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Workers behavior and labor contract : an evolutionary approach

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Abstract

This article investigates the co-evolution of labor relationships and workers preferences. According to recent experimental economics findings on *social preferences*, the workforce is assumed to be heterogeneous. It is composed by both *cooperative* and *non-cooperative* workers. In addition, firms differ by the type of contract they offer (*explicit* or *implicit*). Finally, both the distribution of preferences and the degree of contractual completeness are endogeneized. Preferences evolve through a process of cultural transmission and the proportion of *implicit contracts* is driven by an evolutionary process. The complementarity between the transmission of cooperation and the implementation of *implicit contracts* leads to multiple equilibria which allow for path-dependence. This property is illustrated by the evolutions of American and Japanese labor contracts during the twentieth century.

Résumé

Cet article propose une explication conjointe de la nature des relations de travail et du degrè de coopération des travailleurs. La force de travail est composée de deux types de travailleurs (cooperatifs et non coopératifs). Les firmes se distinguent par la nature du contrat qu'elles offrent (explicite ou implicite). La distribution des préférences ainsi que la proportion de chaque type de contrat sont endogéneisées. Les préférences sont transmises entre les générations à travers un processus de transmission culturelle. La proportion de contrats implicites évolue à travers un processus évolutionnaire. La complémentarité entre la transmission du comportement coopératif et l'instauration d'un contrat implicite induit l'existence d'équilibres multiples et la propriété de dépendance à l'histoire. Celle-ci est illustrée par la comparaison des évolutions du contrat de travail au Japon et aux USA.

JEL Codes: D64, D86, Z10.

Keywords: explicit contract, implicit contract, cultural transmission, preferences for reciprocity, path dependence.

1 Introduction

The international comparisons of employment relationships and contractual practices in large manufacturing firms mainly focus on two major and antagonistic models. On the one hand, the American one, which is based on explicit and legally enforceable agreements between employees and employers. On the other hand, the Japanese one where implicit and ambiguous employment contracts dominate.[1] This co-existence of different types of contract deviates from the traditional economic explanations. Indeed, the standard principal-agent theory predicts that an *explicit contract* provides more incentives to workers than an *implicit contract*. Consequently, this latter should have vanished over time.

However, recent findings in experimental economics mitigate this prediction. They justify the implementation of *implicit contract* through the presence of subjects who exhibit *social preferences*.[2] Fehr and co-authors show that a positive fraction of subjects behaves reciprocally and provides a positive effort even if an *implicit contract* is proposed (see Fehr & Gätcher (2000) for a survey).[3] Then, *implicit contracts* seem to provide intrinsic work motivation to agents who exhibit *preferences for reciprocity*. Moreover, Fehr & Gätcher (2000) and Frey (1997) show that extrinsic motivation (as supervision or monetary rewards) crowd out these intrinsic motivations. As a result, if the proportion of reciprocator workers (workers who exhibit preferences for reciprocity) is large enough, the implementation of *implicit contracts* induces more incentives than *explicit contract*. Then, it could be the optimal choice of a firm. Finally, differences in the distribution of preferences could be at the origin of disparities in employment relationships.

This recent literature reintroduces older views on the distinction between American and Japanese style of management. According to these perspectives, the origin of this discrepancy comes from cultural differences between the two societies (see Morigushi (2000) for further discussions). The more cooperative nature of the Japanese workforce would explain the adoption of the *implicit contract*. However, taking the culture (in our framework,

[1]Morigushi ((2000), (2003)) highlights the non-enforceable nature of the corporate welfare programs, broadly implemented by Japanese firms.

[2]Alternative explanations exist but *social preferences* seem to provide a more relevant explanation (see Bowles (2000)).

[3]These experimental results are obtained even in one-shot interaction. In this framework, the possibility of subsequent gains do not constitute motivations for cooperation.

the distribution of preferences) as given, exogenous and invariant over time, it fails to explain the evolution of labor relationships within the two countries. Morigushi ((2000), (2003)) highlights that evolutions of American and Japanese labor relationships, during the twentieth century, were accurately similar until 1930's. They are characterized by the transition from an *explicit contract* to a more *implicit contract*.[4] The Great Depression appears to constitute a change in the trajectory associated with the return of the *explicit contract* in the large American manufactures. According to these facts, the American workers were sufficiently *cooperative* at the beginning of the twentieth century to allow for the adoption of the *implicit contracts*. However, economic shocks, as the Great Depression, seem to be able to break out the cooperation. To comply with these facts, the culture has to be considered as an endogenous variable.

The literature on the cultural transmission of preferences, originated by works of Cavalli-Sforza & Feldman (1981) and Boyd & Richerson (1985), provides the tools to endogenize the distribution of preference for *reciprocity*. It highlights the role of the *vertical transmission* of preferences, that is the transmission from parents to children. Following Bisin & Verdier (2001), we consider this *vertical transmission* as endogenous. In this framework, Bisin *et al.* (2004) and Olcina & Peñarrubia (2004) analyze the evolution of cooperation. Our work is more closely related to this later article which assumes that a population of agents, heterogeneous according to their preferences for reciprocity, is randomly matched with an homogeneous population of principals to play a *coordination game*. We depart from this framework, assuming that both the population of workers and the population of firms is heterogeneous, which allow us to obtain a co-evolution between the distribution of preferences and the nature of the labor relationhips.

In the present model, both workers and firms are heterogeneous. At each date, a worker is randomly matched with a firm. A firm is characterized through the proposed contract, either *implicit* or *explicit*. An *explicit* contract precisely defines the level of effort required from the worker and the level of reward associated with this effort. A worker providing an effort lower than the level required is detected with a positive probability and dismissed. This threat provides extrinsic motivations to workers. Conversely, an *implicit contract* consists in the promise of a reward in exchange of the worker's effort.

[4]These transition towards the *implicit contracting* manifested by the spread of corporate welfare in both countries (Morigushi ((2000), (2003))).

This contract is not enforceable as both firm and worker have the possibility to break the commitment. However, it provides intrinsic motivation for workers having preferences for reciprocity. Moreover, the joint cooperation of the worker and the firm allows for an additional profit.

In the model, there exist two types of workers within the population, *cooperative* and *non-cooperative*. *Cooperative* workers exhibit a preference for the reciprocity while the decisions of *non-cooperative* workers are only ruled by the material payoffs. It is shown that *non-cooperative* workers have higher effort incentives if the contract is *explicit* than when the contract is *implicit*. Conversely, *cooperative* workers have higher effort incentives if the contract is *implicit* but only if the firm respects its commitment. Consequently, the relative expected profit of a firm which offers the *implicit contracts* (with respect to the firm offering the *explicit contract*) increases with the proportion of *cooperative* workers.

The changes in the proportion of *implicit contracts* are driven by an evolutionary process. As a result, this proportion is increasing if the proportion of *cooperative* workers is large enough (decreasing if this proportion is low). Preferences of workers are assumed to be transmitted from parents to children, through a mechanism of transmission in line with Bisin & Verdier (2001). We assume that parents make an explicit and costly effort of socialization which determines the probability of transmitting their preferences to their children. Parents being altruistic, this effort will depend on the expected utility associated with each type of preferences. Therefore, the more important is the proportion of *implicit contract*, the greater are the incentives of a *cooperative* parent to transmit his own preference.

The joint dynamics of the distribution of contracts and the evolution of preferences potentially induces multiple equilibria. This property implies that two countries having close initial conditions can follow distinct trajectories and converge to different long-run situations. Two long-run equilibria are potentially stable, the *IC-equilibrium* (where all firms adopt the *implicit contract* and the proportion of *cooperative* workers is high) and the *EC-equilibrium* (where *explicit contract* dominates and *cooperative* workers are fewer).

