Skills, Preferences & Organisational Change: An Evolutionary Analysis

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The paper provides with a theoretical framework to analyse the transition from a Tayloristic to a "holistic" division of labour under an integrated "command-and-efficiency" approach. Such an evolution—it is maintained—stemmed from a radical mutation of the knowledge relations between decision-makers and production-workers, which blurred the boundaries between conception and execution and accounted for the emergence of a new organisational paradigm. It does so by proposing an evolutionary game-theoretic model where heterogenous workers are mated with heterogenous firms within a supermodular but random-matching framework. Therein, the historical transition from Taylorism to holism is depicted by combining purely-evolutionary elements (payoff based replication) with quasi-rational features (rational expectations).

KEYWORDS: Division of labour · knowledge· hierarchies· evolutionary games

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1. Introduction

The present paper contributes to the literature on organisational change by analysing the historical transition (hereafter, $T \rightarrow H$) that led from a *Tayloristic* (Taylor, 1911; Coriat, 1979) to a *holistic* division of labour (Lindbeck/Snower, 2000; Eurofound, 2015)[1,2]. Instead of providing an alternative explanation for depicting such process[3], it draws attention to a

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[1] The "holistic" terminology is borrowed from Lindbeck and Snower's (2000) seminal contribution.

[2] Roughly, we understand the holistic paradigm as a *selective imitation* (Doeringer et al., 2003) of the Japanese model (Aoki, 1990). The stylised organisational structure which result is characterised by multitasking, job-rotation, teamwork, quality circles, a "liquified" structure of authority and a significant delegation of decision rights towards the employees.

[3] The existing literature advanced five main explanations for explaining the $T \rightarrow H$ transition: (i) increase in the labour-force educational level/human capital (Acemoglu, 1998; Caroli et al., 2001; Boucekkine/Crifo, 2008); (ii) increase in the complexity of the manufacturing processes via the qualitative changes (customisation) in the demand composition (Spreng et al., 1996; Vandenbosch/Dawar, 2002; Prahalad/Ramaswamy, 2003); (iii) increase in the automatization of repetitive tasks (Autor/Dron, 2013), which in turn entails: increase in the value of social skills (Deming, 2015); (iv) a tremendous development in the I.C. technology (Krueger, 1993; Bresnahan et al., 2002) and (v) the emergence of a new family of "democratic preferences" as concerns the workers' occupational tastes.

significant nexus among two elements already acknowledged by the existing literature: (i) the tremendous increase in the workers' educational level (Caroli et al., 2001) and (ii) the emergent aspirations of the latter as regards the degree of "democracy" in the organisation of production (Aoki, 1990; Boyer, 1991)[4]. To our knowledge, ours is the first contribution that conjointly tackles this twofold issue by showing its inner interrelatedness.

The reason for focusing on this very crux follows from a theoretical consideration: among the elements the literature identified as key to understand the $T \rightarrow H$ transition, the nexus we highlight is the unique variation which accounts for the *political stability* of such change (March, 1962)[5]. Indeed, despite transactional costs and efficiency-oriented motivations may be insightful to explain the emergence of new institutional arrangements (Williamson, 1985), organisational innovations need also to be *power-compatible* so as not to jeopardise the residual rights of control of the firm's principal (Grossman/Hart, 1986; Hart/Moore, 1990).

In the following, we shall therefore present our argument against a "command-and-efficiency" background, where the $T \rightarrow H$ transition is depicted as having responded to a double dilemma. On the one hand, organisations were re-designed to efficiently confront the emergence of a better-skilled labour-force, as not to dissipate the value of a freshly educated labour-force. On the other hand, they provided the industrial system with a brand-new *truce* (Nelson/Winter, 1982: 111)[6] between employers and employees after the tremendously conflictual season that characterised the OECD industrial systems in between the 60s and the 70s (Boltanski/Chiappello, 2005: 167-200; Gorz, 1976, OECD, 1971)[7].

Thought the purpose of the paper is mainly descriptive, we see its results as encompassing a normative dimension too, as the results it yields may provide with indications to streamline

[4] Aspirations for productive democracy may be defined as a twofold adversity: towards hierarchical pressure and towards a rigid separation between *conception* and *execution* (Braverman, 1974). Remarkably, both constitute a cornerstone of Taylorism.

[5] The political dimension of corporate governance fairly exceeds the one we shall consider throughout the paper. We are aware that the firm encompasses multiple constituents, where the variable relationships between shareholders and stakeholders, the diffusion of ownership, the interaction with the surrounding political environment all play a major role in determining specific modes of corporate governance, which in turn determine the owners-managers-workers relationships (Roe/Vatiero, 2015; Vatiero, 2016). Hereafter we shall nonetheless abstract from these latter facets as to evaluate the employer/employees relationships in their "pureness", as to isolate specific objects and analyse them in a tractable way. Furthermore, despite we recognise the persistence of national "bio-diversities" in corporate governance (ivi; Pagano, 2007a), a main intent of ours is to put forward what we maintain to be a common trend in the OECD economies.

[6] On the routine-as-truce argument advanced by evolutionary economists see also Coriat and Dosi (1997). For a law and economics perspective on corporate culture see Langevoort (2005).

[7] In our view, there exists no incompatibility between our reasoning and those listed in footnote 3. On the contrary, we believe the various arguments advanced by the literature to connect with one another within a resilient chain of multiple complementarities, so that the $T \rightarrow H$ transition is a largely *overdetermined* (Althusser, 2010) process. Nonetheless, we maintain that this has « the unity of a structure articulated in dominance » (ivi: 202), where the cornerstone of the entire architecture is the political compromise we dedicate our attention to.

the organisation of labour. Indeed, while analysing the forces that historically supported what is mainly maintained to be a spontaneous evolution, it incidentally sheds some light upon the designed agency which may have allowed the H-model to emerge as a rational alternative to the T-one (see Appendix A). In this view, the $T \rightarrow H$ transition would be no longer understood as a purely evolutionary process, but rather as an intended choice between a *low-road* and a *high-road* strategy (Gordon, 1994). We this duality as reinforcing the theoretical strength of our argument, as it allows it to consider a wide array of different forces that may have (and still do) interplayed to determine the path and pace of the dynamic process we wish to analyse. Of course, we do not presume our findings to apply uniformly to all sectors/industries/countries. Discontinuities are likely to arise in response to exogenously given technological factors (see Appendix C), to the types of goods being produced, to the national customs in work organisation, to the degree of automation, the complexity of production (see Appendix B) and so forth. Nonetheless, we see the core of the theroy as displaying some degree of "transversality" with respect to the entire spectrum of the organisational ladder.

The remainder of the paper is organised as follows. Section 2 presents the general theory. Section 3 proposes an evolutionary game-theoretic model where heterogenous workers are mated with heterogenous firms within a supermodular (Milgrom/Roberts, 1990) but random-matching framework. Therein, the existence of strategic complementarities between organisations and employees determine (i) the latter's motivation and well-being; (ii) the firms' profitability; (iii) the stability of equilibria. The $T \rightarrow H$ transition holism is thus depicted by combining purely-evolutionary elements (payoff-based replication) with quasi-rational features (rational expectations)[8]. The mode of exposition is intendedly stylised, as to isolate the object(s) of interest and discuss them in a tractable way. Section 4 comments the results and concludes.

2. Theoretical framework

We introduce our argument by defining the domain of labour relations as a *subjective game system* (Aoki, 2001: 231-239) where the interested parties (employers/employees) share

[8] We closely follow Hodgson (2001) in claiming that social evolution is Darwinian "*in the last instance*" (Althusser, 2005), as mutations are finally selected because of a more efficient correspondence between the varied trait(s) and the environment where they operate. Nonetheless, social evolution also presents remarkable features of *Lamarckism*, as human agents display intentionality in both learning and teaching—on the latter see Bisin and Verdier (2008). Vatiero (2016) takes the position that the co-existence of multiple organisational equilibria is best explained through this latter Lamarckian character, as the massive imitations of conventions at the "*local*" level allow the emergence of different Pareto-ranked equilibria, the diverse efficiency of which would be otherwise hardly understandable within a pure Darwinian framework.

a mutual understanding of the rules of the game—fair value of the employment (Kaufman, 2009), fair level of commitment. Steady states (Hayekian equilibria) are characterised by stability in preferences and consistency in expectations (Lewin, 1997), or—in the jargon of evolutionary economics—a diffuse and enduring level of *truce*. Whenever a critical mass of agents experiences a gap between aspirations and achievements, a *general cognitive disequilibrium* results (Aoki, ibid.), as conflicting factions compete to fill the institutional vacuum by promoting their own organisational practice (Lazaric/Raybaut, 2005). We interpret the diffuse discontent that caught on the OECD workers in between the 60s and the 70s as a historical manifestation of this kind of mechanism, where the mental representations of a new generation of employees ceased to be aligned with the Tayloristic conventions in the division of labour.

