the amply consolidated idea that networks outperform hierarchies in complex environments and vice-versa, we let the returns to general (specific) skills in networks (hierarchies) to be decreasing (increasing) in the $0 \leq \rho \leq 1$ parameter, with which we capture the routinizability of production—see matrix (1) below[17]. In the dynamic analysis to follow,

[16] It may be useful to provide with an example in support of both of these assumptions, as they are key to the functioning of an evolutionary-game-theoretic mode like ours. Consider an academic organisation employing students as new PhD candidates. At the end of the first phases of the selection process, after the committees evaluated all applicants on the basis of their cv, short interviews and the likes, imagine that a handful of students is still competing for the open positions. It seems reasonable to assume that these students will be very similar in terms of their previous academic achievements, of the quality of their research proposals and so forth. This boils down to assume that they will be fundamentally affine in terms of their task-specific skills, which does not rule the possibility, however, that they may differ in their non-routine knowledge, with the universities having no instruments to deduce the latter from the data at their disposal. In the academic metaphor, generic skills include, but are not limited, the capability of building connections within and outside the academia (social and influence skill), of opening avenues for novel and interdisciplinary research (creativity), of reacting constructively when facing a research impasse (general problem-solving) and so forth. Similarly, if students are competing for more than one positions simultaneously, they cannot know ex-ante in which university they will be empowered with the greater research freedom (decision rights), nor they can foresee which environment will provide them with the greatest learning incentives (learning requirements).

[17] As such, ρ turns out to be an inverse index of the environment's complexity, with the upper and lower bound

this will allow us to identify a threshold value of ρ beyond which networks are more efficient than hierarchies and vice versa—see condition (5) below.

Workers receive a uniform wage $w > 0$ and provide labour services at an objective cost $e_N > e_H > 0$, where e_N and e_H are the costs of effort in N and H organisations respectively. The assumption $e_N > e_H$ is in line with the idea expressed by the advocates of the "intensification thesis" (Handel and Levine, 2004; Askenazy and Caroli, 2006, Freeman/Claimer, 2000) according to whom new work practices—albeit more empowering in terms of learning achievements—substantially increase the level of physical and psychological pressure workers are exposed to[18].

To allow for the possibility that workers may enjoy different levels of job-related well-being depending on the correspondence between their learning dispositions and the organisational features, we draw from the framework presented in Felstead et al. (2015) and assume explicit connections between workers' types and the learning requirements of our heterogenous organisations. More specifically, we assume that those who are endowed with (or are willing to use) general capabilities enjoy working in firms which allow the exploitation and development of the latter—learning disposition: deep; learning requirement: expansive—while those who are devoid of (or are unwilling to use) non-routine skills conversely enjoy being employed in less learning-intense organisations—willing disposition: surface; learning requirement: restrictive. As such, we assume that those who face a learning (mis)match, benefit (suffer) from a utility gain (loss). This is modelled by introducing the $\gamma_i \geq 0, i = K, P$ parameters in the workers' utility-function, so that the utility of K-workers (P-workers) increases by γ_K (γ_P) when she is matched with an N (H) organisation and decreases by γ_K(γ_P) when she is matched with an H (N) organisation. Further, we assume $\gamma_K > \gamma_P \geq 0$ to

---

$\rho = 1$ and $\rho = 0$ indicating perfect routinizability and highest complexity respectively.

[18] Although the assumption $e_N > e_H$ does not affect the dynamics of the game, it will be handy for the welfare analysis carried out later

incorporate the hypothesis tested by Felstead et al. (2015) according to which deep-learners are more sensitive to the fit between their attitudes and the organisational environment and thus incur in higher benefits and costs as a consequence to the matching procedure[19]. The extreme case in which $\gamma_P = 0$ also carries an economically meaningful idea, that is, that P-workers do not hold any preference over work organisation—i.e., their motivation is purely extrinsic and invariant across the two organisational forms.

Finally, we introduce an agency flavor in the model by taking the position that those who suffer from organisational mismatch strive to increase their well-being by economizing on their effort, and they do so proportionately to the magnitude of their organisation-specific disutility. The effectiveness of such attempts, of course, depends on the efficiency of the monitoring technology. The interplay between these two elements—see Appendix A for further elaboration—determines the actual level of compliance within the organisation and thus, the effort-discounting rates $0 \leq \delta_1 \leq 1$ and $0 \leq \delta_2 \leq 1$ to which workers are actually capable of reducing their effort, where δ_1 relates to K workers shirking in H organisations and δ_2 relates to P workers shirking in N organisations. Obviously, the lower the values of δ_1 and δ_2, the lower the effort and the associated disutility.

Given the above, the organisations' payoff matrix writes:

	K	**P**
N	A_1	A_2
H	B_1	B_2

=

	K	**P**
N	$s + g(1-\rho) - w$	$s\delta_2 - w$
H	$(1+\rho)s\delta_1 - w$	$s(1+\rho) - w$

(1)

with $s > 0$, $g > 0$, $0 \leq \rho \leq 1$.

[19] As for the assumption $e_N > e_H$, the assumption $\gamma_K > \gamma_P \geq 0$ does not affect the dynamics of the game, although it yields some interesting implications for the welfare properties of the model.

The workers' payoff matrix results in:

	N	H			N	N	
K	C_1	C_2	=	K	$w - e_N + \gamma_K$	$w - (e_H + \gamma_K)\delta_2$	(2)
P	D_1	D_2		P	$w - (e_N + \gamma_P)\delta_1$	$w - e_H + \gamma_P$	

with $w > 0, e_i > 0, \gamma_j \geq 0$ and $0 \leq \delta_k \leq 1$, with $i = 1, 2$, $i = 1, 2$ and $i = 1, 2$.

3.2 Existence, uniqueness and multiplicity of Nash equilibria

Following the structure of the model proposed in Antoci et al. (2018a), we first identify conditions under which the game admits a unique equilibrium. To do so and without loss of generality, we substitute matrixes (1) and (2) with the following normalized matrixes:

	K	P			K	P	
N	A	0	=	N	$s(1-\delta_1) + g - \rho(g + s\delta_1)$	0	(3)
H	0	B		H	0	$s(1 + \rho - \delta_2)$	

	N	H			N	N	
K	C	0	=	K	$\delta_1(e_N + \gamma_P) - e_N + \gamma_K$	0	(4)
P	0	D		P	0	$\delta_2(e_H + \gamma_K) - e_H + \gamma_P$	

Observing that $B > 0$ always and:

$$A > (<) 0 \Leftrightarrow \rho < (>) \frac{s(1-\delta_1) + g}{g + s\delta_1} \equiv \rho^* \tag{5}$$

$$C > (<) 0 \Leftrightarrow \delta_1 > (<) \frac{e_N - \gamma_K}{e_N + \gamma_P} \equiv {\delta_1}^* \tag{6}$$

$$D > (<) 0 \Leftrightarrow \delta_2 > (<) \frac{e_H - \gamma_P}{e_H + \gamma_K} \equiv {\delta_2}^* \tag{7}$$