In this framework, we assess the possibility of *path dependence* since exogenous shocks have a lasting impact on the evolution of the contract. As an illustration, consider an economy which converges towards the *IC-equilibrium*. During the convergence, both the proportion of *implicit contracts* and the proportion of *cooperative* workers increase. Consider now an exogenous shock in favor of the *explicit contract*. The model predicts that the effects of this shock depend on the structure of preferences in the economy where it occurs. Indeed, the *explicit contract* provide more incentives to *non-cooperative* workers. Thus, the gain of adopting this contract is positively related to the proportion of *non-cooperative* workers. Along the path of convergence towards the *IC-equilibrium*, an early shock occurs when the proportion of *non-cooperative* workers is still sufficiently important. Then, it enhances the probability of bifurcation towards the *EC-equilibrium*.

This property of *path dependence* can help us to understand why U.S. and Japan, originally on the same path (characterized by the decrease of the level of contractual completeness), experienced different evolutions since 1930's. Indeed, the periods of economic recessions can be interpreted as exogenous shocks in support of the *explicit contract*. The Great Depression deeply affected the U.S. economy at a moment where the implementation of the *implicit contracting* was limited and consequently the level of cooperation of the workforce still low. Then, it could explain why the *implicit contract* has been phased out. A comparable shock occurred in Japan almost two decades later (the Japanese post-war depression). At this time, the *implicit contract* was a generalized practice and the level of *cooperation* was sufficiently high to avoid the spread of the *explicit contracts*. Hence, differences in the timing of the shocks may have induced long-term divergences in the type of labor relationships and the distribution of preferences between the two countries.

These findings are in line with Morigushi ((2000), (2003), (2005)). However, our theoretical framework differs broadly from Morigushi's one. She considers an employment system as an equilibrium outcome of a repeated game between workers and firms. This game presents multiple equilibria and the selection of equilibrium depends on the *institutional capital* (level of trust) accumulated by the economy. Hence, culture is assimilated to this *institutional capital* and to beliefs on the behaviors of other players. In our framework, the culture is a distribution of preferences, which evolves over time. Taking into account heterogenous preferences allows to obtain the results of Morigushi without considering repeated interactions between firms and workers. However, the proportion of *cooperative* workers in the present model could be interpreted as *institutional capital* in the Morigushi's studies. Greater is this proportion, higher is the probability to sustain cooperation between employers and workers.

The next section introduces the two worker types, *cooperative* and *non-cooperative* and the two contract types, *implicit* and *explicit*. It also sets out the main assumptions of the model. In section 3, the short-run equilibrium is analyzed. Section 4 endogenizes the distribution of preferences and the distribution of labor contracts. Section 5 presents the long-run dynamics. Section 6 offers observations on the prediction of the model. Finally, section 7 concludes.

2 The model

2.1 Basic structure

The economy is constituted of a continuum of firms and a continuum of workers. Both the population of firms and the population of workers are heterogeneous. Two types of firm co-exist, the type IC offers an *implicit contract* and the type EC offers an *explicit contract*. The proportion of IC firms is denoted by p_t, thus $(1 - p_t)$ denotes the proportion of EC firms. The population of workers is constituted by a proportion q_t of *cooperative* (or reciprocator) workers and a proportion $(1 - q_t)$ of *non-cooperative* (or selfish) workers. Workers live one period. At the begining of their life they acquire their preferences, then they work and make effort to transmit their preferences to their children.[5]

At each date t, a firm is randomly matched with a worker, produces and makes an expected profit $\Pi_t^\varsigma(q_t)$ function of q_t, where $\varsigma \in \{IC, EC\}$ denotes the type of the firm. It is assumed that the firm cannot observe the type of the worker but knows the distribution of preferences (*i.e.* q_t). To simplify, we consider the labor as the unique input. The change in p_t is driven by an evolutionary process and the change in q_t by a mechanism of cultural transmission.

2.2 Nature of the contract

An *implicit contract* is specific as it is not legally enforceable. It consists in an exchange of commitments between the employer and the employee. The employee commits to provide effort and cooperation and the employer commits to provide non-contractable benefits to him. Since the contract is

[5]To simplify a non-overlapping structure has been chosen. This assumption does not influence the results of the model.

not enforceable, the commitment can be unilaterally broken up without costs and with legal impunity.

Conversely, the *explicit contract* specifies precisely the worker's tasks and earnings. It allows for the supervision of employees. If a worker does not accomplish these specific tasks and is detected, he is dismissed. This threat of dismissal provides *extrinsic motivations* to effort for workers.

2.3 Cooperative and non-cooperative types

A *cooperative* worker (indexed by c) exhibits preferences for reciprocity. The trust granted by the principal (the firm) represents an incentive for *cooperative* agents to provide an effort. In this case, a well specified contract that enables a low degree of freedom (*explicit contract*) is considered as a sign of distrust and implies a loss of utility (Frey (1997)). Moreover, a *cooperative* worker suffers a loss whenever either himself or the company chooses to cooperate while the other does not.[6]

A *non-cooperative* worker (indexed by nc) is assumed to be self-regarding. His decisions are independent from the potential *intrinsic motivations* provided by a contract and are only ruled by *extrinsic motivations*.

3 Short-run equilibrium

At each date t, a worker is randomly matched with a firm and knows the contract proposed by it.[7] Whatever the type of contract, the worker has to choose his level of effort. To simplify, we assume that the choice set is discrete ($e^c \in \{\bar{e}, \underline{e}\}$ denotes the effort choice of a *cooperative* worker and $e^{nc} \in \{\bar{e}, \underline{e}\}$ the effort choice of a *non-cooperative* worker). Inside the firm a worker has to choose between working and shirking. *Non-cooperative* workers suffer a disutility of effort d when they choose $\bar{e}$. A subjective cost (or gain) is added to this disutility for the *cooperative* workers. The value of this cost/gain depends on the nature of the contract and the behavior of the principal.

[6]It is a standard assumption to represent the preference for reciprocity. See, for instance Guttman (2003).

[7]It is assumed that accepting the contract is always profitable for the worker. Workers choice of participation is beyond the scope of this article.

3.1 Explicit contract

An *explicit contract* specifies a wage w and a limited set of tasks implying the choice of $\bar{e}$. Moreover, the specification of the tasks allows the firm to check out workers effort with a positive probability s. A detected shirker is dismissed and not paid. As mentionned previously, notice that *cooperative* workers consider the implementation of an *explicit contract* as a sign of distrust. This feeling induces a subjective cost modeled as an additional disutility of effort. $D > d$ denotes the total disutility of effort (objective and subjective) for *cooperative* workers.

$U^{\mu}(e, \varsigma)$ denotes the expected utility of a worker with preferences $\mu \in \{c, nc\}$ choosing the level of effort e, for a contract $\varsigma \in \{IC, EC\}$. This utility is assumed to be linear in the payoffs. The above assumptions induce that:

$$U^{c}(\bar{e}, EC) = w - D \tag{1}$$

$$U^{c}(\underline{e}, EC) = (1 - s)w \tag{2}$$

$$U^{nc}(\bar{e}, EC) = w - d \tag{3}$$

$$U^{nc}(\underline{e}, EC) = (1 - s)w \tag{4}$$

Now, let introduce the following condition:

$$D > sw > d \tag{5}$$

It yields:

Lemma 1 *Under condition* (5), *if an explicit contract is proposed, cooperative workers always choose* $\underline{e}$ *and non-cooperative workers always choose* $\bar{e}$.

