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Abstract

We ask whether young agents prefer to work in different-age or same-age production pairs in an overlapping-generations model where wages are reputation-based. We find that inter-generational teams (i) produce more heterogeneity in the old workers' reputations, (ii) generate a greater share of wages that are close to workers' theoretical productivities, compared to intra-generational teams; and (iii) a high-productivity agent always prefers inter- to intra-generational teams, whereas the opposite holds for a low-productivity agent.

Keywords: Adverse selection; Overlapping Generations; Reputation; Team production.

Résumé

Ce document étudie les préférences des jeunes employés entre des équipes formées de travailleurs d'âges identiques, ou d'âges différents, dans un modèle à générations imbriquées et où les salaires dépendent de la réputation. Nos résultats indiquent que les équipes inter-générationnelles (i) résultent en une plus grande hétérogénéité dans les réputations des travailleurs plus âgés, (ii) génèrent des salaires qui sont plus proches des productivités théoriques et (iii) sont préférées par des travailleurs dont la productivité est élevée, alors que ceux dont la productivité est faible préfèrent les équipes intra-générationnelles.

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1 Introduction

1.1 Motivation and overview

Overlapping generations (OLG) of workers interact in almost all work environments. At any point in time, an organization may employ young workers who eventually replace old workers as the latter retire. Moreover, team work is often the preferred working arrangement (Katzenbach, ed 1998). Rationales for teams include economies of scale, incentive design under information asymmetries, and training of new workers (Marschak and Radner 1971). Given that OLG of workers are often involved, inter- (i.e. different age) and intra-generational (i.e. same age) teams are likely to be found in many organizations.

In light of these elements, this paper asks the following question: if an employer is indifferent between inter- and intra-generational teams, which one is preferred by young workers? Workers may care about the age composition of the team. This occurs because age differences between co-workers are likely to reflect differences in work histories. Current wages may be computed using each teammate's past performance in order to assess individual contributions to a team output. Hence, a worker may prefer a team composition that puts her employment history in a more favorable perspective. For example, a high-productivity worker should favor team arrangements that are more likely to result in her being correctly identified as such.

To gain insight on this question, we consider an agency problem in a dynamic OLG framework with adverse selection. Risk-neutral agents live for two periods, young and old, and supply labor inelastically. Their productive ability is either low or high, and is observed privately, but not by the employer. Employers (principals) have access to an additive technology that combines productivities and exogenous technological shocks. Agents are matched randomly to form two-person production teams that can either be inter- or intra-generational. Observing only the team's production, the employer pays each worker her conditional expected marginal product, based on current and past outputs of each teammate. Wages are thus set to the conditional probability of being a high-productivity worker, and become a worker's reputation in the next period.

We numerically solve for the steady-state distribution of wages, as well as the steady-state expected utility of a worker, depending on her productivity. This exercise is performed for inter- and intra-generational teams. Our model has the particularity that both arrangements yield the same expected profit to the principal. Hence, the employer is indifferent between the two team arrangements. This allows us to concentrate on the workers' preferences instead.

We establish three main results. First, inter-generational teams produce more heterogeneous old workers' reputations than intra-generational teams. Second, inter-generational teams generate a greater share of wages that are close to workers' theoretical productivities, compared to intra-generational teams. Finally, a high-productivity agent always prefers inter- to intra-generational teams, whereas the opposite holds for a low-productivity agent.

In an intra-generational team, two young agents without employment history share an identical 'reputation', and earn the same wage which is constrained by the output set. In comparison, under inter-generational teams, a young agent's wage is a function of an old agent's reputation. In the next period, this young agent's wage becomes her reputation when old, and is again fed in the wage schedule, and so forth. This creates an un-interrupted information chain that links all generations, whereas intra-generational teams break this chain at the end of each period. The inter-generational information chain is useful to the principal in evaluating all workers' contributions to output, and results in more precise estimates of their productivities. Since wages are equal to a worker's expected marginal product, a high-productivity agent prefers an arrangement where wages are close to true productivities. This outcome is obtained under inter-generational teams.

We voluntarily construct our model such that the principal is indifferent between the two team arrangements. However, in real life, inter-generational teams are likely to be found in organizations where training and mentoring of young workers is important, such as in law firms. Moreover, if a firm benefits from the share of high-productivity workers in its labor force, then it should choose the team composition which attracts such workers. Since we find that high-productivity workers prefer inter-generational teams, this would provide a second rationale for a firm to choose inter- over intra-generational teams.