Next, we derive conditions under which the game admits a unique Nash-equilibrium. In particular, the equilibrium is:

$$(H, P) \text{ if } \delta_2 > {\delta_2}^* \tag{8}$$

$$(H, K) \text{ if } \rho > \rho^* \text{ and } \delta_2 < {\delta_2}^* \tag{9}$$

$$(N, K) \text{ if } \rho < \rho^* \text{ and } \delta_1 > \delta_1^* \tag{10}$$

Interestingly, as $B > 0$, the (N, P) equilibrium can never be classified as Nash, so that N is always weakly dominated by N. In addition to the three Nash-equilibria in pure-strategy, the game admits a single mixed-strategy Nash-equilibrium with $0 < x^* < 1$ and $0 < y^* < 1$. The coordinates of such an equilibrium are given by:

$$(x^*, y^*) = \left(\frac{\delta_2(e_H + \gamma_K) - e_H + \gamma_P}{\delta_2(e_H + \gamma_K) - e_H + \gamma_P + \delta_1(e_N + \gamma_P) - e_N + \gamma_K}, \frac{s(1 + \rho - \delta_2)}{s(2 - \delta_1 - \delta_2) + g - \rho[g + s(1 + \delta_1)]}\right) \tag{11}$$

In the (x^*, y^*) equilibrium, organisations play strategy N with frequency x^* and strategy H with frequency $1 - x^*$ and workers play strategy K with frequency y^* and frequency P with frequency $1 - y^*$. As usual with random-matching models, when both types of organisations and workers coexist in equilibrium, the latter are randomly split across the former, as the contrary would require some form of assortative matching—which may stem from on-the-job search and/or selective recruitment—which badly fits with the framework presented in here. The conditions of existence of the (x^*, y^*) equilibrium write:

$$\rho < \rho^* \text{ and } \delta_1 > \delta_1^* \text{ and } \delta_2 > \delta_2^* \tag{12}$$

$$\rho < \rho^* \text{ and } \delta_1 < \delta_1^* \text{ and } \delta_2 < \delta_2^* \tag{13}$$

If condition (13) holds, no other Nash-equilibrium exists. Conversely, if condition (12) holds, the game admits two other Nash-equilibria, (H, P) and (N, K) respectively.

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 originally derived by Taylor and Jonker (1978). The main assumptions behind this kind of selection-mechanism relates to the players' bounded rationality and to their capability of learning-by-imitation. As often recalled in the literature (see e.g., Rowell et al., 2006), there are two alternative ways for understanding such imitative behaviours. In the most classical view, we have populations of pure-strategist who periodically review their choice of action to adopt that which proved the most successful in the past. In the alternative view, we have populations of mixed-strategists who vary the frequency with which they select certain decisions on the basis of them comparing the latter to the choices of their fellow-players. In what follows, we shall stick to this two interpretations interchangeably. This allows for the economically reasonable possibility that organisations delegate only a fraction x of their decision-making power, while retaining the remainder $1 - x$ at the top of hierarchy. Similarly, workers may invest only partially in the acquisition of generic knowledge, or—which is the same—they may not be entirely willing to use it on-the-job.

Recalling that N and H players occur in their population with frequencies $0 \leq x \leq 1$ and $(1 - x)$ respectively, while K and P players occur in their population with frequencies $0 \leq y \leq 1$ and $(1 - y)$ respectively, we derive each strategy's expected payoffs from the normalized matrixes (3) and (4). The expected profits of networks and hierarchies write:

$$\Pi^N = Ay = [s(1-\delta_1) + g - \rho(g + s\delta_1)]y \tag{14}$$

$$\Pi^H = B(1-y) = [s(1+\rho-\delta_2)](1-y) \tag{15}$$

while the expected utility of knowledge and production-workers write:

$$U^K = Cx = [\delta_1(e_N + \gamma_P) - e_N + \gamma_K]x \tag{16}$$

$$U^P = D(1-x) = [\delta_2(e_H + \gamma_K) - e_H + \gamma_P](1-x) \tag{17}$$

The system's dynamics are given by:

$$\begin{cases} \dot{x} = x(1-x)\beta_1(\Pi_N - \Pi_H) \\ \dot{y} = y(1-y)\beta_2(U_N - U_H) \end{cases} \tag{18}$$

where $\dot{x}$ and $\dot{y}$ are the time derivatives of x and y respectively and the frequencies $1 \leq \beta_1 \leq 0$ and $1 \leq \beta_2 \leq 0$ represent the share of organisations and workers who are in "updating mode" (see e.g. Bowles, 2006: 71-75), that is, who are willing to switch their strategy if the latter proves less rewarding than its alternative. As usual in fact, the growth rate of the share of population adopting a certain strategy is proportional to the difference between the expected payoff of that strategy and the expected payoff of its alternative, as players are assumed to imitate (abandon) (un)successful behaviours according to payoff differences in the past. In the dynamic analysis to follow, we shall proceed as if $\beta_i = 1, i = 1, 2$, which is to say, as if all the agents in both populations are apt to modify their behaviour through imitation. In the conclusions however, we shall return on the role of such parameters in influencing the system's evolution. As a matter of fact, there are several elements which may influence—or, more precisely, lower—the values of β_i , $i = 1,2$[20].

[20] The existence of switching costs between the two alternative strategies, for instance, is likely to reduce or even arrest the pace of evolution. Liabilities of this sort include—but are not limited to—purely economic costs of reorganisation for firms and cultural costs for employees and managers characterised by strong intrinsic

4.2 Taxonomy of dynamics regimes

The system's dynamics described in (18) is defined in the unit square $Q = (0,1)^2$. As usual with replicator dynamics, all edges of the square are invariant[21] and the four vertices $(0,0)$, $(0,1)$, $(1,0)$ and $(1,1)$—corresponding to the equilibria (H,P), (H,K), (N,P) and (N,K) respectively—are always stationary states. In equations (8), (9) and (10) we already highlighted the conditions under which the game admits a unique Nash-equilibrium. The corresponding monostable regimes are depicted in fig. 1. More interesting, for our purposes, are the cases in which the mixed-strategy Nash-equilibrium (x^*, y^*) also or exclusively exists, which occur when conditions (12) or (13) are respectively satisfied. More precisely:

PROPOSITION 1—*When the mixed-strategy Nash-equilibrium* (x^*, y^*) *exists—see conditions* (12) *and* (13)*—with* $0 < x^* < 1$ *and* $0 < y^* < 1$*, then*:

(i) *The system exhibits bistable behaviour if condition* (12) *holds. In this case, the equilibrium* (x^*, y^*) *is a saddle and separates the basins of attraction of the two stable equilibria* (H,P) and (N,K) *located at the* $(0,0)$ *and* $(1,1)$ *vertices respectively (see fig. 2a).*

(ii) *The system exhibits cyclical behaviour if condition* (13) *holds. In this case, the equilibrium* (x^*, y^*) *is Lyapunov-stable and all trajectories starting from initial pairs* $(x_0, y_0) \neq (x^*, y^*)$ *are close curves surrounding it in countercyclical oscillations (see fig. 2b)*

Proposition 1 resumes the more interesting regimes that may be observed under dynamics (18), the ones in which different forms of evolutionary traps may spontaneously emerge (see section 5 below). To fully characterise the existence and implications of these

dispositions and attitudes. See section 5 for further elaboration.