To clarify our reasoning further, consider a Tayloristic system shocked by the emergence of a new typology of workers, at the same time, more educated and more demanding in terms of occupational preferences. Methodologically, we *endogenize* preferences (Bowles, 1998) with respect to the process of skills accumulation by following a simple intuition: individuals derive occupational expectations from their educational endowment, so that tastes over the working activity are determined by their level of capabilities. In such view, one needs to abandon the neoclassical abstraction where occupational tastes exclusively follow from financial motivations, as they complementarily stem from qualitative considerations regarding the assignment of tasks, the character of monitoring and so forth[9]. As Pagano (2007b: 37-39) puts forward,

> the introduction of free time into the utility function only captures the circumstance that individuals are sensitive to the greater or lesser quantity of their work; and it implies that they are instead indifferent to the particular tasks that they perform in production processes [...] every work activity is at once consumption and production, and that it is potentially both an end and a mean for the individual who performs it […] the subjectivity of individuals as envisaged by [neoclassical] theory is only the "half subjectivity" of individuals-consumers […] neoclassical subjectivity is still the limited subjectivity of a half-person.

Within a framework where employees are concerned to the way labour is divided, monitored and organised, profitable human assets may be underused if organisationally misallocated. Three competing explanations can be advanced to explain this misallocation and, accordingly, the causal drives that guided the $T \rightarrow H$ transition.

(I)—A first, efficiency-oriented account would claim that poorly educated workers are

[9] Similarly, Bessy and Szpiro (2010) describe the wage as a *hedonic price*, where intrinsic and extrinsic elements contribute to determine its subjective value.

best-employed within firms that rigidly separate raw labour and knowledge-production[10], while better-skilled employees are fully valorised if the former separation is significantly blurred.

(II)—An alternative though compatible fashion to depict the issue is to infer the nature of the employees' motivation from the quality (positively or negatively assortative) of the matching between workers and firms. In this view, workers possessing an inclination towards a specific organisational form are best-employed within firms they are *institutional complements* with (Gürpinar, 2016a), as they are *intrinsically motivated* (Deci/Ryan, 2000; Green/Lepper, 1978) when the matching is positively assortative.

(III)—A third line of reasoning lies in between and partially reconciles these two explanations. As the quest for efficiency requires discretional power to be delegated with the knowledge that is most valuable to any specific decision (Jensen/Meckling, 1990), the proper allocation of *decision rights* (Anghion/Tirole, 1997; Owan, 2011) within a "liquified" hierarchy profoundly differs from that characterising a traditional, Tayloristic-like chain of command. Not only: as Josselin and Marciano (2007: 73) points out « delegation […] generates problems that transcend the context of delegation […] most of the time, agents granted with the right of *juris dictio* go beyond the limits of their prerogatives to achieve the objectives assigned by the principals ». With this respect, any setting characterised by prominent level of conflict would be potentially jeopardised by an increase in the agents' autonomy, (Mohr/Zoghi, 2007), in a way that the $T \rightarrow H$ transition would be hardly explicable under the "political" profile.

This is where the two stories recounted above (I and II) meet and melt together, as the *motivational externalities* resulting from the positive mating between workers and firms provides the process of organisational change with a power-compatible institutional structure (a renewed understanding of the rules of the game), simultaneously accounting for the most productive usage of intensively educated human assets.

Considering a theoretical framework of this sort, the $T \rightarrow H$ historical process can be outlined as follows. While the educational boom following WWII unravelled the knowledge-relations between production-workers and decision-makers (Garicano, 2000)[11], foreseeing

[10] Historical evidences on the diffusion of Taylorism in the USA at the beginning of the 20th century proves the consistency of such view (Coriat, 1979). Back then, employers were confronted with a massive labour-force of uneducated immigrants who could barely speak English. Hence, the only efficient organisational arrangement was one where each worker was attached to a specified job, the timing and modes of execution of which were rigidly prescribed and the variance of internal communications minimised as to reduce the array of interpretation possibilities employees were confronted with.

[11] As both Thomas Hodgskin (1967: 98) and Alfred Marshall (1975, II: 23) already maintained almost two centuries ago, « the wide spread of education among [workers] diminishes daily the value of the labour and skill of almost

entrepreneurs started to envisage the implicit value of investing in holistic assets. In the meantime—as the "anti-Taylorism" protest *signalled* the emergence of "democratic aspirations"[12]—they also realised that this value would have been dissipated in case the organisation of labour did not accommodate the workers' claims, as the returns from *motivational externalities* would have gone missing. Within a continuum of hypothetical institutional arrangements, the feasibility of a new equilibrium started to be perceived, where the latter's optimality was identified at the intersection of utility-maximisation and conflict-minimisation, or—alternatively—in correspondence of the locus where a new cognitive equilibrium was to be set. Boltanski and Chiappello (2005) interprets the process we have just described as the crystallisation of a "new spirit of capitalism", a discourse or ideology[13] which normatively defined a "self-reinforcing" institutional apparatus for which the new typology of employees were committed to engage in production.

3 An evolutionary model

3.1 Setting and assumptions

Consider a model economy populated by M firms and N workers, where M and N are normalised to unit. Each population is composed of two types of heterogenous individuals, the strategy of whom is "genetically" determined by their cultural or organisational genome[14]. We assume the M-population to consist in a portion $p \in [0, 1]$ of *holistic* firms H and a portion $(1 - p)$ of *Tayloristic* firms T. Similarly, the N population is composed of a portion $q \in [0, 1]$ of *flexible* workers F and a portion $(1 - q)$ of *employer* workers E. The economy is also inhabited by a population W of professional *decision-makers* who are fully specialised in functions of conception and supervision. In the following, this latter "specie" will be taken as exogenous and will not enter but indirectly in the evolutionary game, though its presence is key to the structure of the model.

H and T firms differ in the way they organise and discipline labour, where we define their heterogeneity across three interrelated domains: (i) as concerns the internal division of tasks,

all masters and employers by increasing the number of persons who possess their peculiar knowledge » since « the sagacity, the energy, the firmness of character and the technical skill that are required for the successful conduct of business [are] the exclusive property of no one grade of society [for they] are acquired by almost any man who has a good general education ». Remarkably, Marshall used to intend educational improvements as a "general progress of society" (Marshall, 2013: 365-9), as a "free gift" due to no private expense, so that extra-profits deriving from a better educated labour-force are « to be regarded as rent for all purposes » (ivi: 368).

[12] For a definition, see footnote 4 (infra: 2).

[13] In institutional terms, (Aoki, 2001: 241, 271) discourses—just like ideologies—are sets of ideas which compete to alter or maintain the institutional matrix by proposing competing systems of shared believes.

[14] Later, we shall discuss how such genomes are acquired and update.

(ii) the kind of monitoring employed and (iii) the allocation of decision rights within the structure of the hierarchy. More precisely, we assume the following:

Definition 1—Tayloristic firms rigidly separate conception and execution and assign different functionaries (decision-makers/workers) to different activities. To model the idea that the T-model implies a surplus of hierarchical layers *vis-à-vis* the H-model, we assume that the entire W population is employed in T-firms. As a partition of this sort requires the implementation of decisions to be carefully appraised, tight monitoring is accordingly adopted.

Definition 2—Holistic firms allow their agents to freely allocate their productive time across conception and execution (decision rights) as to maximise the *density* of cognitive interactions (Lazaric/Raybaut, 2005: 400-4). Outcomes are evaluated at the end of each productive period and workers are encouraged to engage in functions of reciprocal supervision, while middle-clusters of problem-solvers and overseers are eliminated[15, 16].

Workers, in turn, are heterogenous under a twofold, though interconnected profile. More specifically:

Definition 3—workers differ as far as their human capital is concerned, with the F-types possessing an initial endowment of versatile skills across both conception and execution—generic/portable human capital (Wasmer, 2006; Berton et. al, 2016)—and the E-types who are solely endowed with expertise in execution.

Definition 4—as different capabilities entail different expectations and tastes, we assume the F-types to hold specific *preferences* over the organisation of work, thus favouring multiskilling, soft power and teamwork as an organisational structure, whereas the E-types do not possess any inclination regarding the working activity.

Formally, we express the payoffs for the F-agents as follows,

$$\pi_H^F = w + bp - e_h \tag{1.1}$$

$$\pi_T^F = w - h - (e_l + m\delta 1) \tag{1.2}$$

where π_H^F is the payoff function when a *flexible* worker is matched with a *holistic* firm and

[15] Simplifications of this sort may seem limiting or too abstract. We are aware that all organisations employ specific functionaries exclusively assigned to conception and supervision solely. Nevertheless, as we posit that firms similar to our H-types employ less clusters of decision-makers and overseers vis-à-vis other kind of organisational forms, we conjecture that the essential of our argument is not prejudicated.