1.2 Relevant Literature

Our framework is mainly related to the team literature in the presence of asymmetric information. This strand of research focuses on mechanisms designed to minimize the inefficiencies related to information asymmetry between employees (agents) and the employer (principal). The information asymmetry can be of two types. The employer does not observe: (i) the worker's effort (moral hazard), and/or (ii) the exogenous productive characteristics of the worker (adverse selection).

Moral hazard If output depends on workers' effort, and if this effort is costly to the agent, some team members may find it optimal to shirk. Early research focuses on workers' monitoring and incentives designed to achieve the first-best full-information effort level. Indeed, Alchian and Demsetz (1972) argue that one of the essential purpose of the firm *is* to monitor team production.

Holmstrom (1982) is critical of this assessment. He argues that abandoning the restriction that all output be distributed, can induce the optimal effort without costly verification. When team members are risk averse, Rasmusen (1987) contends that randomization of punishment, or reward, may also support the first-best solution. Extreme punishment such as 'scapegoating' (one team member being arbitrarily punished), or 'massacre' (all but one member being punished) whenever output falls below a threshold, can yield the desired effort level.

The previous literature is characterized by exogenous teams. Itoh (1991) considers instead an environment where there may be incentives to help other agents. Such situations occur when the effort levels extended to other agents increase the expected outcome. Then, teams arise endogenously following the wage structure selected by the principal. In particular, if individual wages are a function of other agents' outcomes, it can become optimal to help others. Moreover, teams can also be optimal for the principal if agents increase their own efforts when they receive help from others.

Che and Yoo (2001) focus on peer pressure in repeated interactions between team members. They distinguish between 'implicit' (obtained through co-workers' control) and 'explicit' (obtained through task and compensation design) mechanisms to ensure optimal effort levels. They show that repeated interactions encourage cooperation among team members through peer sanctions. These implicit mechanisms need to be taken into account when designing optimal explicit schemes. In particular, so-called 'joint performance evaluation' is optimal under repeated interactions. Moreover, the length of the interaction determines whether production teams should be instituted.

Adverse selection Inefficiencies may also occur when the principal does not observe a worker's productive characteristics. McAfee and McMillan (1991) contend that harsh retributions advocated by Rasmusen (1987) may not be appropriate when a team output also depends on unobserved exogenous abilities. Allowing for adverse selection, in addition to moral hazard, they identify optimal payment schemes. Marginal payments are set below the marginal increase in team output in order to capture the informational rent from the employee, and fixed payments are adjusted accordingly so as to restore budget balance.

This linear payment scheme, however, does not achieve the first-best outcome since increasing effort is attained at the cost of a higher informational rent extracted by low-ability workers. If *contributions*, i.e. effort plus ability, can be monitored, then Vander-Veen (1995) shows that it is possible to increase the principal's revenues when agents are risk averse. By monitoring contributions, the principal can remove the uncertainty concerning the other agents' inputs and reduce her payment to workers, without reducing their expected utility.

From a different perspective, Meyer (1994) focuses on the informational content of a team output composed of two different-age workers. Her objective is the optimal allocation of junior members' time in junior-senior teams when information on workers' types is gathered sequentially. Under a 'no-sharing' rule, juniors specialize by working on a single project, yielding two distinct observations on an employee before a promotion decision is made. The 'junior-sharing' rule has junior members allocating their time between various projects. In this case, no information is gathered on the junior member, but the team's output is informative about the senior member's ability. Depending on the relative volatility of types and exogenous shocks, Meyer shows that corner solutions favoring either rule are obtained.

As in Itoh (1991), Auriol, Friebel and Pechlivanos (2002) analyze cooperation among team members. However, they focus on a principal who cannot commit to a given remuneration scheme. In their framework, productivity is observed by neither the agent nor the principal, and wages reflect a worker's reputation. They find that workers have an incentive to maximize their reputation, even at the expense of others. This reluctance to cooperate with colleagues can be addressed by having recourse to collective payments.

Breton, St-Amour and Vencatachellum (2002) consider a dynamic OLG environment with adverse selection. They study two-person teams composed of a young and an older worker, where wages are reputation-based. As in Itoh (1991), teams are endogenous. Workers are matched randomly, they observe each other's type and decide whether or not to form a team, possibly exchanging side payments to convince a reluctant teammate. Breton et al. (2002) numerically solve for the Nash-equilibrium strategies of agents. In particular, they identify regions in the workers' reputations where only teams composed of two good-type workers are observed.