By Lemma 1,[8] the utility of each type of worker when he is matched with a firm implementing the *explicit contract* is:

$$U^{c}_{t}(EC) = (1 - s)w \quad \text{and} \quad U^{nc}_{t}(EC) = w - d \tag{6}$$

[8] This dichotomous result (*all* cooperatives choose $\bar{e}$ and *all* non-cooperatives choose $\underline{e}$) can be easily relaxed by assuming an additional heterogeneity. For instance, it can be assumed that the disutility D is heterogeneous among cooperative workers. However, this assumption would not crucially affect our results.

The level of effort $\bar{e}$ (respectively $\underline{e}$) induces a level of output π^H (respectively π^L) for the firm, with $\pi^H > \pi^L$. In addition, costs of production are assumed to be exogenous and constant (denoted by ψ). From the Lemma 1, the expression of the expected profit when the contract is *explicit* is:

$$\Pi_t^{EC}(q_t) = q_t\pi^L + (1 - q_t)\pi^H - \psi = \pi^H - q_t\Delta\pi - \psi \tag{7}$$

with $\Delta\pi = \pi^H - \pi^L > 0$. This level of profit is then a decreasing function of the proportion of *cooperative* workers.

3.2 Implicit contract

3.2.1 Framework of the game

An *implicit contract* consists in a fixed wage w (assumed to be similar to the wage specified by an *explicit contract*) and the promise of an additional payment δ in exchange of workers effort and cooperation.[9] Such an exchange of promises is by nature non enforceable. The firm can respect the contract (*Cooperate*) or not (*Renege*). In the same way, the worker can cooperate ($\bar{e}$) or not ($\underline{e}$).

The choices of a firm and a worker matched together can be represented as a simultaneous game. The payoffs matrices of this game (in the case where the firm faces *cooperative* workers and *non-cooperative* workers) are the following:

	C	R
$\bar{e}$	$w + \delta, \pi^H + \gamma - \delta - \psi$	$w - c, \pi^H - \psi$
$\underline{e}$	$w + \delta - c, \pi^L - \delta - \psi$	$w, \pi^L - \psi$

cooperative worker

	C	R
$\bar{e}$	$w + \delta - d, \pi^H + \gamma - \delta - \psi$	$w - d, \pi^H - \psi$
$\underline{e}$	$w + \delta, \pi^L - \delta - \psi$	$w, \pi^L - \psi$

non-cooperative worker

[9]Notice that δ may be a non-monetary reward, as the implementation of corporate welfare programs (See Morigushi (2000) and (2003) for illustrations of corporate welfare programs set up both in Japan and in U.S.). In the same way, the effort expected from workers may be *higher* than $\bar{e}$. For instance, it may consist in an investment in specific human capital (see Morigushi (2005)). To simplify, we assume that $\bar{e}$ is the same if the contract is *implicit* or *explicit*.

ψ, d, π^H and π^L are defined as in the case of *explicit contract*. γ denotes the gain of cooperation for the firm[10] and c the subjective cost suffered by the *cooperative* worker in case of non-cooperative outcome. This cost comes from the preferences for reciprocity of *cooperative* agents. These latter dislike both to exploit or to be exploited by his partner (here, the firm). Let us note that, due to this preference for reciprocity, he does not suffer disutility in the case $(\bar{e}, C)$.

Since the contract is non enforceable, the firm has the possibility to renege on it (to choose the strategy R), in this case δ is unpaid. In the same way the firm cannot protect itself against shirking behavior of workers. The analysis is restricted to the case where δ is lower than γ. The following condition holds:

$$\gamma \geq \delta \tag{8}$$

3.2.2 Resolution of the game

It is assumed that firms do not observe the type of the worker they are matched with. They only know the proportion q_t of *cooperative* workers. The appropriate equilibrium concept in this case is the Bayesian Nash equilibrium. The following assumption allows for the selection of one equilibrium in case of multiple equilibria.

Assumption 1 *When multiple equilibria arise, it is assumed that the Pareto optimal equilibrium is selected.*

Consider the triplet of strategies $(s, e^c, e^{nc}) \in \{C, R\} \times \{\bar{e}, \underline{e}\} \times \{\bar{e}, \underline{e}\}$[11] and define:

$$\tilde{q} \equiv \frac{\delta}{\gamma} \tag{9}$$

The following lemma provides the triplets of strategies corresponding to a Bayesian equilibrium of the game:

Lemma 2 *If $q_t < \tilde{q}$, the unique Nash Bayesian equilibrium of the game is $(R, \underline{e}, \underline{e})$. If $q_t \geq \tilde{q}$, $(R, \underline{e}, \underline{e})$ and $(C, \bar{e}, \underline{e})$ are the two Nash Bayesian equilibria of the game and $(C, \bar{e}, \underline{e})$ Pareto dominates $(R, \underline{e}, \underline{e})$.*

[10] The fact that the cooperation between the firm and the worker increases the joint surplus is well documented (see Morigushi (2005) for a survey).

[11] Notice that the analysis is restricted to pure strategies.

Proof See Appendix □

Non-cooperative workers always play their dominant strategy, that is choose $\bar{e}$. Under Assumption 1, the *IC* firms honor the contract when q_t is higher than $\tilde{q}$ and renege on it when q_t is lower than $\tilde{q}$.[12] In the same way, *cooperative* workers choose $\bar{e}$ when the firm *Cooperates* and $\underline{e}$ when the firm *Reneges*. Indeed, when the proportion of *non-cooperative* workers is high the probability to employ a shirker is greater for the *IC* firm. Thus, it does not honor the contract. *Cooperative* workers, who anticipate this behavior, choose to shirk too. In this case, the cooperation is not sustainable.

These optimal behaviors yield the following expected profit when the contract is *implicit*:

$$\Pi_t^{IC}(q_t) = \begin{cases} \pi^L - \psi & \text{if} \quad q_t < \tilde{q} \\ q_t(\gamma + \pi^H) + (1 - q_t)\pi^L - \delta - \psi & \text{if} \quad q_t \geq \tilde{q} \end{cases} \tag{10}$$

and the following utility for each type of worker matched with a firm which implements the *implicit contract*:

$$U_t^c(IC) = U_t^{nc}(IC) = \begin{cases} w & \text{if} \quad q_t < \tilde{q} \\ w + \delta & \text{if} \quad q_t \geq \tilde{q} \end{cases} \tag{11}$$

The utility of the two types of workers is the same, although the *cooperatives* choose $\bar{e}$ when $q_t \geq \tilde{q}$ while the *non-cooperatives* choose $\underline{e}$ when $q_t \geq \tilde{q}$. This result comes from the fact that a shirker cannot be punished if the contract is *implicit* and that *cooperative* workers suffer no work disutility when the contract is *implicit*.