[16] Sure enough, the adoption of different monitoring technologies does not solely stem from efficiency-oriented considerations, as it must be sustained (ex-ante) by different expectations regarding the workers' attitude and behaviour. It may be said that T-firms arrange their organisational setup from an "antagonistic", *theory-X* mindset (McGregor, 1960), while H-firms move from a more cooperative, *theory-Y* viewpoint. Remarkably, as the tightness of monitoring is likely to play a key role in determining the degree of conflict within the firm, both theories act as self-fulfilling prophecy.

π_T^F represents her payoff when she is matched with a T-firm. We assume the workers' utility to depend positively on the wage w and negatively on the effort e, where $e \in [e_l, e_h], \delta 1 = e_h - e_l$ and b is a benefit parameter whose interpretation is the following. First, as *flexible* employees explicitly favour the holistic organisation of work, they are *intrinsically motivated* when employed in H-firms, thereby providing the optimal effort level e_h when coupled with the latter. Conversely, they suffer a psychological disutility h when employed in T-organisations. As such, we let the intensity of their effort when employed in T-firms to depend positively upon the effectiveness of the monitoring technology m, where $0 \leq m \leq 1$[17]. Second, we assume the F-types to benefit from working in H-firms as they foster their *general human capital* by improving their multi-skilling and versatility. By doing this, they also become more valuable to the remainder of H-firms in the outside market, thus improving their *fallback position* in case their incumbent occupation should be terminated. To model this idea, we let the benefit b to depend positively on the fraction p of holistic firms in the market.

Payoff functions for N-agents playing strategy E are,

$$\pi_H^E = w - [e_l + (pq)^\gamma \delta 1] \tag{2.1}$$

$$\pi_T^E = w - (e_l + m\delta 1) \tag{2.2}$$

where the interpretation of the parameters is identical to that provided above, with a single caveat. We assume the effort supply of the E-types working in the H firms to depend upon the twofold influence that the F-types play on their behaviour. On the one hand, we posit the presence of a significant share of intrinsically-motivated workers as having a *trickle-down,* virtuous effect on the remainder of the labour force. On the other hand, as H-firms assign projects to teams that enjoy a significant degree of discretionality and performances are evaluated only post-facto, *peer-to-peer* monitoring is likely to arise, in that workers engage in functions of reciprocal supervision that burden the organisation with no extra-costs and subtract no time to production. To model this idea, we let the E-types' effort to depend positively upon $(pq)^\gamma$, which is a *network effect* that captures the disciplinary benefit of an increase in the fraction pq of the F-workers employed in H firms[18]. As the discipline environment may benefit from organisational economies independently from the composition

[17] Throughout the paper, we shall take m as exogenous. The idea is borrowed from the various variants of the "shirking model" (Shapiro/Stiglitz, 1984; Bowles/Gintis, 1999), where the level of commitment is determined by the probability of being caught shirking and, accordingly, of being fired.

[18] For simplicity, we assume the two types of workers to be *uniformly* distributed across the firms composing the T and H industries (their distribution function has $\sigma = 0$), so that an increase in pq produces a homogenous effect in each individual company. This allows our formal exposition to treat the two industries (H and T) as a whole.

of its labour-force[19], we allow the exogenously given $\gamma \in [0, 1]$ parameter to further increase the network effect—for $\gamma < 1$.

As the discussion unfolded hitherto should have made clear, there exists an *institutional complementarity* (Aoki, 2001: 225-30; Pagano/ Rossi, 2004; Pagano, 2007c; Gürpinar, 2016b) between flexible preferences and holistic organisations. As such, the following proposition holds:

PROPOSITION 1—*within the worker's population N, the benefit from belonging to the flexible type F increases when the latter is matched with a holistic firm H, that is, when H instead of T is selected in M.*

Proposition 1 can be summarised by the following relation, which also formalises its conditions of existence: $\pi_H^F - \pi_H^E \geq \pi_T^F - \pi_T^E \Leftrightarrow bp + E \geq -h$;

where $E = [(pq)^\gamma - 1]\ \delta 1$.

Turning to the firms' side, payoff functions for *M* agents playing strategy *H* are,

$$\pi_F^H = B_F + lpq - w \tag{3.1}$$

$$\pi_E^H = B_E + lpq - w \tag{3.2}$$

where B_F and B_E are individual benefits when a *holistic* firm is matched with a *flexible* and an *employer* worker respectively and lpq represents a *network effect* akin to that described above, with the following qualification. There, the complementarity between *H*-firms and *F*-workers was assumed to produce a virtuous effect on the firm's discipline environment. Here, lpq is understood as capturing the non-additive outcome of the *F*-types' *intellectual* cooperation, where l measures the magnitude of the effect.

Payoff functions for *T*-agents are,

$$\pi_F^T = \pi_E^T = B_n + B_W - (1 + G)w - c_m \tag{4}$$

where B_n is the individual benefit when a *Tayloristic* firm is matched with a *flexible* and an *employer* worker indifferently[20], B_W is the benefit from hiring additional clusters of decision

[19] In the previous section, we maintained that the $T \rightarrow H$ organisational change was intendedly designed to meet the claims expressed by the discontent emerged during the 60s and 70s towards the Tayloristic organisation of labour. In that, we assumed that *hierarchical delayering* and a *flexible division of tasks* were strategically adopted to meet the *F*-types' emerging preferences so that the improved quality of their human capital was entirely valorised. Consequently, $\gamma < 1$ may be understood as a byproduct of such strategy, as the *E*-types are likely to enjoy—at least partly—the same psychological benefits that the *F*-types derive from being employed in *H*-firms.

[20] A significant implication of our assumptions is worth stressing. In our setting, the Tayloristic division of labour nullifies the differentials in the workers' productivity across both conception and execution, so that *T*-organisations are indifferent to whom they are coupled with. Indeed, as the content of each task is rigidly defined *ex-ante* by decision-makers, comparative advantages in conception are offset. Accordingly, the combination of

makers and overseers[21], Gw is the wage perceived by decision-makers[22] and c_m represents monitoring costs. In what follows, we shall assume $B_W > B_F > B_n \geq B_E$. The reasoning behind such ordering is illustrated in Appendix B.

Intuitively, it should be evident that the complementarity explored by proposition 1 runs both ways, so that the following proposition can be similarly advanced:

PROPOSITION 2—*in the organisational domain M, the benefit from belonging to the holistic type H increases if the H-type is matched with a flexible worker, that is, when F instead of E is selected in N.*

Proposition 2 can be summarised by the following relation, which also formalises its conditions of existence: $\pi_F^H - \pi_F^T \geq \pi_E^H - \pi_E^T \Leftrightarrow B_F \geq B_E$.

Table 1 below summarises the payoff matrix.

	F	***E***
H	$B_F + lpq - w$; $w + bp - e_h$	$B_E + lpq - w$; $w - [e_l + (pq)^\gamma \delta 1]$
T	$B_n + B_W - (1+G)w - c_m$; $w - h - (e_l + m\delta 1)$	$B_n + B_W - (1+G)w - c_m$; $w - (e_l + m\delta 1)$

TABLE 1: Payoffs

3.2 Multiple equilibria and stability

After having described the static conditions of our model economy, we now proceed to the analysis of its dynamics. Consider a random matching game where agents of the two population are coupled to engage in a productive activity. The workers' behaviour is determined by their cultural genome (F or E). Traits are instilled during the primary and secondary phases of socialisation (Bisin/Verdier, 2008). Asynchronous discrepancies between education and preferences may randomly occur with the exogenous emergence of new occupational tastes (*variation*). As steady states require consistency in expectations[23], conventions are established between skills and inclinations at the end of each "variation-

highly standardised routines with tight monitoring imposes a "machine-pace" (Taylor, 1911) to human inputs which unravel comparative advantages in execution.

[21] See footnote 15 (infra: 7).

[22] Where $G > 1$ is the *employment rent* (Bowles, 2006: 256) given to decision makers to secure their full participation.

[23] See infra: 3.

period". Cultural transmission is assumed to evolve in a *decentralised* fashion, as the agents of socialisation *react* to the outside economic incentives by endowing their pupils with the attributes (skills and preferences) the labour market rewarded in previous periods (*imitation*), so that workers' types mutate by best-responding to payoff-differences in the past.

Organisational forms are expected to evolve in a similar fashion, as specific investments are costly or even impossible to relocate and take considerable time to be re-adapted to a new setting. Since «"profit maximization" is *meaningless* as a guide to specifiable action [when] foresight is uncertain » (Alchian, 1950: 211), the firms' owners—or their representatives—*myopically*[24] choose the design which is expected to maximise efficiency by nonetheless remaining within the self-reinforcing range of their control. A mechanism of selection *à-la* Darwin will successively operate to determine which organisation is best equipped to survive. At the inception of each productive period, those firms that were thrown out of the market are replaced by a new family of enterprises which assume the form that had proved to be the most profitable in the preceding period[25].