[21] 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 e $y = 1$ respectively, where $0 \leq \hat{x} \leq 1$ and $0 \leq \hat{y} \leq 1$.

traps, however, we need to study the welfare properties of the model. The evolutionary literature on the existence of such traps has indeed defined the latter as situations in which the system converges to a stable equilibrium which is nonetheless Pareto-dominated by another critical state, regardless of the stability properties of the latter (see Carrera 2017, Antoci et al., 2018b, Antoci et al., 2007).

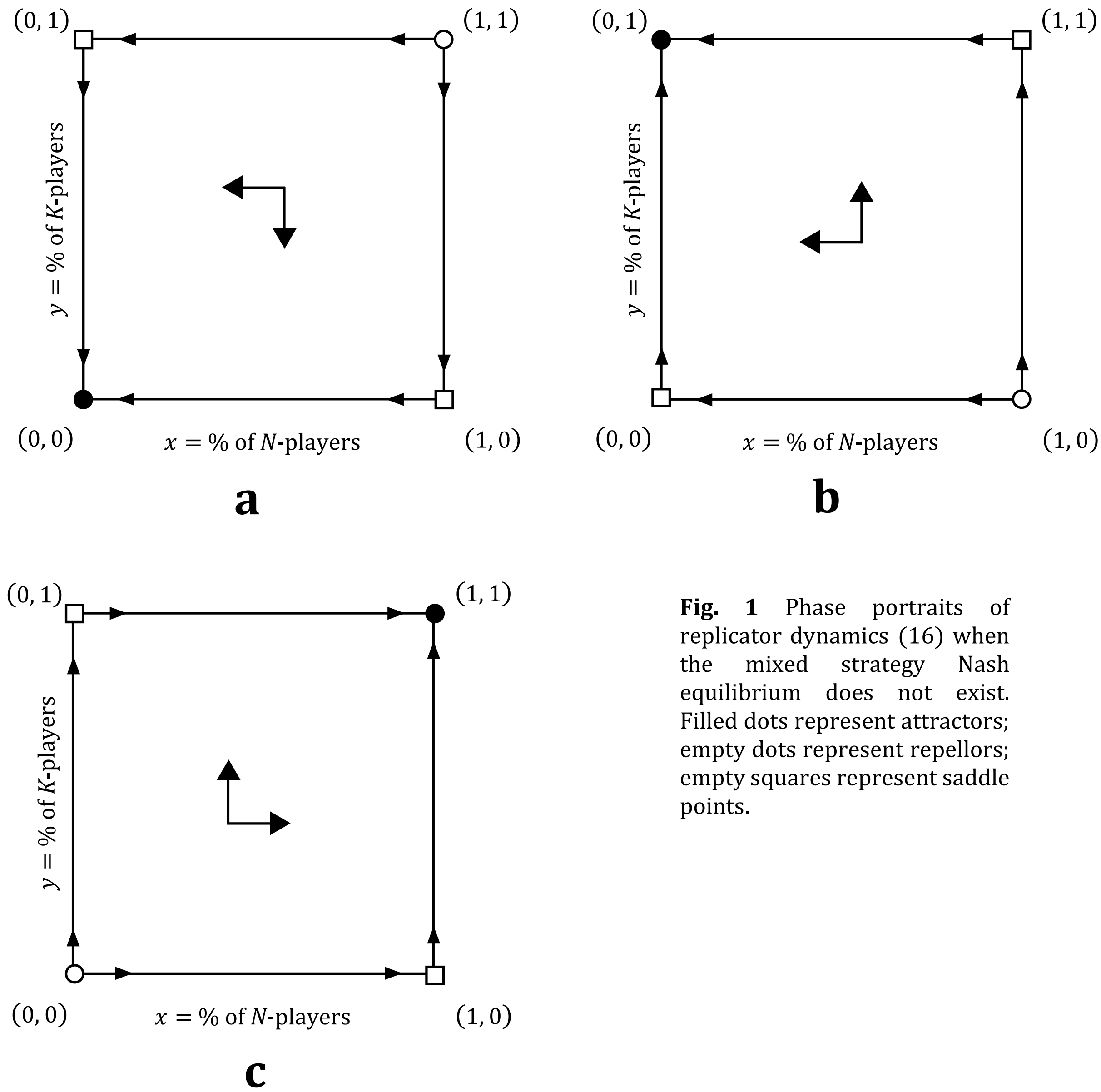

Fig. 1 Phase portraits of replicator dynamics (16) when the mixed strategy Nash equilibrium does not exist. Filled dots represent attractors; empty dots represent repellors; empty squares represent saddle points.

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 behaviour. Profitability is measured by evaluating the organisations' average payoff at the relevant equilibria—see matrix (1). In the bistable regime, we have three Nash equilibria, $(0,0)$, (x^*, y^*) and $(1,1)$, and the organisations' average payoffs write:

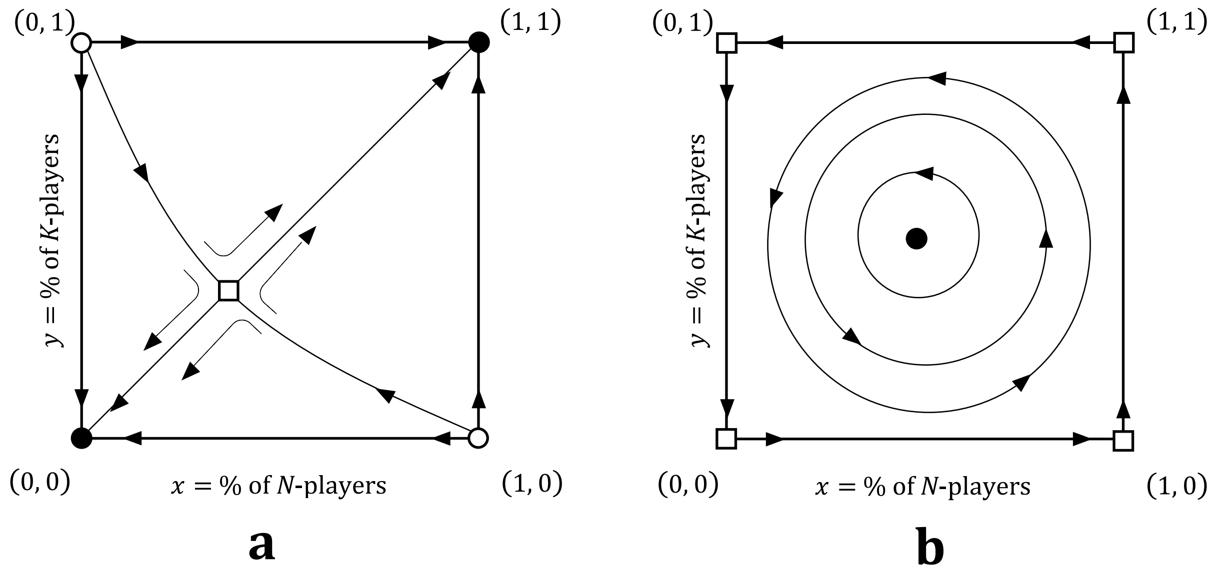

Fig. 2 Phase portraits of replicator dynamics (16) when the mixed strategy Nash equilibrium exists. Filled dots represent attractors; empty dots represent repellors; empty squares represent saddle points. In fig. 2a, the saddle path running rom north-east to south-west and connecting the (H,K) and (N,P) sources is the separatrix of the dynamical system and divides the basins of attraction of the (N,K)-the area above the separatrix-and (H,P)-the area below the separatrix-attractors.