4 The evolutionary set-up

4.1 Evolution of labor relationships

At the end of each date, firms which offer the less profitable contract have a positive probability to be replaced by firms which offer the alternative contract. This probability of change is assumed to be an increasing function

[12] The selection of equilibrium is beyond the scope of the analysis, the assumption 1 allows for a simple criterium of selection. Morever, notice that if γ is high enough, $(C, \bar{e}, \underline{e})$ is both Pareto-dominant and risk-dominant. Such a restriction on the value of γ does not crucially affect the results of the model.

of the profit differences.[13] Thus, the evolution of p_t between the date t and $t+1$ is given by the rule[14]:

$$\Delta p_t = p_{t+1} - p_t = p_t(1-p_t)\varphi(\Pi_t^{IC}(q_t) - \Pi_t^{EC}(q_t)) \tag{12}$$

where φ is a positive constant, low enough to ensure that $\varphi(\Pi_t^{IC}(q_t) - \Pi_t^{EC}(q_t)) \in (0,1)$. It reflects the fact that, greater is the payoff difference, higher is the probability of switching from a contract to another. Expressions (7) and (10) imply:

$$\Pi_t^{IC}(q_t) - \Pi_t^{EC}(q_t) = \begin{cases} -(1-q_t)\Delta\pi & \text{if} \quad q_t < \tilde{q} \\ q_t(\gamma + 2\Delta\pi) - (\Delta\pi + \delta) & \text{if} \quad q_t \geq \tilde{q} \end{cases} \tag{13}$$

By Lemma 2, the cooperation is not sustainable if the contract is *implicit* and q_t is lower than $\tilde{q}$. As a consequence, the profit of a firm *IC* equals $(\pi^L - \psi)$ which is lower than the profit of a firm which implements an *explicit contract*. If, q_t is higher than $\tilde{q}$, the relative profit of each type of contract depends on the proportion q_t. Let us define:

$$\bar{q} \equiv \frac{\delta + \Delta\pi}{\gamma + 2\Delta\pi} \tag{14}$$

$q_t < \bar{q}$ implies $q_t(\gamma + 2\Delta\pi) < (\Delta\pi + \delta)$, then *explicit contract* allows for greater profits than *implicit* one, even if $q_t > \tilde{q}$ (conversely if $q_t \geq \bar{q}$).

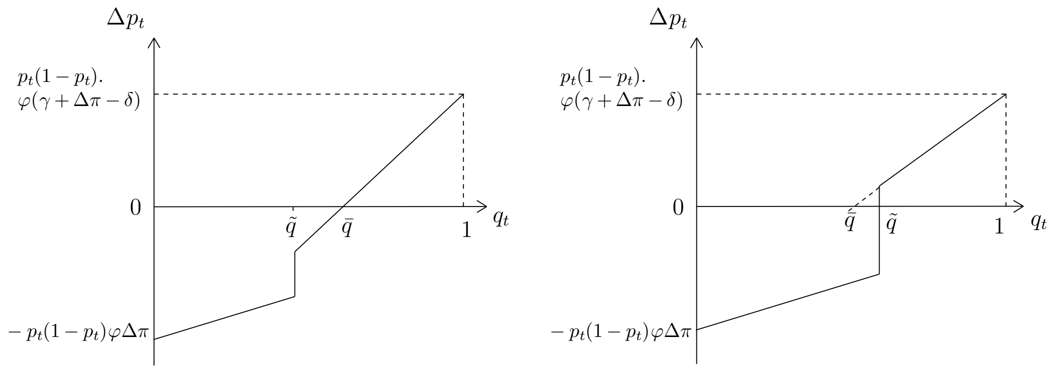
Through the evolutionnary process (12), the variation of p_t depends on the value of the relative profit $(\Pi_t^{IC}(q_t) - \Pi_t^{EC}(q_t))$. Figure 2 represents the value of this variation function of q_t for a given p_t.

If q_t is low (lower than $\max\{\bar{q}, \tilde{q}\}$), *explicit contracts* always allow for a higher profit than the *implicit* ones. The converse is true if $q_t > \max\{\bar{q}, \tilde{q}\}$. Thus, through the evolutionnary process:

$$\begin{cases} \Delta p_t < 0 & \text{if} \quad q_t < \max\{\bar{q}, \tilde{q}\} \\ \Delta p_t \geq 0 & \text{if} \quad q_t \geq \max\{\bar{q}, \tilde{q}\} \end{cases} \tag{15}$$

[13]The fact that, at each date, each firm has a positive probability to observe the profit of a rival and to adopt its contract if this profit is higher than its own could be a justification. Another interpretation is that firms having the less successful form of contract have a greater probability to disappear due to the competitive process. For further justifications see Nelson & Winter (2002).

[14]See the Appendix for a formal analysis.



(a) *Case where* $\bar{q} > \tilde{q}$ (b) *Case where* $\bar{q} < \tilde{q}$

Fig. 1. *Variation of* p_t *function of* q_t

Notice that, for $q_t \in (\bar{q}, \tilde{q})$, the *implicit contract* should be more profitable than the *explicit* one if the *cooperative* worker and the *IC* firm cooperate. However, since $q_t < \tilde{q}$ the cooperation is not sustainable and $\Pi_t^{IC}(q_t) < \Pi_t^{EC}(q_t)$. This configuration can occur only if $\tilde{q} > \bar{q}$ and then if the following condition holds:

$$\gamma < 2\delta \tag{16}$$

It occurs when the gains of cooperation (γ) are low compared to the cost of cooperation (δ).

4.2 Evolution of preferences

Consider that the preference for *reciprocity* is transmitted from parents to children through a mechanism of cultural transmission. In line with Bisin & Verdier (2001), the adoption of one preference by a child is the result of a double influence. Consider a child with parental preferences $i \in \{c, nc\}$. First, he is directly exposed to the parent's preference (and adopts this preference with a probability τ^i chosen by the parent). If this direct socialization fails (with a probability $(1-\tau^i)$), he adopts the preference of a role model randomly chosen in the population. Hence, with a probability q_t he becomes *cooperative* and with a probability $(1-q_t)$ *non cooperative*.

$P_t^{i,j}$ denotes the probability for a parent with preference i to have a child with preference j at time t. We deduce the probability for a parent of each type to have a child with the same preferences:

$$P_t^{c,c} = \tau_t^c + (1-\tau_t^c) q_t \tag{17}$$

$$P_t^{nc,nc} = \tau_t^{nc} + (1-\tau_t^{nc})(1-q_t) \tag{18}$$

The dynamics of q_t is ruled by the following equation:

$$q_{t+1} = P_t^{c,c} q_t + (1-P_t^{nc,nc})(1-q_t) \tag{19}$$

by substitution of (17) and (18) in (19):

$$\Delta q_t = q_{t+1} - q_t = q_t(1-q_t)(\tau_t^c - \tau_t^{nc}) \tag{20}$$

The probability τ^i of direct (parental) transmission of preferences is endogenous. A parent of type i chooses $\tau^i \in [0,1]$ in order to maximize:

$$P_t^{i,i} V_{t+1}^{i,i} + P_t^{i,j} V_{t+1}^{i,j} - C(\tau^i) \tag{21}$$

where $C(\tau) = \tau^2/2k$ is the cost of the educational effort τ. $V_{t+1}^{i,j}$ is the utility for the parent of type i to have a child of type j. The solution of this socialization problem is written as follow:

$$\tau^c = (1-q_t) k \Delta V_{t+1}^c \text{ and } \tau^{nc} = q_t k \Delta V_{t+1}^{nc} \tag{22}$$

where $\Delta V_{t+1}^i = V_{t+1}^{i,i} - V_{t+1}^{i,j}$. Let us notice that the probability of transmission of *reciprocity* by oblique socialization is negatively related to the proportion of *cooperative* workers. The higher is this proportion, the weaker are the incentives for *cooperative* parents to transmit their preferences directly and the higher are these incentives for *non-cooperative* parents.[15]

The expected utility $V_{t+1}^{i,j}$ depends on two elements. First, parents are altruistic, then it depends on the expected utility of a child of type j. Second, we assume that parents prefer to have a child having their own preferences. Formally, it implies that:

$$V_{t+1}^{i,i} = U_{t+1}^i + \theta^i \text{ and } V_{t+1}^{i,j} = U_{t+1}^j \text{ with } \theta^i > 0 \tag{23}$$