Formally, we express the expected payoffs to M-agents as follows,

$$\pi^H = q(B_F + lpq - w) + (1-q)(B_E + lpq - w) \tag{5.1}$$

$$\pi^T = B_n + B_W - (1+G)w - c_m \tag{5.2}$$

while the expected payoffs of the N-agents are given by the functions,

$$\pi^F = p(w + bp - e_h) + (1-p)[w - h - (e_l + m\delta 1)] \tag{6.1}$$

$$\pi^E = p\{w - [e_l + (pq)^\gamma \delta 1]\} + (1-p)[w - (e_l + m\delta 1)] \tag{6.2}$$

As an outcome of the myopic updating process described above, *replicator dynamics* (Bowles, 2006) are given by the following system of ordinary differential equations in the state variables (p, q),

$$\dot{p} = p(1-p)\Delta M = p(1-p)(\pi^H - \pi^T) \tag{7a}$$

$$\dot{q} = q(1-q)\Delta N = q(1-q)(\pi^F - \pi^E) \tag{7b}$$

Substituting equations (5.1) and (5.2) in eq. $(7a)$ and equations (6.1) and (6.2) in eq. $(7b)$ and letting $\delta 2 = B_F - B_E$, $\delta 3 = B_E - (B_n + B_W)$ and $C = Gw + c_m$; we have

[24] For a discussion of myopias, inertia, bounded rationality and their place in evolutionary thinking, see Aoki (1998).

[25] It should be noted that imitative evolutionary mechanisms which drives both the agents of socialization and the new entrepreneurs is rather Lamarckian than Darwinian in its spirit. See footnote 8 (infra: 3).

$$\dot{p} = p(1-p)(q\delta 2 + \delta 3 + lpq + C) \tag{7.1}$$

$$\dot{q} = q(1-q)[p^2 b + p(h+\delta 1) - p^{1+\gamma} q^{\gamma} \delta 1 - h] \tag{7.2}$$

Recalling that rest points of the dynamics are obtained whenever $\dot{q} = 0 \cup \dot{p} = 0$, qualitive analysis of the phase plane proves the following:

PROPOSITION 3—*There are five stationary points for the best-response replicator dynamics. Among them, only one is Pareto-efficient* (*for both populations*) *and two are asymptotically stable. i.e. they are evolutionary equilibria.*

Proof: see Appendix A.

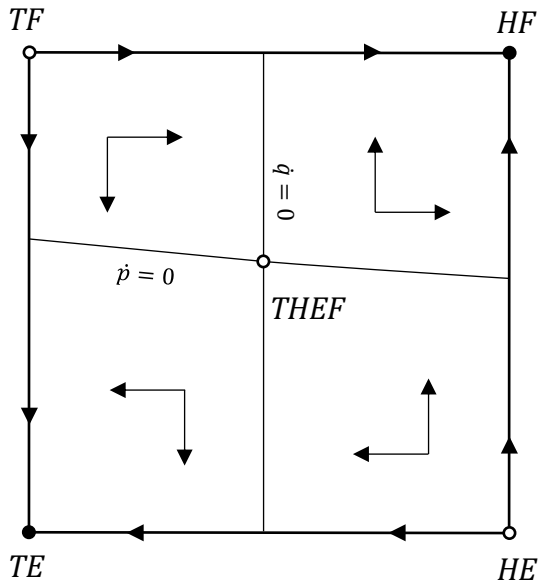

FIGURE 1: Topology

Equilibria	Conditions of Existence[26]	Stability
HF	$(p^*, q^*) = (1,1)$	*Stable*
TE	$(p^*, q^*) = (0,0)$	*Stable*
TF	$(p^*, q^*) = (0,1)$	*Unstable*
HE	$(p^*, q^*) = (1,0)$	*Unstable*
THEF	$(p^*, q^*) = [2(b - q\gamma\delta 1)]^{-1}\{-(h+\gamma\delta 1) \pm [(h+\gamma\delta 1)^2 + 4(b - q\gamma\delta 1)h]^{\frac{1}{2}}, -(\delta 3 + C)(\delta 2 + lp)^{-1}\}$	*Saddle*

TABLE 2: Equilibria and stability

[26] The interior fixed point is obtained by solving the system

$$\begin{cases} \Delta M = q\delta 2 + \delta 3 + lpq + C = 0 & (a) \\ \Delta N = p^2 b + p(h+\delta 1) - p^{1+\gamma} q^{\gamma} \delta 1 - h = 0 & (b) \end{cases}$$

Table 2 summarises the results[27], while figure 1 illustrates the topological properties of our evolutionary game. Therein, the white-dotted equilibria are asymptotically unstable, while the laws of motion of the state space are indicated by the arrows along and inside the diagram. The stability conditions are discussed in Appendix A. In figure 2, the A and B areas containing the evolutionary stable equilibria are their respective *basins of attraction*, which is to say, the sets of initial points that eventually converge towards the closest institutional attractor via replicator dynamics. The stable manifold of the saddle $THEF$ is the separatrix of the dynamical system.

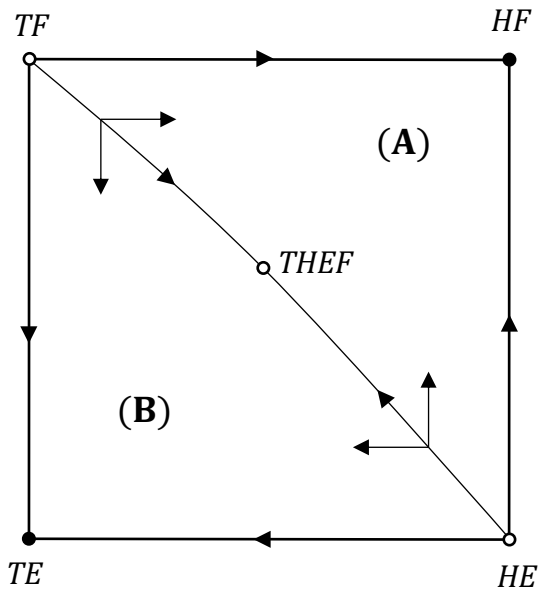

FIGURE 2: Basins of attraction

The next proposition provides with a more complete analysis of the Pareto-ranking of our five equilibria. Considering only the case where both organisations are successful in tackling their "disciplinary issue"—respectively, for $m = 1$ and $\gamma = 0$—the following proposition holds under the above assumptions:

PROPOSITION 4—*the Pareto ranking of the five equilibria displays a discrepancy between organisational efficiency* (*M-population's expected payoff*) *and workers' well-being* (*N-population's expected payoff*).

Proposition 4 can be summarised by the following relations:

$$N\text{-ranking: } HF \succ HE \succ THEF \succ TE \succ TF$$
$$M\text{-ranking: } HF \succ TE = TF \succ THEF \succ HE$$

[27] The following simulation values have been used for all tables and figures: $\delta 3 = -0.6, C = 0.4, \delta 2 = 0.3, l = 0.1, b = 0.3, h = 0.14, m = 1, \gamma = 0$.

It is worth noting that the global superiority of the HF equilibrium further demonstrates the existence of the institutional complementarities advanced in Proposition 1 and 2. In addition to that, it should be kept in mind that it is only the M-ranking which is informative about the productive status of the economy, though the payoffs that workers experience in production indirectly influence the process. On this latter point, two considerations follow. First, as long as the F-workers are intrinsically motivated (i.e., for $b > 0$), they provide with the optimal effort level e_h, so that their well-being has a positive impact on productive efficiency—which, incidentally, justifies the double Pareto-optimality of the HF equilibrium. Second, whenever $(pq)^{\gamma} < 1$, the E-types employed in H-organisations experience a "disruptive utility gain", as their cheating on their duties plays a negative effect on the efficiency of production[28], which explains the low position occupied by the HE equilibrium in the N ranking.

We wish to conclude this section by discussing an issue which is key to the purpose of a multiple-equilibria setting like ours, which is to say, by analysing the forces that determine which state the economy will converge to after the dynamics has extinguished his motion. Remember that the inception of our story is not indeterminate, as it is assumed to start within a TE scenario. Since a purely Darwinian setting is uniquely affected by the initial state of the system—or by the emergence of exogenous mutations—prohibitive critical variations in the two populations' composition must occur for the economy to jump from one basins of attraction to the other, as clearly suggested by the boundary in figure 2.