$$\Pi^O_{(0,0)} = B_2 = s(1+\rho) - w \tag{19}$$

$$\Pi^O_{(x^*,y^*)} = B_2 + (B_1 - B_2)y^* = s(1+\rho)[1-(1-\delta_1)y^*] - w \tag{20}$$

$$\Pi^O_{(1,1)} = A_1 = s + g(1-\rho) - w \tag{21}$$

Simple algebra on (19) and (21) shows that $\Pi^O_{(0,0)} > \Pi^O_{(x^*,y^*)}$ always[22]. In addition,

[22] Since $\Pi^O_{(0,0)} - \Pi^O_{(x^*,y^*)} = s(1+\rho)(1-\delta_1)y^*$ and $(1-\delta_1)y^* > 0$ by construction.

observe that $\Pi^O_{(1,1)} > \Pi^O_{(0,0)}$ requires[23]:

$$\rho < \frac{g}{s+g} \equiv \rho^{**} \tag{22}$$

Observing that $\rho^* > \rho^{**}$ always—see condition (6)—is is straightforward to see that the model admits a parametrisation in which $\Pi^O_{(0,0)} > \Pi^O_{(1,1)}$ in both regimes, more precisely, when $\rho^{**} < \rho < \rho^*$. This is due to the effect that the effort-discounting rate of P-workers exerts on the system's evolution. As a matter of fact, when the degree of intraorganisational conflict within networks equals zero ($\delta_1 = 0$) we have that $\rho^* = \rho^{**}$, and the condition under which the game admits a mixed-strategy Nash-equilibrium coincides with that in which $\Pi^O_{(1,1)}$ Pareto-dominates $\Pi^O_{(0,0)}$. Perhaps counterintuitively then, if P-players benefit from working in a more challenging environment and thus attempt to reduce their effort less strongly (see Appendix A), the evolutionary constraint in eq. (6) tightens and the threshold value of ρ below which organisations find profitable to decentralise decisions decreases. This is consistent with the idea expressed by those critics who maintain that the introduction of high involvement practices is not simply a matter of informational efficiency, but it can rather be seen « as a method for co-opting workers into a managerial perspective in order to preserve hierarchical authority without bureaucratic control » (Antonioli et al., 2009: 68; see also Vidal, 2007).

In the same vein, we measure job-related well-being by evaluating the workers' average payoff U^W at the relevant equilibria—see matrix (2). In the bistable regime, we have three Nash equilibria, $(0,0)$, (x^*, y^*) and $(1,1)$, and the organisations' average payoffs write:

$$U^W_{(0,0)} = D_2 = w - e_H + \gamma_P \tag{23}$$

$$U^W_{(x^*,y^*)} = D_2 + (D_1 - D_2)x^* = w - e_H + \gamma_P + [e_H - \gamma_P - \delta_1(e_N + \gamma_P)]x^* \tag{24}$$

[23] Of course, since $\Pi^O_{(0,0)} > \Pi^O_{(x^*,y^*)}$ always, when condition (22) holds, by transitivity we have that $\Pi^O_{(1,1)} > \Pi^O_{(0,0)} > \Pi^O_{(x^*,y^*)}$

$$U^W_{(1,1)} = C_1 = w - e_N + \gamma_K \quad (25)$$

Simple algebra on (24) and (25) shows that $U^W_{(1,1)} > U^W_{(x^*,y^*)}$ always[24]. To study the sign of $U^W_{(1,1)} - U^W_{(0,0)}$, in turn, we introduce some notations which will be handy for future analysis. Recalling that $\gamma_K > \gamma_P$ and $e_N > e_H$ by assumption—see section 4.1—we define $\gamma_K - \gamma_P \equiv \gamma$ and $e_N - e_H \equiv e$. These expressions resume the two conflicting positions expressed in the literature as concerns the effect of new-work practices on job-related well-being (see footnote 4). As a matter of fact, γ and e can be interpreted, respectively, as the "intensification" and the "empowerment" factor, the former conveying the idea that high involvement practices entail substantial costs to workers in terms of effort increase, and the latter that they conversely raise job satisfaction by allowing own-skills exploitation and improvements in the sense of organisational belonging and self-fulfilment. Allowing for the coexistence of these two elements has relevant implications for the welfare properties of the model. As a matter of fact, the (N, K) equilibrium Pareto-dominates both the (H, P) and the (x^*, y^*) equilibrium when[25]:

$$\gamma > e \quad (26)$$

that is, when workers are more than compensated in terms of subjective well-being for incurring in higher effort costs when employed in N-organisations—i.e., the empowerment effect cancels out the intensification effect. Conversely, when (26) does not hold, (N, K) is always dominated by (H, P). These results are summarized in the following proposition—for a more complete analysis of these Pareto-orderings see Appendix B.

---

[24] Defining $a \equiv e_N + \gamma_K, b \equiv e_H + \gamma_P; c \equiv (e_N + \gamma_P)\delta_1$ and $d \equiv (e_H + \gamma_K)\delta_2$ and recalling that $x^* = \frac{b+d}{a+b+c}$ in this notation—see the expression of x^* in (11)—we can easily check that $U^W_{(1,1)} > U^W_{(x^*,y^*)}$ always, as $\frac{b-a}{b+c} < \frac{b+d}{a+b+c}$ always, both in the bistable—where $a > c$ and $b > d$—and in the cyclical dynamics—where $c > a$ and $d > b$.

[25] The proof that $U^W_{(1,1)} > U^W_{(0,0)}$ when condition (26) holds is straightforward. For that concerning $U^W_{(1,1)} > U^W_{(x^*,y^*)}$ see Appendix B.