U_{t+1}^i denotes the expected utility of a worker of type i for the date $t+1$. Under the assumption of myopic expectations: $U_{t+1}^i = U_t^i$. This utility depends on the current proportion of each type of contract in the economy (p_t). θ^i denotes the additional utility for a type i parent to have a child with

[15] This property is named *cultural substitution* by Bisin & Verdier (2001).

the same preferences of him rather than other preferences. It is a measure of the cultural intolerance of a parent of type i.[16] It follows that:

$$\Delta V_t^i = \theta^i + \Delta U_t^i \tag{24}$$

With $\Delta U_t^i = U_t^i - U_t^j$ and then $\Delta U_t^i = -\Delta U_t^j$. From expression (6) and (11), we deduce:

$$\Delta U_t^c = p_t \Delta U_t^c(IC) + (1-p_t)\Delta U_t^c(EC) = -(1-p_t)(sw-d) \tag{25}$$

$$\Delta U_t^{nc} = p_t \Delta U_t^{nc}(IC) + (1-p_t)\Delta U_t^{nc}(EC) = (1-p_t)(sw-d) \tag{26}$$

We introduce the following assumption which ensures that ΔV_t^c is positive for all values of $p_t \in [0,1]$ [17]:

$$\theta^c > sw - d \tag{27}$$

Substitute (22), (24), (25) and (26) into (20) give a new equation of the dynamics of q_t:

$$\Delta q_t = q_t(1-q_t)k[\theta^c + (1-p_t)(d-sw) - (\theta^c + \theta^{nc})q_t] \tag{28}$$

It is straightforward that, for a given p_t, this dynamics has three stationary states: 0, 1 and

$$\hat{q}(p_t) = \frac{\theta^c - (sw-d) + (sw-d)p_t}{\theta^c + \theta^{nc}} \tag{29}$$

Figure 2 describes the dynamics of q_t for a given value of p_t.

It shows the stability of the interior equilibrium $\hat{q}(p_t)$. Indeed:

$$\begin{cases} \Delta q_t < 0 & \text{if} \quad q_t > \hat{q}(p_t) \\ \Delta q_t \geq 0 & \text{if} \quad q_t \leq \hat{q}(p_t) \end{cases} \tag{30}$$

This property of stability comes from the *cultural substitution* between the parental socialization and the socialization by the society. Indeed, greater

[16]Choosing this formulation, we depart from the Bisin & Verdier (2001) assumption of *paternalistic altruism*. However, we obtain, in a simple way, the property that parents prefer to have a child adopting the same cultural trait as their own.

[17]This assumption is not necessary to obtain our results, however it simplifies the presentation.

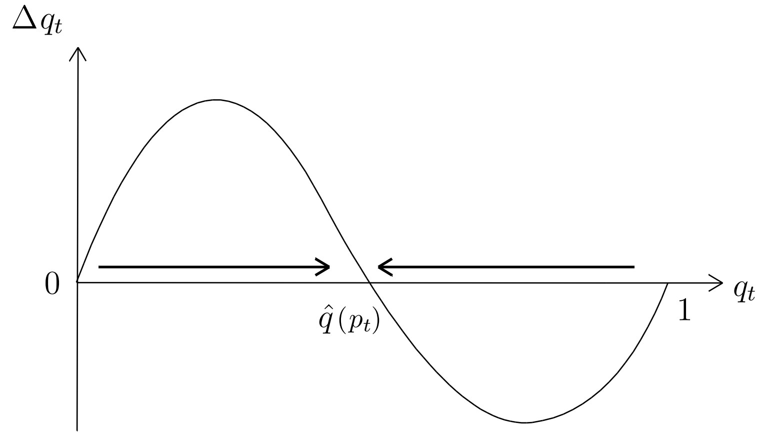


Fig. 2. *Dynamics of q_t for a given value of p_t*

is the proportion q_t, higher is the probability that a child adopts the preference for reciprocity in the second step of socialization (socialization by the society). Then, greater is q_t, lesser are the incentives for parents to transmit *cooperation* directly.

Moreover, notice that the steady state $\hat{q}(p_t)$ is an increasing function of p_t. The greater is the proportion of firms which propose the *implicit contract*, the higher is the relative utility derived from cooperation (ΔU_t^c). Then, a rise in p_t induces an increase of the incentives to transmit the *cooperative* behavior.

5 Long-run dynamics

5.1 Co-evolution between preferences and labor relationships

Figure 1 and 2 show that the dynamics of q_t depends on the value of p_t and the dynamics of p_t depends on the value of q_t. By relations (12), (13) and (28), the dynamical process $(q_t, p_t)_{t\geq 0}$ is described by the following system of equations:

$$\begin{cases} \Delta p_t = \begin{cases} p_t(1-p_t)\varphi[-(1-q_t)\Delta\pi] & \text{if} \quad q_t < \tilde{q} \\ p_t(1-p_t)\varphi[q_t(2\Delta\pi+\gamma)-(\Delta\pi+\delta)] & \text{if} \quad q_t \geq \tilde{q} \end{cases} \\ \Delta q_t = q_t(1-q_t)k[\theta^c-(1-p_t)(sw-d)-(\theta^c+\theta^{nc})q_t] \end{cases} \tag{31}$$

The dynamic properties of this system are closely dependent on the relative value of $\max\{\bar{q}, \tilde{q}\}$ and $\hat{q}(p_t)$. Three cases have to be considered:

(i) $max\{\bar{q}, \tilde{q}\} \leq \hat{q}(0)$

(ii) $max\{\bar{q}, \tilde{q}\} \in (\hat{q}(0), \hat{q}(1))$

(iii) $max\{\bar{q}, \tilde{q}\} \geq \hat{q}(1)$

Notice that, by expression (29):

$$\hat{q}(0) = \frac{\theta^c - (sw - d)}{\theta^c + \theta^{nc}} \quad \text{and} \quad \hat{q}(1) = \frac{\theta^c}{\theta^c + \theta^{nc}} \tag{32}$$

5.1.1 Case (i) : $max\{\bar{q}, \tilde{q}\} \leq \hat{q}(0)$

(15) implies that p_t increases (repectively decreases) when q_t is higher (respectively lower) than $max\{\bar{q}, \tilde{q}\}$. By (30), q_t increases (respectively decreases) when q_t is lower (respectively higher) than $\hat{q}(p_t)$. It follows the phase diagram represented in Figure 3.

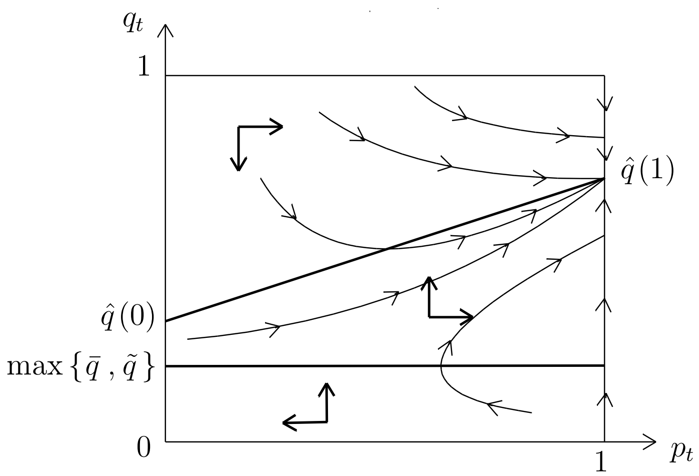


Fig. 3. *Co-evolution of* q_t *and* p_t *when* $max\{\bar{q}, \tilde{q}\} \leq \hat{q}(0)$

In this diagram one can observe that the only equilibrium globally stable is $(\hat{q}(1), 1)$, named the *IC-equilibrium*. At this equilibrium, all firms implement the *implicit contract* and the proportion of *cooperative* workers is relatively important (equal to $\hat{q}(1)$).