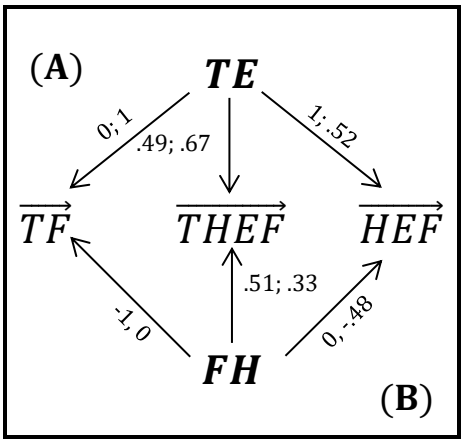

FIGURE 3: Costs of transition

Figure 3 illustrates further the required magnitude of such variations within a framework

[28] Remarkably, the HE-equilibrium ranks second in the N-ordering, as the workers' population improves its well-being by economising on its effort—so that its expected payoffs increases by $\delta 1 = e_h - e_l$. Unsurprisingly, this has a negative effect on the efficiency of production, as shown by the position where the HE-equilibrium is located in the M-ranking.

where the five equilibria are considered as the only possible states of the economy. Therein, the first number represents Δp and the second Δq, so that simultaneous mutations exceeding such thresholds transport the entire system from one basins of attraction to another. An ungraceful way to disentangle the dilemma would describe the specular changes in the two populations as unrelated variations. In such case, the simultaneous coevolution of the two terms of a unique complementarity would be depicted as a completely random phenomenon, whose magnitude is significant enough for dropping a hypothesis of this sort. Luckily, something more compelling can be advanced.

The extension presented in the next section concludes and solves the puzzle by introducing an element of *rational foresight* into the model (Krugman, 1991; Matsuyama, 1991), where self-fulfilling expectations divert the economy's dynamical path from its evolutionary track. Hitherto, social evolution has been chiefly discussed from a "Darwinish" viewpoint, where decentralised and inert mechanisms of selection and mutation were mainly used as explanatory devices. In the following, the Lamarckian character of our reasoning—which up to here was limited to the assumption of intra-population imitative behaviours[29]—is reinforced by introducing almost-rational responses to environmental changes. Indeed, while the Darwinian component of our argument is maintained by understanding the exogenous emergence of the F-types as producing an *alteration* in the context of embeddedness, the introduction of creativity as an intended response to the mutating conditions of the outside economic incentives strengthens the Lamarckian feature of our argument[30].

3.3 Extension A: history and expectations

As the previous section has already argued, the $E \rightarrow F$ *mutation* alone cannot account for the process of organisational change which led from a Tayloristic to a holistic division of labour, as the stability of the T-system is not affected by variations in the labour-force composition unless these reach the prohibitively critical thresholds depicted in figure 3. Should evolutionary best-response be the only dynamics operating in the system, the potential utility-gains entailed by the $T \rightarrow H$ transition would be likely to remain unexploited, with the workers' well-being that keep declining as their claims remain unmet.

To model a deviation from such "evolutionary trap", we follow the Krugman-Matsuyama history-versus-expectations story by allowing a random subset of the M population

[29] See footnote 8 (infra: 3)

[30] Incidentally, we believe that the "environment ad*o*pts" versus "agency ad*a*pt" (Alchian, 1950) controversy—which may be also relabelled as the Darwin versus Lamarck dilemma—is partly unproductive, as there exists an almost inseparable interplay between the two poles of this tension.

(innovators) to correctly perceive the implicit value B^H of adopting an H rather than a T organisational structure, so that the growth-rate of foreseeing innovators investing in H is rising for $B^H > 0$ and is falling for $B^H < 0$. Furthermore, as the future returns from possessing the holistic asset chiefly depend upon the F-types' expected growth, we endow the innovative group with a subjective appraisal of the latter, so that a further dynamical element is introduced in determining entrepreneurial decisions[31]. Q represents the estimation, so that $Q\dot{B^H}$ defines the rate of capital gains on the shadow asset[32].

Thus, the organisational value of an H firm is determined at the level where the current income from investing in such form equals the wealth obtainable from riskless properties. From a formal viewpoint,

$$Q\dot{B}^H + \Delta M = rB^H \tag{8.1}$$

Where $r > 0$ is the interest rate on safe stocks and $\Delta M = \pi^H - \pi^T = q\delta 2 + \delta 3 + lpq + C$ represents the difference in earnings between H and T-entrepreneurs. Rearranging, we obtain the following system of ordinary differential equations, which describes the expectations-based dynamics in the state space (p, B^H),

$$\dot{p} = \alpha B^H \tag{9.1}$$

$$\dot{B^H} = Q^{-1}(rB^H - \Delta M) \tag{9.2}$$

Where $\alpha \in [0, 1]$ is the entrepreneurial spirit in the economy, or—alternatively—the size of the foreseeing group. Hence, the following proposition holds:

PROPOSITION 5—*while payoff-based dynamics cannot explain the $T \to H$ transition, expectations-based dynamics does. Indeed, if entrepreneurs can correctly foresee the growth rate of the F types ($Q > 0$) and/or the transition's implicit value ($\partial\Delta M/\partial p > 0$), the path diverges towards the HF Pareto-optimal equilibrium even when its starting point lies outside the HF's basin of attraction.*

Proof: see Appendix B.

Additionally, we assume the foreseeing entrepreneurs to implement a set of complementary policies to secure the value of their investment, where we define the latter as a combination of two elements: (i) a *selection strategy*, according to which the applicants' type is

[31] One may understand these perceptions as being based on the conjoint observation of the average educational level in the outside society and of the (dis)satisfaction workers enjoy in production, so that the discontent expressed in between the 60s and the 70s can be interpreted as *signalling* the F-types' emergence.

[32] As foresights may not correspond to the actual growth-rate of the H-types, a significant element of bounded rationality (myopia) is maintained.

carefully appraised; and (ii) a *training strategy*, as to correct the potential mismatches and instil a sense of belonging into the new members of the organisation. The outcome of this twofold, *high-road* policy is to provide the foreseeing organisations with a labour-force homogenously composed of F-types. Remarkably, this leads to the emergence of an organisational *niche*, the survival of which is independent from the evolutionary pressure of the outside economic environment. Conversely, the latter may react by *imitating* the successful strategy implemented by the group of innovators, which act as a *reagent* for the general progress of organisational change[33].

One concluding, though fundamental remark is worth noting. While our story may seem to unfold within a sort of institutional vacuum, where neither the features of the employment regulation nor those of the labour market appears to influence the evolutionary dynamic, we are aware of the key influence that they both play on the process we have been describing. Indeed, if labour markets are tight and workers are mobile, payoff-based replication may freely drive the adjustment process by transporting the system from a TE to a HF equilibrium, as the labour force reacts to the outside well-being incentives by moving towards those industries or firms that provide with the holistic benefits. Conversely, in the presence of excessive labour supply and involuntary unemployment, the diffusion of the H-model may be significantly slowed or even impeded, as the stickiness of labour mobility distances holistic organisations form the kind of employees they are complement with. Accordingly, the introduction of legal disincentives to the pursue of T-organisational strategies (e.g., high labour standards) or the presence of strong countervailing powers are likely to enhance the speed of the $T \rightarrow H$ transition, while an opposite framework may blur the entrepreneurial foreseeing capacity by providing organisations with a handy, short-termed strategy. To conclude, geographical and industrial discontinuities in the pace and path of evolution are straightforwardly explained by these kind of institutional barriers, whose outmoded or forward-looking interplay play a substantial role in determining both payoff-based and rational replication.

3.4 Extension B: integrated production processes

The framework developed hitherto was designed to describe the coevolution of worker's types and organisational forms, with the relevant shortcoming of abstracting (i) from the qualities of the goods being produced and (ii) from the eventuality of intra-firms integration

[33] In the following, we shall implicitly assume that an affine reasoning can be applied to the N-population, where a random subset of the agents of socialisation (infra: 11) is assumed to perceive the implicit value of possessing an F rather than an E cultural endowment, so that the expectations-based dynamics described by proposition 5 holds for both populations.

and exchange[34]. By relaxing this twofold limitation, we allow our setting to fit more realistic production processes, the phases of which unfold within chains connecting diverse organisations specialised in complementary activities (Jones, 2011). Furthermore, should organisations have a comparative advantage in specific activities vis-à-vis the remainder of the industrial population, the division of labour at the *social* and at the *technical* level (Vincent-Lancrin, 2003) are likely to influence and integrate each other. To enter the framework and provide with an opening glimpse of what we have in mind, consider the following. Previously, we held the HF complementarity responsible for blurring the separation between conception and execution at the *organisational* level, while nothing was said about what happens at a higher scale. As trivial as it may seem, our contention is that firms employing a better-skilled and motivated labour force are likely to have a comparative advantage in creative and complex activities, therefore reproducing the partition between knowledge-production and raw-labour from the firm to the market level[35].