PROPOSITION 2—*In both dynamics, the* (N, K) *and the* (H, P) *equilibria are never simultaneously dominated by the mixed-strategy Nash equilibrium with* $0 < x^* < 1$ *and* $0 < y^* < 1$*. The* (N, K) *equilibrium, in turn, dominates* (H, P) *when both conditions* (22) *and* (26) *simultaneously hold. If it is only condition* (22) *which is met, organisations enjoy higher profits in the* (N, K) *than in the* (H, P) *equilibrium, but the levels of job-related well-being are higher in the* (H, P) *than in the* (N, K) *equilibrium. Similarly, when it is only condition* (26) *which is met, organisations enjoy higher profits in the* (H, P) *than in the* (K, H) *equilibrium, while the levels of job-related well-being are higher in the* (N, K) *than in the* (H, P) *equilibrium.*

Proposition 2 proved the possibility for the (N, K) and the (H, P) stable equilibria to Pareto-dominate one another, thus presenting clear support to the hypothesis that the system may remain stuck into an evolutionary trap when converging to the either of the two. In addition, it unambiguously showed that this is always the case when the dynamics exhibits cyclical behaviour, as the (x^*, y^*) equilibrium is invariably dominated by either (N, K) or (H, P) in at least one population. Propositions 3 and 4 in Appendix B further presents conditions for qualifying the system's evolution as "symbiotic"—when the expected profits and utilities evaluated at the relevant states have the same Pareto-ranking—or "non-symbiotic"— when the expected profits and utilities evaluated at the relevant states differ in their Pareto-ranking. As the effect of new work-practices on workers' well-being is still a debated matter in the literature (see footnote 4), the possibility of this "non-symbiotic" evolution may be interpreted in light of the "intensification versus empowerment" dilemma that keeps dividing the advocates of these two competing hypotheses. It should also be noted that that we are now able to identify two different types of evolutionary traps, the "trap of path-dependence" which may arise in bistable dynamics—see section 5.2 below for further comments—and the "trap of organisational conflict" which inevitably emerges when the system exhibits cyclical behaviour. In this framework, the employees who are organisationally mismatched enjoy higher payoffs than their complying coworkers because of the low values of their effort discounting rate—see Appendix A and condition (13). Although it may be difficult to empirically assess the relevance of such trap because of the scarce available data on monitoring efficiency, we believe that having noted the possibility of its existence is noteworthy, as this suggests multiple avenues for the emergence of failures in organisational behaviour.

5.2 Comments of the results

More interesting for the purpose of drawing economically meaningful comments from the results in proposition 2 are the cases which better-fit with the up-do-date empirical evidence. The scenario which deserves the utmost consideration—the one we have already recalled in the introduction—relates to the decline in job-discretion within countries characterised by high levels of production complexity and non-routine skills—in the context of our model, by low values of ρ and high fractions of K-workers. If our working hypothesis is correct and decentralised forms of work organisations do benefit from the diffusion of generically skilled workers in complex environment, Western organisations are likely to be already stuck into an evolutionary trap, the possible explanations to the emergence of which will be listed in a moment. What remains to be understood though—and this is largely an empirical matter—is whether the trap's negative implications are also affecting the workers' population, and this brings us back to "intensification versus empowerment" dilemma recalled in the above.

Despite definitive conclusions are yet to be drawn, the study by Greenan et al. (2013) convincingly suggests that the decreasing trend in the quality of working life in Europe over the decade 1995-2005 must be related to the wide-spread contraction of job-discretion, while the evidence presented in Calapez et al. (2014) relates the evidence according to which Scandinavian countries fare better in terms of job-satisfaction—see also Gallie (2007) and Davoine et al. (2008)—to the fact that work autonomy levels in Denmark, Finland, the

Netherlands and Sweden are above the EU average for all groups of workers. Counterfactually then, this seems to suggest that condition (26)—i.e., $\gamma > e$—holds for all European countries and thus, that those who are recording a declining trend in job-discretion are stuck into an evolutionary trap affecting both populations. How can we explain the emergence of such an impediment in the system's evolution?

On first thoughts, one may refer to the model as predicting that, whenever generic-human capital is abundant in the economy, the system will eventually converge to the (N, K) equilibrium and thus point to the situation described above as a case against its explanatory power. On second thoughts however, when the truly coevolutionary nature of the replicator dynamics in two-populations is given the appropriate consideration, it is easy to see that a shift from one basins of attraction to the other may only be achieved if relatively high fractions of both populations invest in complementary profiles—in our model, K and N or P and H—regardless of how abundant a certain type is in either of the two populations alone. This is well-depicted by the extreme case in which one of the two group is almost entirely composed by a single type of individual, while the other group conversely consists in a 100% of its opposite—rather than its complements. Looking at fig 2a thus, we can imagine situations in which an economy almost entirely populated by, say, K-workers, will remain stuck in the (H, P) equilibrium because little or even no organisation invest in the diffusion of decision rights[26].

As it is well-known with replicator dynamics in fact—just as with any other form of non-ergodic process—multistable systems may gravitate to sub-optimal equilibria due to adverse initial conditions or poor equilibrium selection (see Carrera et al., 2018; Antoci et al. 2018b;

[26] From an analytical viewpoint, it may be useful to insist upon a mathematical property of the replicator dynamics in two-populations—though the same considerations hold for games of dimension > 2. As previously recalled in fact, the edges of the unit square $Q = (0,1)^2$ over which the replicator dynamics is defined are invariant, meaning that all trajectories starting on either of the four sides of the square—rather than on its interior—will remain on that side along their entire path. Imagine a situation then, when the initial state of the system is given by, say, $(x_0, y_0) = (0, 0.9)$. As this point is located on the left-hand edge of Q with $(0, \hat{y})$, $0 \leq \hat{y} \leq 1$, the entire trajectory starting from (x_0, y_0) will unfold across the edge. By looking at fig 2a, we see that the arrow indicating the laws of motion on this edge points downward towards (H, P), that is the state that will be eventually reached starting from (x_0, y_0).

and Antoci et al. 2018b). We call this kind of trap the "trap of path-dependence". Observe that this arises only when the system exhibits bistable behaviour, that is, when condition (12) rather than (13) holds. As already recalled in the introduction and further sketched in footnote 20, there are several elements which may play a role in the emergence of the trap of path-dependence, the first of which relates to the correlation between managerial culture and business cycle. While periods of economic expansion are likely to prompt organisations to invest in the diffusion of decision rights, periods of economic stagnation are likely to prompt the concentration of the latter, as managers' may invest in strategies that are perceived to increasing their span of control. This provides with a rationale to explain both the rise and the decline of job discretion before and after the crisis of 1991.

Similar forms or cultural resilience, in turn, may also influence the workers' behaviour. Work ethics in the form of a "we against them", for instance, is likely to be incompatible with the adoption of a K-profile and so are the elements—like a conflictual system of industrial relations—which are likely to reinforce such an antagonistic attitude. Antonioli et al. (2009), for instance, find a robust linkage between working conditions, as dependent variable, and innovative work practices and cooperative industrial as covariates. This loosely suggests some kind of complementarity between more cooperative systems of industrial relations and the introduction of organisational innovations based on the diffusion of decision rights.

Last but not least, the presence of switching costs between both the organisational forms and the workers' types—when the latter may be purely economic if referred to, say, investments in further education and/or psychological if referred to changing work attitudes, ethics or disposition—are likely to reduce the pace of evolution. While the system's initial conditions depicted by the exogenously given initial pairs (x_0, y_0) may suffice to capture the forms of cultural resilience listed in the previous paragraph, there is a further factor which may analytically express the existence of switching costs between alternative strategies. The replicator equations in dynamics (18) in fact, are both weighted by the $\beta_i = 1, i = 1, 2$ parameters, which capture the fractions of the organisations and workers who are in "updating-mode", that is, who are actually willing to best-respond to payoff difference in the past. It is therefore reasonable to assume that the presence of switching costs will result in low-values of the $\beta_i = 1, i = 1, 2$ parameters, thus slowing or even impeding the evolutionary process altogether.