The convergence towards the *IC-equilibrium* depends both on the property of *cultural substitution* in the process of preferences transmission and on the fact that $max\{\bar{q}, \tilde{q}\}$ is relatively low. Indeed, the *cultural substitution* induces that the proportion of *cooperative* workers progressively brings closer to $\hat{q}(p_t)$. Due to this effect and since $max\{\bar{q}, \tilde{q}\} \leq \hat{q}(0)$, along the path of convergence, the proportion q_t becomes higher than $max\{\bar{q}, \tilde{q}\}$. In this case, p_t monotonously increases until reaching 1. Hence, in the long run, $(q_t, p_t)_{t\geq 0}$ converges towards $(\hat{q}(1), 1)$.

5.1.2 Case (ii) : $max\{\bar{q}, \tilde{q}\} \in (\hat{q}(0), \hat{q}(1))$

The phase diagram corresponding to the case (ii) is given by Figure 4.

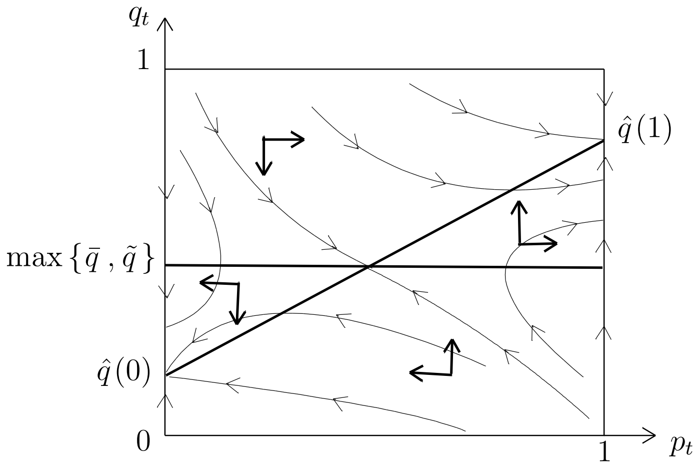


Fig. 4. *Co-evolution of* q_t *and* p_t *when* $max\{\bar{q}, \tilde{q}\} \in (\hat{q}(0), \hat{q}(1))$

It shows that both equilibria $(\hat{q}(0), 0)$, named the *EC-equilibrium*, and $(\hat{q}(1), 1)$ are stable and that the dynamics admits a saddle point: $(max\{\bar{q}, \tilde{q}\}$, $\hat{q}^{-1}(max\{\bar{q}, \tilde{q}\}))$. The presence of multiple equilibria induce that, the long-run equilibrium reached by the economy depends on the initial situation. If (q_0, p_0) is under the saddle path, the economy converges towards $(\hat{q}(0), 0)$. If (q_0, p_0) is above the saddle path, the long run equilibrium is $(\hat{q}(1), 1)$.

This result comes from the complementarity between *cooperative* behavior and the proportion of *implicit contracts*. On the one hand, when q_t is low, the relative profit of the IC firms is low and p_t decreases. On the other hand, a decrease of p_t induces a fall of the incentives to transmit the preference for *reciprocity* and thus a decrease of q_t.

5.1.3 Case (iii) : $max\{\bar{q}, \tilde{q}\} \geq \hat{q}(1)$

Figure 5 represents the phase diagram for this last case. It allows to conclude that $(\hat{q}(0), 0)$ is the only globally stable equilibrium. The economy will converge towards the *EC-equilibrium*, whatever the initial situation.

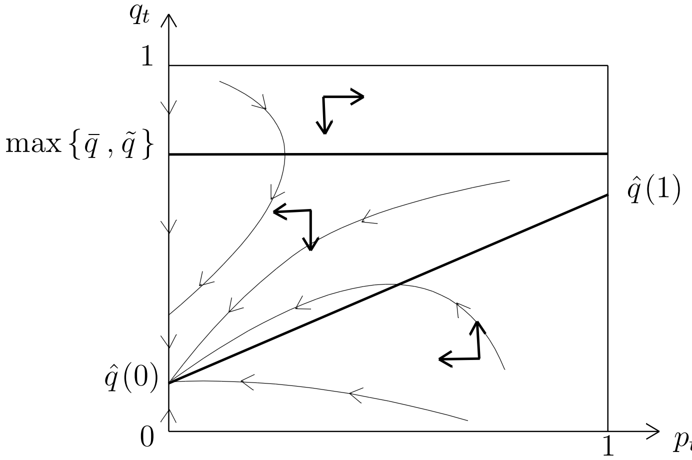


Fig. 5. *Co-evolution of q_t and p_t when $max\{\bar{q}, \tilde{q}\} \geq \hat{q}(1)$*

5.2 Consequences of exogenous shocks

This section takes the situation represented by Figure 3 as a starting point. In this configuration, the economy converges towards $(\hat{q}(1), 1)$. If (q_0, p_0) is close to $(\hat{q}(0), 0)$, the convergence path is characterized by a progressive increase of the proportion of *cooperative* workers and *implicit contracts*. The following subsections deal with the consequences of two exogenous shocks on this path.

5.2.1 Effects of a wage increase

Consider the consequences of an increase in w. For all values of $p_t < 1$, $\hat{q}(p_t)$ is a decreasing function of w and the lower is p_t, the higher is this effect.

Indeed, if an *explicit contract* is proposed, a rise of w allows for a higher rise in the expected reward for a non-shirker (equal to w) than for a shirker (equal to $(1-s)w$).[18] By Lemma 1, if the contract is *explicit*, *cooperative* workers choose the high level of effort and *non-cooperative* workers the low level. Then, an increase in w has a larger positive influence on the expected utility of a *non-cooperative* worker than on the expected utility of a *cooperative* worker (increase in ΔU_t^{nc}).[19] This induces a fall of the relative incentive to transmit reciprocity.

In particular, a rise of w induces a fall of $\hat{q}(0)$. If the increase of w is large enough to induce $\hat{q}(0) < max\{\bar{q}, \tilde{q}\}$, the dynamical properties of the model are affected. The case *(ii.)*, illustrated by Figure 4, holds. Then, as a result of the shock, $(\hat{q}(0), 0)$ and $(\hat{q}_1(1), 1)$ are two stable equilibria. The long-run equilibrium reached by the economy depends on the distribution of preferences at the date of the shock.

Consider the initial situation described by Figure 3, the consequences of an increase in w depend on the date of such a shock. If it is early, when it occurs the proportion p_t and q_t are relatively low. Consequently, the probabilty to be matched with a firm implementing the *implicit contract* is low. The incentives to transmit reciprocity fall sharply. Then, q_t decreases and, if it becomes lower than $\bar{q}$, p_t decreases too. In this case, the long-run situation will be the *EC-equilibrium*. The converse is true if the shock is late, at a moment when the proportion of *cooperative* workers is great.

Notice that, in the case of a return towards the *EC-equilibrium*, the fall of q_t implies a decrease of the proportion of shirkers if the implemented contract is *explicit*. This result complies with the standard contract theory: the average level of effort rises with the wages and the supervision level. However, the mechanism is different here. This increase does not come from a rise of incentives to provide effort, but from the rise of incentives to transmit the *non-cooperative* behavior.