In this section, we discuss the case in which two diverse economies (industries/countries) historically stabilised at the HF and TE-equilibria respectively coexist and interplay, where the respective compositions of the workers' populations are taken as exogenously fixed. Furthermore, we assume the HF-economy to be specialised in knowledge-intensive productions, while the TE-one manufactures intermediate goods (Schwarz/Suedekum, 2014)[36]. The environment is one where *inter-organisational externalities* result from the complementarity between the T and the H-products. The game is random-matching and firms are coupled to produce a single unit of a complex output. Expected payoffs are formalised as follows,

$$\Pi_{HF} = \pi^H + (1-n)a_1\pi^T \tag{10.1}$$

$$\Pi_{TE} = \pi^T + na_2\pi^H \tag{10.2}$$

Where n and $(1-n)$ represent the relative magnitude of the two economies, π^H and π^T

[34] Among the other shortcomings of the model, one is particularly worth considering, namely, that referred to the impact of *technological change* upon the structure of our assumptions. Appendix C provides with a rough extension on this.

[35] The idea is strongly complementary to that expressed in Pagano (2007a), where the "revenge" of a "global Taylorism" based on the unequal accumulation of intellectual property rights rigidly separates conception and execution at the world-market level. Within such framework, discrepancies in the qualities of different labour-forces (technological-domain) may be further reinforced by discrepancies in the initial endowments of IPRs (legal-domain), so that underdeveloped countries may be locked in a "poverty trap", where self-reinforcing complementarities between technology and rights (Pagano/Rowthorn, 1994) make the stability of the system (interior equilibrium) difficult to upset.

[36] As the purpose of the section partly exceeds the paper's general aim, we kept the formalisation as simple as possible by avoiding modelling the type of production each organisation specialises in. Despite its simplicity, we believe the discussion to carry the essentiality of our intuition.

are the payoffs they enjoy in production—as defined by eq. (6.1) and (6.2)—and the a_1 and a_2 parameters capture the degree of dependence/interrelatedness of each production with respect the other, in a way that players benefit from the latter's well-being (payoff). To keep consistency with the biological metaphor adopted hitherto, complementary organisations may be understood as *symbionts* which fruitfully inhabit the same environment, though their co-existence is not key to their baseline survival. Indeed, it is worth noting that the above modelling implies that each economy may subsist in the absence of the other, though Pareto-optimality can be only achieved via organisational diversity. Homogenous matchings ($HH - TT$) can be interpreted as producing a zero-level of interaction between the players, so that firms operating in correspondence of the corner equilibria $n^* = 0$; $n^* = 1$ handle their production-process from the staples to the final goods.

$$\dot{n} = n(1-n)[\pi^H - (1-a_1)\pi^T - n(a_1\pi^T + a_2\pi^H)] \qquad (11.1)$$

Equation (11.1) describes the replicator dynamics of this one-dimensional system, whose topology yields an intuitive and economically meaningful result. We summarise it in the following proposition:

PROPOSITION 6—*in the presence of integrated production process and intra-firms comparative advantages, organisational diversity represents the only evolutionary (asymptotically stable) equilibrium, while both corner equilibria* ($n^* = 0$; $n^* = 1$) *are unstable and converge towards the unique attractor in* $n^* = (a_1\pi^T + a_2\pi^H)^{-1}[\pi^H - (1-a_1)\pi^T]$.

Proof: See Appendix A.

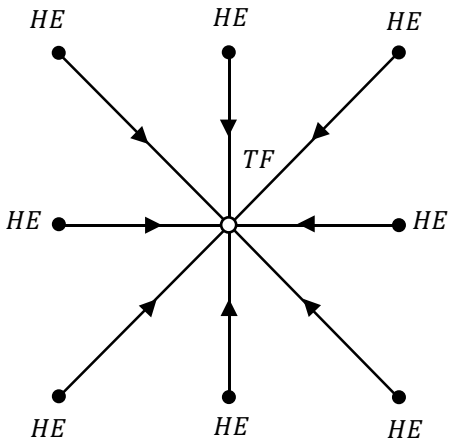

FIGURE 4: Stylization of the intra-organisational game

Figure 4 reports a stylization of the intra-organisational integration, where we assume $a_1 \ll a_2$ to model a twofold idea: (i) the HF-economy (hub) conceptualises and assembles complex products requiring multiple Tayloristically-produced components, while (ii) the

industries populating the TE-economy are intensively dependent on the contracts they have with the central hub. Figure 5 illustrates the evolution of payoffs as a function of the population's composition, where the arrows on the y-axis display the laws of motion of the system.

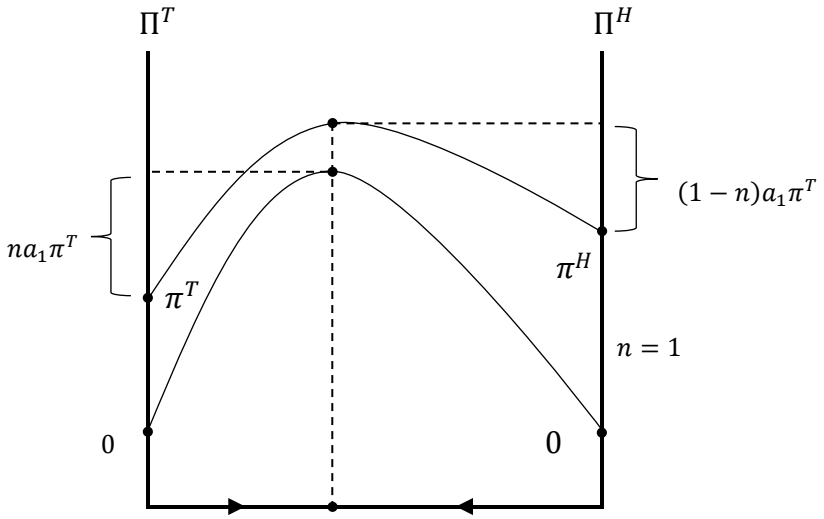

FIGURE 5: Frequency-dependent payoffs in the intra-organisational game

The framework developed in this section tentatively frames our model within a broader picture, despite the results it yields raise further issues that cannot be tackled in here, e.g. worker's mobility, labour-markets integrability and so forth, whose complexity deserves further attention that potentially suggest directions for future research.

4. Conclusions

We wish to conclude the present paper by discussing the empirical relevance of our model. Indeed, the picture depicted hitherto may rightfully seems at odds with some of the empirics that characterise the contemporary organisation of work, where managerial control over the workers' activity seems to have increased rather than decreased[37] and the decency of working conditions has been gravely undermined by the de-regulation of employment standards and protection (Supiot, 1999; Eurofound, 2002, 2010, 2012). Within a framework of this sort, the efficiency-oriented practices transplanted from the Japanese model (multi-

[37] Pohjola (1996) discusses the relationship between workers' well-being and the new models of production, where he sees no evidence—neither theoretical nor empirical—of an unambiguous correlation between the two. Indeed, while some pieces of literature interpret the "Japanese practices" as enhancing the workers' sense of belonging and commitment—therefore pointing towards a more co-operative model of industrial relations—some other insist on the "digitally Tayloristic" (Parenti, 2001) features of the model, where the adoption of ICTs increases the tightness of monitoring and the level of hierarchical pressure. The very existence of this ambiguity also attracted some significant attention from the public debate (Kantor/Streitfeld, 2015; Sparrow, 2015). As a robust conclusion is yet to be drawn, Pohjola (1996: 150) provisionally highlights a dimension which is also key to the argument developed in here, namely, that « we should not view the situation merely as a problem of industrial engineering but as one of social control ».

tasking, job-rotation etc.) are often de-bundled from the welfare-enhancing ones (decision rights, workers' voice, lifetime employment etc.) and combined with the exacerbation of monitoring and control[38], so that the hybrid which results is best-viewed as relying on a T rather than an H institutional arrangement[39]. In such context, one may challenge the validity of the story recounted in here by claiming that the existence of "good" and "smart" organisations that willfully adapt their structure to meet the emerging preferences of a mutating labour-force is at least striking if confronted to the topicality of organisational practices.

Nonetheless, although these *low-road*[40] (Gordon, 1994) patterns seem to constitute a significant trend in nowadays OECD economies, the presence and persistence of *high-road* experiences (Kochan, 2015)—which often present a productive profile which is at least as good as that characterizing their more "antagonistic" competitors—suggests the existence of some interior equilibrium in organisational variety. Whether we allow the mechanism of equilibrium selection to depend upon the action of the replicator, or, alternatively, upon the dynamic-expectations framework outlined in extension A[41], the model is versatile enough to escape the deterministic oscillation between dichotomic regimes (TE/HF) and account for intermediate scenarios where both model coexist. Furthermore, the very existence of this mixed settings suggests—discursively—some degree of "stickiness" in the process of organisational innovation, as more conservative entrepreneurs may be reluctant to invest in the development of new structures and routines which decrease the span of their control over their (human and non-human) assets (Pagano/Rowthorn, 1994), thus witnessing how profoundly "fettered" the productive potentials of our society is by the specifically capitalist institutional structure of our economy (Bowles, 1985). As Veblen (1914: 25) famously wrote «history records […] spectacular instances of the triumph of imbecile institutions over life and culture». Within a framework where the knowledge in possession of the workers is increasingly key to the fostering of competitiveness, the purse of low-road patterns in organisational development may precisely constitutes one of the instances of such institutional imbecility.