6 Conclusion and policy suggestions

The paper presented an evolutionary-game theoretic model to study the adoption of work-practices based on the diffusion of decision rights. In doing so, it developed a framework where decentralised systems of workers' coordination and the use of non-routine skills coevolve under the pressure of environmental complexity. Besides, it also derived different levels of job-related well-being from the fitness between the workers learning dispositions and the organisations' learning requirements. While commenting the results of the model, it finally identified two different types of evolutionary traps which may actually impede the system's optimal evolution.

The key finding of the paper are in line with the associated empirical literature according to which the contemporary contraction in the levels of job-related well-being are likely to be related to the specular decline of job-discretion which is characterizing a great deal of nowadays' Western economies. At first thought—as already argued by Green et al. (2016)—the political leverages to countervail such declining trend are not easily identifiable, as job-design is largely—if not entirely—a private matter for employers and employees. However, there are several institutional factors which may somehow affect the organisation of work. Trade unions, for instance, may affect it either indirectly—by stimulating a cooperative climate of industrial relations—or directly, if one imagines situations in which shop stewards are explicitly involved in job-design. The kind of institutions which may more likely channel this form of cooperation between unions and firms are those operating at the shop-level and who are, in addition, largely—if not entirely—devoid of bargaining power[27]. This is to minimize the risk that wage-bargaining—though of course absolutely appropriate in other contexts—may spoil the possibility for unions to have a role in job-design.

The other elements which are likely to affect the quality of the organisational practices—and thus, the associated levels of profitability and job-satisfaction—include the public policy commitment to the latter and other societal factors which may however be influenced by the actions of the regulator. As a matter of fact, while the role of the State in affecting job-design through judicious and long-term regulation is straightforward, the latter may also operate indirectly by acting upon the public discourse and/or by introducing workplace innovations in the or semi-public public sector. Should these organisational experiments prove successful, there is the possibility for the State to lead by example the entrepreneurial population, which may look up to these positive experiences and thus modify its behaviour through learning-by-imitation. Finally, various forms of partnerships and communication between industrial confederations, academic institutions and public commissions may be also envisaged.

To conclude with a skeptical note however, all the suggestions listed above requires political actors and regulators to operate in a very stable environment, as these actions not only are very unlikely to be effective in the long and even medium-run, but further require policy-makers to invest in operations which somehow exceed both the daily administration and the most urgent concerns related to the country's global stability. In other words, the suggestions sketched in the above are quite unlikely to have a significant impact on the policy discourse of today, where the rise of populism and the increase tendency towards political shortermism must be related to the unbridled diffusion of various forms of anxiety among Europeans and Western people in general, the political representative of which are therefore unlikely to invest

[27] German work councils may be referred to as a good example of this kind of institutions.

in political actions which may have a little effect in sedating this kind of widespread discontent.

Acknowledgments: The author would like to thank Fabio Berton, Thomas Kochan, Alain Marciano, Ugo Pagano, Michele Rosenberg, Massimiliano Vatiero, all the participants to the 2017 WINIR conference on "Institutions and open societies", all the participants to the 2017 Trento Summer School "New thinking on the firm" and two anonymous referees for their very useful comments on earlier versions of the paper. The usual caveats apply.

References

Acemoglu D, Aghion P, Lelarge C, Reenen JV, Zilibotti F (2007) Technology, information, and the decentralization of the firm. Q J Econ 122(4): 1759-1799

Aghion P, Bloom N, Luckling B, Sadun R, Van Reenen J (2016) Turbulence, firm decentralization and growth in bad times. NBER Working Paper 23354

Aghion P, Tirole J (1997) Formal and real authority in organizations. J Polit Econ 105(1): 1-29

Antoci A, Maccioni AF, Russu P (2018a) Medical practice and malpractice litigation in an evolutionary context. J Evol Econ 28(4): 915–928

Antoci A, Sabatini F (2018b) Online networks, social interaction and segregation: an evolutionary approach. J Evol Econ 28(4): 859–883

Antoci A, Sacco PL, Vanin P (2007) Social capital accumulation and the evolution of social participation. J Soc Econ 36(1): 128-143

Antonioli D, Massimiliano M, Pini P (2009) Innovation, industrial relations and employee outcomes: evidence from Italy. J Econ Stud 38(1): 66-90

Aoki M (1986) Horizontal vs. vertical information structure of the firm. Am Econ Rev 76 (5): 971-83

Aoki M (1995) An evolving diversity of organizational mode and its implication for transitional economies. J Jpn Int Econ 9: 330-353

Arundel AE, Lorenz BA, Lundvall and A. Valeyre (2007), How Europe's economies learn: a comparison of work organization and innovation mode for the EU-15. Ind Corp Change 16(6): 1175–1210.

Askenazy P, Caroli E (2006) Innovative work practices, information technologies and working conditions: evidence for France. Discussion Paper No. 2321, IZA, Bonn

Boltanski L, Chiappello E (2005), The new spirit of capitalism. New York: Verso

Bowles S (1985) The production process in a competitive economy: Walrasian, neo-Hobbesian, and Marxian models. Am Econ Rev 75(1): 16 -36

Bowles S (2006) Microeconomics. Behavior, institutions, and evolution. Princeton: Princeton University Press

Braverman H (1974) Labor and monopoly capital. The degradation of work in the twentieth century. New York: Monthly Review Press

Brenner M, Fairris D, Ruser J (2004) Flexible work practices and occupational safety and health: exploring the relationship between cumulative trauma disorders and workplace transformation. Ind Relat (43)1: 242-66

Calapez T, Lagoa L, Lopes H (2014) Work autonomy, work pressure, and job satisfaction: An analysis of European Union countries. Econ Labour Relat Rev 25(2): 306-326

Caroli E, Greenan N, Guellec D (2001) Organizational change and skill accumulation. Ind Corp Change 10(2): 481-506

Carrera JS (2018) Evolutionary dynamics of poverty traps. J Evol Econ: 1-20

Christie AA, Joye LP, Watts RL (2003) Decentralization of the firm: theory and evidence. J Corp Financ 9(1): 3-36

Colombo M, Delmastro M (2004) Delegation of authority in business organizations: an empirical test. J Ind Econ 2 (1): 53–80

Cortes GM (2017) Disappearing routine jobs: Who, how, and why? J Monet Econ 91:69 -87

Davoine L, Ehrel C, Guergoat-Lariviere M (2008) Monitoring quality in work: European Employment Strategy indicators and beyond. Int Labour Rev (147)2-3: 163-198.

Deming DJ (2017) The growing importance of social skills in the labor market. Q J Econ 132(4): 1593-1640

Dessein W, Santos T (2006) Adaptive organizations. J Polit Econ 114(5): 956-995

Doeringer PB, Lorenz E, Terkla DG (2003) The adoption and diffusion of high-performance management: lessons from Japanese multinationals in the west. Cambridge J Econ 2: 265-286

Eurofound (2011) Cox A, Higgins T, Speckesser S. Management practices and sustainable organisational performance: An analysis of the European Company Survey of 2009. Eurofound, Dublin.