5.2.2 Effects of an economic slowdown

Kandel & Pearson (2001) and Morigushi (2000, 2003, 2005) highlight that the productivity gains, stemming from the greater commitment of the firm to its

[18] In this section, we consider an increase of w but the results are unaffected if a rise of s is considered. Indeed, such a rise induces a decrease of the expected payoff of shirkers if the contract is *explicit*.

[19] $\frac{\partial \Delta U_t^{nc}}{\partial w} = -p_t s$. Thus, this effect is greater when p_t or s are higher.

employees, decrease during economic slowdowns. Hence, in our framework, a period of recession can be modeled as a fall of γ.

Consider the situation illustrated by Figure 3 as a starting point. A decrease of γ implies a rise both of $\bar{q}$ and $\tilde{q}$ (see expression (9) and (14)). Then, if this decrease is large enough, such as $max\{\bar{q}, \tilde{q}\} > \hat{q}(0)$, the case *(ii.)* holds (illustrated by Figure 4). In this case, the consequences of the fall of γ are qualitatively similar to the consequences of a wage increase. As highlighted in the previous section, if p_t and q_t are sufficiently low at the date of the shock, the economy will converge towards $(\hat{q}(0), 0)$. However, the driving force is different. Here, the relative profit of firms which implement the *explicit contract* increases. As a consequence, the *explicit contract* progressively replaces the *implicit contract* (see expression (12)). This decrease of p_t induces a fall of the incentives to transmit *cooperative* behaviors and then a decrease of q_t which reinforces the initial movement.

Notice that, if the fall of γ is large enough, such as condition (16) is satisfied, the proportion of *IC* firms decrease while it could be more profitable then *EC* firms. Indeed, if following the shock $q_t \in (\tilde{q}, \bar{q})$, the cooperation inside the *IC* firms is no more sustainable. Neither the firm nor the worker honnor their commitments. Hence, the *implicit contract* becomes less profitable and tend to be excluded.

6 Discussion

The previous section highlights the existence of multiple equilibria. As a result, the consequences of a shock depend in a crucial way of the distribution of preferences when it occurs. These properties provide a possible explanation of the international differences in the type of contract. This discussion focuses on the comparison between the Japan and the U.S.

As mentionned previously, both in Japan and U.S., the *implicit contract* spreads over at the begining of the twentieth century. How explain that the American Great Depression induced a return to the *explicit contract* while a comparable shock in Japan (the post-war depression) did not affect the generalization of the *implicit contract*[20]? According to our analysis, earlier shock in U.S. played a central role. Indeed, this shock in favour of the

[20]Obviously, the nature of these two shocks was different. However, the length and the extent of the Japanese depression should have induced similar negative consequences on the gain of cooperation.

explicit contract (see section 5.2.2), occured in an economy where cooperative behaviors of both workers and firms were relatively low. Due to this lack of cooperation, the expected profit of a firm which had implemented an *implicit contract* fell and the *implicit contracts* rapidely disappeared. When the shock is sufficiently large, the model predicts that *implicit contract* does not longer allow for a commitment between the firm and the workforce. Such a widespread failure to meet their promises precipitates the fall of the *implicit contracting*. In the present model, the disappearance of the *implicit contract* comes with the decrease of the proportion of *cooperative* workers, which lead to a new increase of the relative profit of *explicit contracts*.[21] Conversely, the Japanese post-war depression happenned as both the proportion of *implicit contracts* and *cooperative* workers had already raised. Consequently, when this shock occured (even if its magnitude was similar to the American Great Depression) the expected profits of *implicit contracts* were sustained by the cooperative behavior of the workforce. Hence, the *explicit* form of contract failed to suplant the *implicit* form of contract.

At the same time, the twentieth century is characterized by a global increase in wages. This might make permanent the consequences of the originally temporary shocks. Indeed, as mentionned in section 5.1, the negative effect of a wage increase on the transmission of cooperation, rises with the proportion of *explicit contracts*. Following our analysis, the Great Depression, allowing the spread of such a contract, reinforces the disincentive effect of wages on the transmission of reciprocity. Conversely, in Japan, where the *implicit contract* was suficiently frequent, a wage increase had a few impact on the transmission of cooperation. Formally, the equilibrium $(\hat{q}(1), 1)$ cannot be destabilized by an increase of w. Hence, even if the shock is temporary, due to the rise of wages both IC and EC equilibria remain stable and the consequences of the shock are still lasting.

7 Conclusion

Several studies point out the major role played by cultural factors in the international differences in labor relationships. However, few works explore the origins and evolution of such differences. The present paper aims at fill-

[21]Morigushi ((2000), (2003), (2005)) highlights the consequences of the Great Depression on the fall of *implicit contracting* in U.S.

ing that gap, using experimental results on *social preferences* and theoretical results on the cultural transmission of these preferences. In doing this, it provides an example of the co-evolution between institutions (types of labor relationship) and culture (levels of cooperation).[22] In this framework, the level of cooperation of the workforce and the proportion of *implicit contracts* are complements. Indeed, the more the workers are cooperative, the more profitable is the implementation of *implicit contracts*. Hence, this type of contract spread rapidly. In the same way, the decrease of the degree of contractual completeness implies more incentives to transmit the *cooperative* behaviors. This complementarity induces the possibility of multiple long run equilibria. As a consequence, an exogenous shock may have long lasting impact both on the distribution of preferences and the degree of contractual completeness. As an illustration, the consequences of the timing of the Great Depression on the divergence between American and Japanese ways to contract on the labor market is highlighted. In this analysis, the cause of the emergence of two models (the American and the Japenese one) is not the character intrinsically more cooperative of the Japanese workers. Indeed, this character is a product of the economic history and is co-determined with the nature of the labor relationship.

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[22]See Bowles (1998) for a motivation of such a line of research.

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Appendix

Proof of Lemma 2

Consider the game described in section 3.2. $\mathbf{P} \equiv \{W, F\}$ denotes the set of players, with W for worker and F for firm. The set of action of the player k is denoted $\mathbf{S}_k$ with $\mathbf{S}_F \equiv \{C, R\}$ and $\mathbf{S}_W \equiv \{\bar{e}, \underline{e}\}$. The workers can be of two types, the set of workers types is denotes $\mathbf{T} \equiv \{c, nc\}$. The proportion

q_t of workers of type c is assumed to be common knowledge. $\mu_F(e|t)$ denotes the belief of the firm on the probability to play the action $e \in \mathbf{S}_W$ for the worker of type t. In a similar way, $\mu_t(e')$ denotes the belief of the worker of type t on the probability to play the action $e' \in \mathbf{S}_F$ for the firm. Strategies $s_W(t)$ for a worker of type t and s_F for the firm are defined as the following functions:

$$s_W(t) : \mathbf{T} \times \mathbf{S}_F \to \mathbf{S}_W$$

$$s_F : \mathbf{S}_W \to \mathbf{S}_F$$

The payoff of a worker is denoted $U_t(s_F, s_W(t))$ and the the payoff of a firm is denoted $\Pi(s_F, s_W(t))$.

$s^* = (s_F^*, s_W^*(c), s_W^*(nc))$ is a Nash Bayesian equilibrium if s_F^* is the best response to $(s_W^*(c), s_W^*(nc))$ and if $s_W^*(t)$ is the best reponse to s_F^* for all $t \in \mathbf{T}$.

Let us compute the best response of the workers for given beliefs on the action of the firm.

The nc worker as a strategy dominant, he chooses $s_W(nc) = \underline{e}$ for all beliefs on s_F.