Relation with the literature Our analysis also focuses on adverse selection in a dynamic OLG setting, and abstracts from moral hazard. We are closer in spirit to the literature that assumes that teams are exogenously given (Alchian and Demsetz 1972, Holmstrom 1982, McAfee and McMillan 1991, Vander-Veen 1995). We share a number of similarities with Meyer (1994). First, we emphasize the age composition of the team. Second, team arrangements are decided by the principal as one-time decisions that do not involve any technological considerations, and are executed by the workers. Finally we also focus on steady state. However, we differ from Meyer (1994) in several ways. First, by construction, the principal is indifferent between the two team arrangements. This allows us to focus on workers' preferences over the age composition of the team. Second, our model is fully dynamic. Workers' reputations evolve endogenously and are persistent over time, while they affect the agents' welfare. In contrast, Meyer's criterion for optimality is based solely on the quality of a terminal promotion decision.

As in the 'career concern' literature, wages are determined by past performance, and workers prefer arrangements that maximize their reputation (Holmstrom 1999, Auriol et al. 2002). Other recent reputation analyses focus on the market for 'names', where departing agents can sell acquired reputations by selling property rights over brands. These markets are shown to alleviate some of the problems associated with moral hazard. When reputation becomes a traded asset, and if those transactions are not observed by the principal, agents become concerned about the evolution of their reputations (Mailath and Samuelson 2001, Tadelis 2001).

Our framework also shares similarities with the reputation market studied by Tadelis (1999). He shows that information inefficiencies persist in an OLG setting with adverse selection. This occurs because 'bad' types find it harder to build up their own reputation than 'good' types. All equilibria involve some of the good types selling their names to the bad types. Similar transactions are studied by Breton et al. (2002) who allow for reputation sharing through side payments within the team. We abstract from these transaction issues here. Agents are randomly matched and make no decisions.

The remainder of the paper is organized as follows. Section 2 presents the model economy, as well as the timing of events. We focus on the steady-state analysis, and outline the numerical methods used to compute workers' expected utility in Section 3. Section 4 discusses the results. Section 5 summarizes the main findings. All tables, proofs, and most figures are in the appendix.

2 Model

Consider an OLG economy, where multiple heterogeneous agents (the workers) and a representative principal (the employer) interact through an organization. Workers differ in age, productive abilities, and employment histories. Let superscripts denote an agent's identity and subscripts denote age and time. An agent i is characterized by her age $a = 1, 2$, respectively young and old and her productivity $\eta = 0, 1$, respectively low productivity (LP) and high productivity (HP), and is referred to as η_a^i. We assume that productivity is (i) not publicly observed, (ii) given at young age and (iii) time-invariant, i.e. $\eta_1^i = \eta_2^i$, for all agents i. Finally, we assume that there is an equal and large number n of young and old agents, and a proportion ϕ of HP agents in the population.

Agents are randomly matched in production pairs (teams) denoted (η_a^i, η_b^j) for ages $a, b \in \{1, 2\}$. Output is obtained as the sum of individual productivities plus i.i.d. random technological shocks associated with each teammate:

$$y_t = \eta_a^i + \eta_b^j + \epsilon_t^i + \epsilon_t^j, \tag{1}$$

where ϵ_t^i is a shock from nature that equals 1 (respectively 0) with probabilities μ (respectively $1 - \mu$).[1] Note that the technology (1) admits only five possible outputs, i.e. $y_t \in Y = \{0, 1, 2, 3, 4\}$.

Wages $w_{a,t}^i$ are paid after output is observed by the principal. Each individual wage is set equal to a worker's conditional expected marginal product, given past wages for each team member, and current output. Under our assumption of additive technology (1), this amounts to paying the *ex-post* probability of being HP:

$$w_{a,t}^i(w_{a-1,t-1}^i, w_{b,t-1}^j, y_t) = \frac{\Pr(\eta_a^i = 1, y_t \,|\, w_{a-1,t-1}^i, w_{b,t-1}^j)}{\Pr(y_t \,|\, w_{a-1,t-1}^i, w_{b,t-1}^j)}. \tag{2}$$

Table 1 in Appendix A gives the numerator (column 2) and denominator (column 3) probabilities in (2). Note that an output of 0 (or 4) yields a wage of 0 (or 1), otherwise $w_{a,t}^i \in (0, 1)$. We will return to columns 4 and 5 of Table 1 in Section 3.