European Commission (2009) Commission Working Document. Consultation on the future EU 2020 Strategy, 647/3. European Commission, Brussels

Felstead A, Gallie D, Green F, Inanc H (2015) Fits, misfits and interactions: learning at work, job satisfaction and job-related well-being. Human Res Manag J 25(3): 294-310

Green F, Felstead A, Gallie D, Henseke G (2016) Skills and work organisation in Britain: a quarter century of change.

J Labour Market Res 49:121–132
Gallie D (2005) Work pressure in Europe 1996-2001: trends and determinants Brit J Ind Relat 43(3): 351-375
Gallie D (2007) Task discretion and job quality. in Gallie D (Ed.) Employment Regimes and the Quality of Work: Oxford, Oxford University Press, pp. 105-136.
Garicano L. (2000) Hierarchies and the organization of knowledge in production. J Polit Econ 108(5): 874-904
Gibbson R, Roberts (2012). The handboof of organozational economics. Princeton: Princeton University Press
Goos M, Manning A, Salomons A (2014) Explaining job polarization: routine-biased technological change and offshoring. Am Econ Rev, 104(8): 2509-2526
Green F (2004) Why has work effort become more intense? Ind Relat 43(4) 709-41
Green F (2012) Employee involvement, technology and evolution in job skills: A task-based analysis. Ind. Labor Relat. Rev. 65(1), 35–66 (2012)
Green F, McIntosh S (2001) The intensification of work in Europe. Labour Econ 8(2): 291-308
Greenan N, Kalugia E, Walkowiak E (2013) Has the quality of working life improved in the EU-15 between 1995 and 2005? J Ind Corp Change, 23(2): 399-428
Handel M Levine, D (2004) Editors' introduction: the effects of new work practices on workers. Ind Relat 43(1): 1-43
Holm RJ, Lorenz E (2015) Has "Discretionary Learning" declined during the Lisbon Agenda? A cross-sectional and longitudinal study of work organization in European nations. Ind Corp Change 24(6) 1179–1214
Holman D, Rafferty A (2018) The convergence and divergence of job discretion between occupations and institutional regimes in europe from 1995 to 2010. J Manag Stud 55(4): 619-647
Jensen MC, Meckling HW (1990) Specific and general knowledge and organizational structure. In Werin L, Wijkander H (Eds.) Contract economics, Oxford, Blackwell: 251-274
Jonker LB, Taylor PD (1978) Evolutionarily stable strategies and game dynamics. Math Biosci 40:145-156
Katayama H, Meagher KJ, Wait A. (2018) Authority and communication in firms. J Econ Behav Organ. Online version
Lindbeck A, Snower DJ (2000) Multitask learning and the reorganization of work: from Tayloristic to holistic organization. J Labor Econ 18(3): 353-76
Nelson R, Winter S (1982) An evolutionary theory of economic change. Harvard: Belknap Press
Marginson D, McAaulay L (2008) Exploring the debate on short-termism: a theoretical and empirical analysis. Strat Manag J 29(3): 273–292
McElheran K (2014) Delegation in multi-establishment firms: evidence from I.T. purchasing. J. Econ Manage Strategy 23 (2), 225–258
Mookherjee D (2006) Decentralization, hierarchies, and incentives: a mechanism design perspective. J Econ Lit 44(2): 2006
Morita H (2005) Multi-skilling, delegation and continuous process improvement: a comparative analysis of Us-Japanese work organizations. Economica 72(285): 69-93
O.E.C.D. (1972). The emerging attitudes and motivations of workers, report of a management experts' meeting. Paris: Manpower and Social Affairs Directorate.
Reijnders L (2018) Technology, offshoring and the rise of non-routine jobs. J Dev Econ 135:412 -432
Rowell JT, Ellnser SP, Reeve HK (2006) Why Animals Lie: How Dishonesty and Belief Can Coexist in a Signaling System. Am Nat 168(6): 180-204
Shapiro C, Stiglitz JE (1984) Equilibrium unemployment as a worker discipline device. Am Econ Rev 74(3): 433-44
Taylor FW (1911) The Principles of Scientific Management. New York and London: Harper & Brothers
Vidal, M (2007) Manufacturing empowerment? 'Employee involvement' in the labour process after Fordism. Socio-Econ Rev 2(5): 197-232
Williamson OE (1976) Hierarchical control and optimum firm size. J Polit Econ 75(2): 123-138
Williamson OE, Watcher ML, Harris JE (1975) Understanding the employment relation: the analysis of idiosyncratic exchange. Bell J Econ 6(1): 250-278

Appendix A: effort-discounting rates

In the text, we did not introduce any explicit restriction on δ_1 and δ_2, as two opposite effects are likely to interact and possibly cancel out each other in determining the values of the latter. The first effect is of motivational nature, while the second refers' to the allegedly different monitoring efficiency of the two organisational forms.

In analysing the former, we shall take the position that mismatched workers may experience different utility losses—and thus engage in weaker attempts to reduce their effort—as a consequence of their different dispositions and organisational environments. In particular, we allow for the possibility that P-workers employed in N-organisations may experience a minor utility loss than that K-workers employed in H-organisations, either because they may benefit from working in a more challenging environment or that they have weaker organisational preferences and thus are less sensitive to organisational misfits. Recalling that we have already assumed that $\gamma_K > \gamma_P \geq 0$—see footnote 19 in the next—we finally impose that $\bar{\gamma} \geq \gamma_K$, where $\bar{\gamma}$ is an exogenously given upper bound. Formally, we let $0 \leq q^i \leq 1, i = K, P$ be the probabilities that a K and P worker will abide with her duties even when organisationally mismatched, and we further assume that:

(i) $\frac{\mathrm{d}q^i}{\mathrm{d}\gamma_i} > 0, i = K, P$—the higher the utility loss, the higher the effort-reducing attempt;

(ii) $q^P = 1$ if $\gamma_K = \bar{\gamma}$—when the disutility from organisational misfits reaches its maximum, K-workers shirk incessantly;

(iii) $q^K = 0 \ \ \gamma_P = 0$ when the disutility from organisational misfits reaches its minimum, P-workers never shirk.

so that $1 \leq q^P < q^K \leq 0$ hold by construction. Observe that q^i turns out to be an inverse index of the degree of intraorganisational conflict, with $q^i = 0$ and $q^i = 1$ respectively representing the absence and the maximum pervasiveness of the latter.

If the motivational issue discussed hitherto would be the sole determinant of the effort-discounting rate of both workers, we would have that $\delta_1 < \delta_2$, as P-workers employed in networks would try to shirk less than K-workers employed in hierarchies. However, as organisations are reasonably assumed to invest in monitoring technologies to detect defections, the degree to which shirkers are actually successful in their effort-reducing attempts depend of the efficiency of the two systems of workers' supervision. Let $0 \leq p^j \leq 1, j = N, H$ be the monitoring efficiencies of H and N organisations, where we have assumed that $p^H > p^N$ to model the idea that monitoring is more efficient in hierarchies, as the diffusion of decision rights is likely to slacken—*ceteris paribus*—the process' monitorability. Given the above, the effort-discounting rates of as P-workers employed in networks and try of K-workers employed in hierarchies are given by:

$$\delta_K = (1 - q^K)p^N + q^K \tag{A.1}$$

$$\delta_P = (1 - q^P)p^H + q^H \tag{A.2}$$

where it should be observed that:

(i) $\delta_i = 1$ if $q^i = 1$

(ii) $\delta_i = q^i$ if $p^j = 0$

(iii) $\delta_i = p^j$ if $q^i = 0$

with $i = K, P; j = N, H$.