The c worker chooses $s_W(c) = \bar{e}$ for a given value of $\mu_c(C)$ if:

$$\mu_c(C)U_c(C, \bar{e}) + (1 - \mu_c(C))U_c(R, \bar{e}) \geq \mu_c(C)U_c(C, \underline{e}) + (1 - \mu_c(C))U_c(R, \underline{e})$$

$$\mu_c(C)[w + \delta] + (1 - \mu_c(C))[w - c] \geq \mu_c(C)[w + \delta - c] + (1 - \mu_c(C))[w]$$

$$\mu_c(C) \geq \frac{1}{2} \tag{33}$$

Consider now the best response of the firm. It chooses $s_F = C$ for a given value of $\mu_F(\bar{e}|c)$ if:

$$q_t[\mu_F(\bar{e}|c)\Pi(C, \bar{e}) + (1 - \mu_F(\bar{e}|c))\Pi(C, \underline{e})] + (1 - q_t)\Pi(C, \underline{e}) \geq$$
$$q_t[\mu_F(\bar{e}|c)\Pi(R, \bar{e}) + (1 - \mu_F(\bar{e}|c))\Pi(R, \underline{e})] + (1 - q_t)\Pi(C, \underline{e})$$

$$\pi^L - \delta - \psi + q_t\mu_F(\bar{e}|c)[\Delta\pi + \gamma] \geq \pi^L - \psi + q_t\mu_F(\bar{e}|c)\Delta\pi$$

$$\mu_F(\bar{e}|c) \geq \frac{\delta}{q_t\gamma} \tag{34}$$

Since nc worker has a dominant strategy ($s_W(nc) = \underline{e}$) and since only the pure strategies are considered, four equilibria are possible: $(R, \underline{e}, \underline{e})$, $(R, \bar{e}, \underline{e})$, $(C, \underline{e}, \underline{e})$, $(C, \bar{e}, \underline{e})$. We will check for each of them if it is a Nash Bayesian Equilibrium.

$(R, \underline{e}, \underline{e})$ is based on the system of beliefs: $\mu_c(C) = 0$ and $\mu_F(\bar{e}|c) = 0$. Under these beliefs, $\mu_F(\bar{e}|c) < \delta/(q_t\gamma)$ then, by (34), the optimal strategy of the firm is $s_F = R$. This strategy confirmed the belief of the worker $\mu_c(C) = 0$. In the same way, $\mu_c(C) < 1/2$ then, by (33), the optimal strategy of the c worker is $s_W(c) = \underline{e}$. It confirmed the belief of the firm $\mu_F(\bar{e}|c) = 0$. Then $(R, \underline{e}, \underline{e})$ is a Bayesian Nash equilibrium of all values of q_t.

$(R, \bar{e}, \underline{e})$ is based on the system of beliefs: $\mu_c(C) = 0$ and $\mu_F(\bar{e}|c) = 1$. Under these beliefs, $\mu_c(C) < 1/2$ then, by (33), the optimal strategy of the c worker is $s_W(c) = \underline{e}$. Then, the belief $\mu_F(\bar{e}|c) = 1$ is not confirmed. $(R, \bar{e}, \underline{e})$ is not a Bayesian Nash equilibrium.

$(C, \underline{e}, \underline{e})$ is based on the system of beliefs: $\mu_c(C) = 1$ and $\mu_F(\bar{e}|c) = 0$. Under these beliefs, $\mu_F(\bar{e}|c) < \delta/(q_t\gamma)$ then, by (34), the optimal strategy of the firm is $s_F = R$. Then, the belief $\mu_c(C) = 1$ is not confirmed. $(C, \underline{e}, \underline{e})$ is not a Bayesian Nash equilibrium.

$(C, \bar{e}, \underline{e})$ is based on the system of beliefs: $\mu_c(C) = 1$ and $\mu_F(\bar{e}|c) = 1$. Under these beliefs, $\mu_c(C) > 1/2$ then, by (33), the optimal strategy of the c worker is $s_W(c) = \bar{e}$. Then, $\mu_F(\bar{e}|c) = 1$ is confirmed. In the same way, $\mu_F(\bar{e}|c) \geq \delta/(q_t\gamma)$ only if $q_t \geq \gamma/\delta$. In this case and only in this case the firm choose $s_F = C$ and the belief $\mu_c(C) = 1$ is confirmed. Then, $(C, \bar{e}, \underline{e})$ is a Bayesian Nash equilibrium is $q_t \geq \tilde{q}$.

It is straightforward that, since $\gamma \geq \delta$ and $\pi^H > \pi^L$, $(C, \bar{e}, \underline{e})$ Pareto dominates $(R, \underline{e}, \underline{e})$.

Formal analysis of the dynamics of p_t

Assume that at the end of each date t each firm observes both the contract and the profit of another firm randomly chosen. Consider x the firm which observes (its profits in t are denoted Π_t^x) and y the firm which is observed (its profits in t are denoted Π_t^y). If x and y have the same contract, x retained its contract. In the same way, if x and y have different contracts and $\Pi_t^x > \Pi_t^y$, x retains its contract. Finally, if x and y have different contracts and if $\Pi_t^y > \Pi_t^x$, x adopts the contract of y with a probability $\varphi(\Pi_t^y - \Pi_t^x)$.

$Q_t^{i,j}$ denotes the probability for a firm which has the contract i at date t to have the contract j at date $t+1$. We deduce from this evolutionary process the following probability of transition:

$$Q_t^{IC,IC} = p_t + (1 - p_t)\min\{1, 1 - \varphi(\Pi_t^{EC}(q_t) - \Pi^{IC}(q_t))\}$$

Indeed, with a probability p_t, a firm IC observes a firm of same type and does not change its contract. With a probability $(1-p_t)$ it observes a firm EC and changes its contract with a probability $\varphi(\Pi_t^{EC}(q_t)-\Pi^{IC}(q_t))$ only if $\Pi_t^{EC}(q_t)>\Pi^{IC}(q_t)$. In the same way, it yields:

$$Q_t^{EC,IC}=p_t\max\{0,\varphi(\Pi_t^{IC}(q_t)-\Pi^{EC}(q_t))\}$$

The dynamics of p_t is deduced from these probabilities of transition:

$$p_{t+1}=p_tQ_t^{IC,IC}+(1-p_t)Q_t^{EC,IC}$$

In the case where the expected profit of the EC firms is higher than the expected profit of the IC firms $(\Pi_t^{EC}(q_t)>\Pi^{IC}(q_t))$, we obtain :

$$\min\{1,1-\varphi(\Pi_t^{EC}(q_t)-\Pi^{IC}(q_t))\}=1-\varphi(\Pi_t^{EC}(q_t)-\Pi^{IC}(q_t))$$

$$\max\{0,\varphi(\Pi_t^{IC}(q_t)-\Pi^{EC}(q_t))\}=0$$

and

$$p_{t+1}=p_t+p_t(1-p_t)\varphi(\Pi_t^{IC}(q_t)-\Pi^{EC}(q_t))$$

If $\Pi_t^{EC}(q_t)<\Pi^{IC}(q_t)$:

$$\min\{1,1-\varphi(\Pi_t^{EC}(q_t)-\Pi^{IC}(q_t))\}=1$$

$$\max\{0,\varphi(\Pi_t^{IC}(q_t)-\Pi^{EC}(q_t))\}=\varphi(\Pi_t^{IC}(q_t)-\Pi^{EC}(q_t))$$

and it follows:

$$p_{t+1}=p_t+p_t(1-p_t)\varphi(\Pi_t^{IC}(q_t)-\Pi^{EC}(q_t))$$