[38] Doeringer et al. (2003) provide with an empirical analysis of these "selective transplants" to draw the following conclusion: despite the national heterogeneity in the patterns of adoption, the most commonly transplanted practices are those related to productive efficiency, while compensation and punishment schemes seem to display higher resilience.

[39] This is to stress the idea that it is not in the spirit of this paper to claim that whichever innovation vaguely resembling a "Japanese routine" automatically ascribes the organisation which adopts to the H-type.

[40] We take the liberty to map the low-road/high-road juxtaposition into our T-H distinction. We feel the core of our argument as being perfectly aligned with that presented in Gordon (1994, 1996).

[41] Where a subset of foreseeing entrepreneurs succeeds in escaping the low-trap of the T equilibria (TE and TEF) and creates a *niche* whose survival depends on the time-consistency of their self-fulfilling foresights.

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Appendix A: Proofs

Proof of Proposition 3

(a) is the characteristic polynomial of the system defined by eq. (7.1) and (7.2),

$$\lambda^2 - \lambda\left(\frac{\partial \dot{p}}{\partial p} + \frac{\partial \dot{q}}{\partial q}\right) + \left(\frac{\partial \dot{p}}{\partial p}\right)\left(\frac{\partial \dot{q}}{\partial q}\right) - \left(\frac{\partial \dot{p}}{\partial q}\right)\left(\frac{\partial \dot{q}}{\partial p}\right) \qquad (a)$$

while (b) provides a sufficient condition for its dynamical stability,

$$\left(\frac{\partial \dot{p}}{\partial p} + \frac{\partial \dot{q}}{\partial q}\right) < 0 \cup \left(\frac{\partial \dot{p}}{\partial p}\right)\left(\frac{\partial \dot{q}}{\partial q}\right) - \left(\frac{\partial \dot{q}}{\partial p}\right)\left(\frac{\partial \dot{p}}{\partial q}\right) \geq 0 \Leftrightarrow \frac{\partial \dot{p}}{\partial p} \leq 0 \cup \frac{\partial \dot{q}}{\partial q} \leq 0 \qquad (b)$$

The topological properties of the phase plane are obtained by evaluating the Jacobian matrix at each equilibrium point, where J results in:

$$\frac{\partial \dot{p}}{\partial p} = -3lqp^2 - 2p[q(\delta 2 - l) + \delta 3 + C] + q\delta 2 + \delta 3 + C \qquad (c.1)$$
$$\frac{\partial \dot{p}}{\partial q} = p(1-p)(lp + \delta 2) \qquad (c.2)$$
$$\frac{\partial \dot{q}}{\partial p} = (1-q)q[-d(\gamma)p^{\gamma}q^{\gamma} + 2bp + h] \qquad (c.3)$$
$$\frac{\partial \dot{q}}{\partial q} = (2q-1)\{p[\delta 1(q^{\gamma}p^{\gamma} - 1) - bp - h] + h\} + \delta 1\gamma p^{\gamma+1}(q-1)q^{\gamma} \qquad (c.4)$$

Table 3 summarises the stability conditions of the two evolutionary equilibria (TE and HF) and proves the instability of the nodes TF and HE. The qualitative nature of $THEF$ (saddle) was obtained numerically by plugging a set of simulation values into J. The values were selected as to fit the two stability conditions $l + B_F > B_W + B_n - C$ and $-\delta 3 > C$. Incidentally, these very values were also used for all tables and figures (see infra: 12, footnote 27). Note that both $\partial \dot{q} / \partial p$ and $\partial \dot{q} / \partial q$ have been written simplified for $\gamma = 0$. The optimal values of p^* and q^* were obtained by solving the system described in footnote 26 (infra: 12).

Equilibria	Jacobian Matrix	Conditions
HF	$\begin{pmatrix} -l-\delta 2-\delta 3-C & 0 \\ 0 & -b \end{pmatrix}$	$l+B_F > B_W + B_n - C$ [42]
TE	$\begin{pmatrix} \delta 3+C & 0 \\ 0 & -h \end{pmatrix}$	$-\delta 3 > C$ [43]
TF	$\begin{pmatrix} \delta 2+\delta 3+C & 0 \\ 0 & h \end{pmatrix}$	/
HE	$\begin{pmatrix} -\delta 3-C & 0 \\ 0 & \delta 1+b \end{pmatrix}$	/
$THEF$	$\begin{pmatrix} -3lqp^2-2p[q(\delta 2-l)+\delta 3+C]+q\delta 2+\delta 3+C & p(1-p)(lp+\delta 2) \\ q(q-1)(-2bp-h) & (2q-1)[p(bp-h)+h] \end{pmatrix}$	/

TABLE 3: Stability conditions

Proof of Proposition 5

The characteristic roots of the system described by equations (9.1) and (9.2) are $\lambda = 1/2\,[rQ^{-1} \pm [(rQ^{-1})^2 - 4\alpha Q^{-1} lq]^{\frac{1}{2}}$, the solutions of which imply the four scenarios summarised in table 4.

	$\boldsymbol{q_{(t)} > 0;\ 0 \le p_{(t)} \le 1;\ q_{(t)}}$	$\boldsymbol{q_{(t)} = 0;\ 0 \le p_{(t)} \le 1;\ q_{(t)}}$
$\boldsymbol{Q > 0}$	(I) → Complex roots, positive real parts	(III) → One positive root
	Unstable (spiral point)[44]	*Unstable* (proper node)
$\boldsymbol{Q < 0}$	(II) → One negative and one positive root	(IV) → One negative root, linearly independent eigenvectors
	Unstable (saddle point)	*Stable* (proper node)

TABLE 4: Expectations-based dynamics

In IV, where $\partial\Delta M/\partial p = 0$ and $Q < 0$, the system is *stable* and does not diverge from its initial state, as the F-types' estimated growth is below the threshold for which innovators find profitable to endeavour in the process of organisational change. In III, though $\partial\Delta M/\partial p = 0$, $Q > 0$, so that $\dot{p} > 0$ and the system steadily diverges from its starting point[45]. In II, though

[42] Discursively, this condition can be interpreted as follows. The H-model outsets the T-model when the full benefit deriving from the HF complementarity $(l + B_F)$ exceeds the *net* benefit $(B_W + B_n - C)$ from adopting a T rather than an H-organisational form.

[43] When this condition holds, the extra-costs of monitoring (c_m in eq. 4, infra: 10) and personnel (Gw, ivi) born by the T-model do not cancel out the productive efficiency of a Tayloristic division of labour $(B_W + B_n)$, so that a T-form is organisationally rational.

[44] Note that we only consider the case in which $r^2/4Q\alpha < lq$, as the opposite would require: (i) the future to be unreasonably discounted $(r \gg 0)$; (ii) the F-types' expected growth to be almost insignificant $(Q \ll 1)$; (iii) the size of the foreseeing group to be extremely small $(\alpha \ll 1)$; (iv) the networking cooperation among the F-types to be almost unproductive $(l \to 0)$; (v) the outside presence of the F-types to be equally small $(q \ll 1)$. Specifically, conditions (ii) and (v) are economically unmeaningful in the present context, as we posited that innovators make investment decisions according to the outside status of the N population.

[45] This latter case entails a level of "Olympic" clairvoyance, as innovators are supposed to be capable not only of foreseeing the implicit value of the HF complementarity, but also to anticipate the very emergence of the F-types.

$\partial\Delta M/\partial p > 0$, $Q < 0$, which implies $\dot{p} < 0$, whereas, in I, where $Q > 0$ and $\partial\Delta M/\partial p > 0$, the system diverges from its centre in expanding oscillations. In all scenarios, should the expectations formed at t withstand throughout the unfolding of the dynamics, there exists a set of self-fulfilling prophecies for which the system eventually converges towards one of the nine equilibria. Specifically, in settings I and III and for $p_{(t)} = 0, \dot{p} > 0$, the system diverges from its evolutionary track and escapes the stability of the Tayloristic system even when the starting point of the dynamics lies outside the holistic basin of attraction; Q.E.D.

Proof of Proposition 6

Given the one-dimensionality of the system, the stability of equilibria requires $\partial\dot{n}/\partial n < 0$. For $n = 0$, $\partial\dot{n} = (a_1 - 1)\pi^T + \pi^H$. Evaluating π^H in HF and π^T in TE (see proposition 4) where $\pi^H > \pi^T$, the stability condition does not hold. For $n = 1$, $\partial\dot{n} = (a_2 + 1)\pi^H + \pi^T$, which clearly is > 0. As recalled by Bowles (2006: 81), in one-dimensional systems where pure strategies are both unstable there must exists an asymptotically stable interior equilibrium, in our case where $n^* = (a_1\pi^T + a_2\pi^H)^{-1}[\pi^H - (1 - a_1)\pi^T]$, Q.E.D.