Appendix B: Pareto-rankings

B.1 Organisations

Given the expressions (19), (20) and (21) in the text, and the already proven results according to which $\Pi^O_{(0,0)} > \Pi^O_{(x^*,y^*)}$ always and $\Pi^O_{(1,1)} > \Pi^O_{(0,0)}$ if $\rho < \rho^{**}$—see condition (22) — we derive the condition for which $\Pi^O_{(1,1)} > \Pi^O_{(x^*,y^*)}$. In particular, this occurs when:

$$\frac{s + g(1-\rho)}{s(1+\rho)} > 1 - (1-\delta_1)y^* \tag{B.1}$$

with $0 < 1 - (1-\delta_1)y^* < 1$ by construction and $\frac{s+g(1-\rho)}{s(1+\rho)} > 1$ if condition (22) holds and $0 < \frac{s+g(1-\rho)}{s(1+\rho)} < 1$ if condition (22) does not hold. Since $\frac{s+g(1-\rho)}{s(1+\rho)} > 1 - (1-\delta_1)y^*$ always when $\frac{s+g(1-\rho)}{s(1+\rho)} > 1$, (22) is a sufficient condition for the ordering $\Pi^O_{(1,1)} > \Pi^O_{(0,0)} > \Pi^O_{(x^*,y^*)}$ to hold. Conversely, when (22) does not hold, condition $(\mathrm{B.1})$ may be either met or unmet depending on the model parametrisation. The results are resumed in the following proposition:

PROPOSITION 3—*The Pareto-ranking of the organisations' average payoffs write:*

(i) $\Pi^O_{(1,1)} > \Pi^O_{(0,0)} > \Pi^O_{(x^*,y^*)}$ *if condition* (22) *holds.*

(ii) $\Pi^O_{(0,0)} > \Pi^O_{(1,1)} > \Pi^O_{(x^*,y^*)}$ *if condition* (22) *does not hold, while condition* $(\mathrm{B.1})$ *hold.*

(iii) $\Pi^O_{(0,0)} > \Pi^O_{(x^*,y^*)} > \Pi^O_{(1,1)}$ *if conditions* (22) *and* $(\mathrm{B.1})$ *do not hold simultaneously*.

The scenario in which $\Pi^O_{(x^*,y^*)} > \Pi^O_{(1,1)}$ is consistent with the idea that partial delegation outperforms complete delegation—but not complete centralisation—when the environment is characterised by high levels of intraorganisational conflict.

B.2 Workers

Given the expressions (23), (24) and (25) in the text, and the already proven results according to which $U^W_{(1,1)} > U^W_{(x^*,y^*)}$ always and $U^W_{(1,1)} > U^W_{(0,0)}$ if $\gamma > e$—see condition (26) —we derive the condition for which $U^W_{(0,0)} > U^W_{(x^*,y^*)}$. In particular, this occurs when:

$$\delta_1(e_N + \gamma_P) > e_H - \gamma_P \tag{B.1}$$

The left-hand side of eq. (B.2) is the sum of the objective and subjective effort cost of P-workers employed in N-organisations—discounted by δ_1—while the right-hand side is the objective effort-cost of P-workers employed in H-organisation discounted by their organisation-specific preferences γ_P. Eq. (B.2) simply state that, for the employees' population to enjoy higher payoff (on average) in $(0,0)$ than in the $(x^*,\ y^*)$, P-workers must incur higher costs when employed in N than in H-organisations, that is, that their effort discounting rate δ_1 must remain above a critical threshold. Solving (B.1) for δ_1 we see that $U^W_{(0,0)} > U^W_{(x^*,y^*)}$ requires:

$$\delta_1 > \frac{e_H - \gamma_P}{e_N + \gamma_P} \equiv \delta_1^{**} \tag{B.2}$$

Observing that $\delta_1^{**} > \delta_1^*$ and $\delta_1^{**} < \delta_1^*$ when condition (26) is met and unmet respectively and recalling that bistable and cyclical dynamics require $\delta_1 > \delta_1^*$ and $\delta_1 < \delta_1^*$ respectively—see conditions (12) and (13)—it is easy to check that $U^W_{(0,0)} - U^W_{(x^*,y^*)}$ may take either signs depending on the interplay between the form of the dynamics—bistable or cyclical—and condition (26)[28]. The results are resumed in the following proposition:

PROPOSITION 4—*The Pareto-ranking of the workers' average payoffs write:*

(iv) $U^W_{(1,1)} > U^W_{(0,0)} > U^W_{(x^*,y^*)}$ *if conditions* (26) *and* (B.2) *simultaneously hold.*

[28] In particular $U^W_{(0,0)} > U^W_{(x^*,y^*)}$ always if $\gamma < e$ and $\delta_1 > \delta_1^*$ (bistable dynamics), $U^W_{(0,0)} > U^W_{(x^*,y^*)}$ never if $\gamma > e$ and $\delta_1 < \delta_1^*$ (cyclical dynamics), $U^W_{(0,0)} > U^W_{(x^*,y^*)}$ if $\gamma > e$ and $\delta_1 > \delta_1^{**}$ (bistable dynamics) and $U^W_{(0,0)} > U^W_{(x^*,y^*)}$ if $\gamma < e$ and $\delta_1^{**} < \delta_1 < \delta_1^*$ (cyclical dynamics).

(v) $U_{(1,1)}^{W} > U_{(x^*,y^*)}^{W} > U_{(0,0)}^{W}$ *if conditions* (26) *holds, while condition* $(\mathrm{B}.2)$ *does not hold.*

(vi) $U_{(0,0)}^{W} > U_{(1,1)}^{W} > U_{(x^*,y^*)}^{W}$ *if condition* (26) *does not hold.*

The comparison between the Pareto-rankings listed in propositions 3 and 4 further allows us to identify cases in which the populations of workers and firms are homogenously affected by the system's evolution. This happens when both orderings assume exactly the same configuration, and thus, when conditions (26), (22) and $(\mathrm{B}.2)$ simultaneously hold or when conditions (26), (22) and $(\mathrm{B}.1)$ simultaneously do not hold. The coevolution of workers and firms, in this cases, may be labelled as "symbiotic", while "non-symbiotic" form of coevolution may emerge when the orderings in proposition 3 and 4 assume different structures. "Non-symbiotic" coevolution, in turn, may be of two types: "strongly non-symbiotic", when the workers and the organisations' ranking are completely different—for instance, when condition (26) and $(\mathrm{B}.2)$ simultaneously hold but conditions (22) and $(\mathrm{B}.1)$ do not—or "weakly non-symbiotic"—for instance, when conditions (26) and (22) hold, while condition $(\mathrm{B}.2)$ does not.