Appendix B

Individual Benefits

The purpose of the present extension is to provide with the basic idea behind the assumption concerning the ordering of individual benefits ($B_W > B_F > B_n \geq B_E$). The intent is chiefly clarificatory, rather than analytical *per se*.

All firms are characterised by an only-human-inputs production function of the kind $\Theta^{\alpha}\Phi^{1-\alpha}$ (Caroli et al., 2001), where Θ represents conception and Φ execution. In the T-model, different functionaries (decision makers/production workers) are assigned to different activities (to conception and execution respectively), while the H-model entails no rigid separation between the two domains, so that agents are free to allocate their productive time $1 \leq \tau \leq 0$. In turn, agents differ in their idiosyncratic productivity (human capital) according to the following assumptions:

$$\vartheta^F > \vartheta^E \qquad (b)$$

$$\varphi^F > \varphi^E \qquad (c)$$

$$\vartheta^F/\vartheta^E > \varphi^F/\varphi^E \qquad (d)$$

where ϑ represents productivity in conception, φ represents productivity in execution and (d) models the idea that the F-types' comparative advantage is greater in domain Θ than it is in

domain Φ. Finally, we define individual benefits as a function of effort and productivity, where both are weighted according to the elasticity of production with respect to conception and execution activities. Remarkably, these are also dependent on the way labour is divided, as the F-types' intellectual productivity does not affect the T-outcome,

$$B_F = e_h\{(\tau\vartheta^F)^\alpha + [(1-\tau)\varphi^F]^{1-\alpha}\} \qquad (e)$$

$$B_E = [e_l + (pq)^\gamma \delta 1](\tau\vartheta^E)^\alpha + [(1-\tau)\varphi^E]^{1-\alpha}\} \qquad (f)$$

$$B_n = (e_l + m\delta 1)(\varphi^n)^{1-\beta} \qquad (g)$$

$$B_W = e_h(\vartheta^M)^\beta \qquad (h)$$

Where we assume $\vartheta^W > \vartheta^F > \vartheta^E$; $\varphi^F > \varphi^n \geq \varphi^E$, and $\alpha > \beta$, so that there exist a set of values for which $B_W > B_F > B_n \geq B_E$.

Appendix C

Extension C: Technology and skills

In this extension, we discuss the (key) role that the process of technical change plays in the story recounted hitherto. We are aware of the empirically recognised complementarity between skilled labour and ICTs (Krueger, 1993; Acemoglu, 1998; Bresnahan et al., 2002; Autor et a., 2013), whose strength has been amply understood as providing with a firm evidence to support the skill biased technical change hypothesis[46]. We see our results as complementary to this view, as all processes of economic change are *overdetermined* by the interplay of multiple and qualitatively diverse factors, where the social, technical, institutional and behavioural elements are largely indiscernible from one another. Below, we provide with a simple extension of the model to incorporate the technological factor among those influencing the process of organisational change. Though quite elementary, we see the modelling strategy as conveying the essential argument.

Consider an economy composed by n sectors, $i = 1, \dots, n$. Each sector is characterised by an idiosyncratic technological sensitivity $1 \leq k_i < 0$, where the parameter captures the degree of knowledge-intensiveness of the production process. Knowledge-intensive sectors are identified with low values of k, so that the n elements defining the knowledge-based economy are inversely ordered, from the most ($k_i \ll 1$) to the least ($k_i = 1$) elastic with respect to

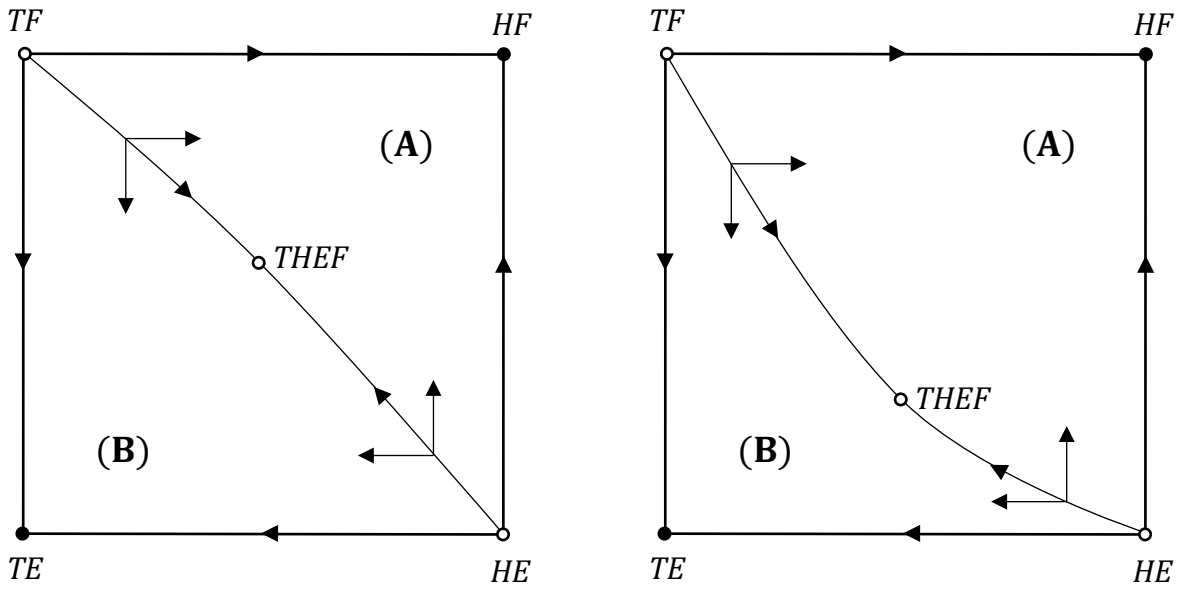
[46] Methodologically, we abstracted from the technological issue to isolate the object of our interest (the skills-preferences nexus) and analyse it in a tractable way. Obviously, this was not to underestimate or even ignore the prominent role of technology is a story as ours.

conception activities. k_i also captures the level of technological complexity of each sector and—accordingly—its sensitivity with respect to the workers' cognitive skills. Payoffs are therefore variable across sectors, as the institutional complementarity between H-organisations and F-workers is further reinforced by the technological nature of each productive process. Formally, we express the payoff of the two organisational forms in each sector as follows:

$$\Pi_i^H = q\Delta 2 + \frac{lpq}{k_i} - w \tag{12.1}$$

$$\Pi_i^T = \pi_T \tag{12.2}$$

Where Π_i^H is the expected payoff of an H-organisation operating in sector $i, \Delta 2 = \frac{B_F}{k_i} - B_E$ and π_T are Tayloristic average payoffs as defined by eq. (5.2)[47]. (12.2) formalise the idea that the T-organisation of labour is not affected by the technological component, as workers are entrusted with no decision right over their activity, which prevents their knowledge to have any effect on the outcome of production.



INDUSTRY 1: $k_1 = 1$ **INDUSTRY 2: $k_2 < 1$**

FIGURE 6: Technology, skills & organisation.

Figure 6 exemplifies our reasoning by showing how the complementarity between technology and skills affects the breadth of the two basins of attraction[48]. Two different industries characterised by decreasing values of k are represented, so that the knowledge-intensiveness

[47] Infra: 11.
[48] An increase in $\delta 2$ and/or lp shifts $THEF$ downwards, thus enlarging the holistic basin of attraction. Note that the latter is also enlarged if b increases and/or if h decreases.

of their production process are ranked from the lowest (industry 1) to the highest (industry 2). The qualitative nature of the phase plane is not affected by such changes.

a Cross-industry heterogeneity in the breadth of the H-basins of attraction allows our framework to account for an organisational division of labour (at the *social* level) where the H model tends to concentrate in knowledge-intensive sectors[49], thus depicting a scenario where the complementarity between skills, preferences and technological change can explain the "bio-diversity" of organisational practices[50]. Although the reasoning developed in here is far from being exhaustive, it may provide with a starting point to incorporate our setting within a broader (and already investigated) picture. Furthermore, it may shed some additional light upon the inequality characterising a knowledge-based economy (Lindbeck/Snower, 1996; Garicano/Rossi-Hansberg, 2006). Indeed, when both instrinsic and extrinsic aspirations are considered, the gap between those occupying the top and the bottom of the job ladder is likely to expand, and so is that between high and low-road practices. We believe there is room for future research in analysing the degree of congruence between the two gaps, or, in other words, in controlling the cross-industry concentration of high-road strategies for the knowledge-intensiveness of each sector.

[49] The argument may be pushed even further by allowing the k parameter to assume negative values in extremely simple productions, up to a point where the additional benefit of employing an F rather than an E type is nullified, and the efficiency of production is perfectly inelastic with respect to the worker's knowledge.

[50] The framework developed in here is highly complementary to that presented in Extension B (infra: 18), as it provides with a rationale for the historical formation of heterogenous routines within different economies (industries/countries etc.).