Hence, wages reflect the conditional beliefs on a worker's productivity. As such, they summarize an agent's employment history and can be interpreted as her reputation. We assume that a young worker begins the period with no employment history. Consequently, the employer uses the unconditional probability that a young agent is HP as past wage in evaluating (2) i.e. $w_{a-1,t-1}^i = \phi$, for $a = 1$.

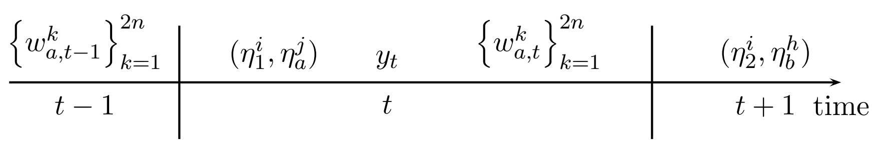
Table 1 verifies a number of properties of *ex-post* wages. First, wages are increasing in output y. Second, wages are also increasing in self-reputation w^i. Hence, as in the 'Reputation Maintenance Effect' of Tadelis (1999), the technology (1) implies that an HP worker can expect higher outputs than an LP worker. Consequently, it is easier for an HP worker to attain and maintain higher *ex-post* reputations than an LP worker. However, contrary to the 'Reputation Start-up Effect' of Tadelis, it is not more difficult for LP workers to start their own reputation, since all young workers begin with a cohort 'reputation' of ϕ. Third, wages are decreasing in the other teammate's reputation w^j. Fourth, wages also fall in the probability of a positive shock from nature μ. Hence, increasing worker

[1] Alternatively, (1) can be interpreted as individual productivities being measured with exogenous noise.

j's reputation implies that she is attributed a higher output share. Consequently, the expected contribution of agent i is reduced. Similarly, nature can be interpreted as a third 'teammate'; a higher μ is tantamount to increasing nature's reputation. It follows that the expected contribution of *both* teammates is lower.

The sequence of events from a young agent's perspective is represented in Figure 1. At the beginning of period t, a young agent i is randomly matched with an agent j. Output then takes place. At the end of the period, the principal computes all wages taking into account past reputations, and current output. At the beginning of the next period $t+1$, aging occurs, and new teams are formed with i being matched randomly with agent h.

Figure 1: Time sequence for young agent i



Note: $w^k_{a,t}$ denotes agent k's wage; a is her age in period t; wages are computed using (2); η^k_a is her productivity; y_t is output given by (1).

We consider two alternative team arrangements:

- Inter-generational teams are composed of one young and one old worker. In Figure 1, this corresponds to (η^i_1, η^j_2) in period t and to (η^i_2, η^h_1) in period $t+1$.
- Intra-generational teams are composed of two young or two old worker. In Figure 1, this corresponds to (η^i_1, η^j_1) in period t and to (η^i_2, η^h_2) in period $t+1$.

We denote by a tilde ($\tilde{}$) a variable evaluated under intra-generational team, otherwise, inter-generational teams are assumed.

Finally, we assume that each agent has risk-neutral von Neuman-Morgenstern preferences given by:

$$v^i_{1,t} = E[w^i_{1,t} + \beta v^i_{2,t+1}(w^i_{1,t}) \mid \eta^i_1], \tag{3}$$

$$v^i_{2,t+1}(w^i_{1,t}) = E[w^i_{2,t+1} \mid w^i_{1,t}, \eta^i_1], \tag{4}$$

where $v^i_{1,t}$ is the *ex-ante* young agent i's expected utility, at the beginning of period t before matching occurs, E is an expectations operator, and $\beta \in (0,1)$ is a subjective discount factor. Note that a young agent conditions on her ability when evaluating her expected utility. Next, when old, given (2), the agent also uses her period-t wage as conditioning information in calculating her expected wages.

3 Steady State

We now focus on agents' preferences between the inter- and intra-generational teams. For that purpose, we calculate a worker's long-run expected utility. Suppose there is a limited number M of wages $\mathsf{w}^m \in \mathsf{W} \equiv \{\mathsf{w}^m : m = 1, \ldots, M\}$.[2] Consider any match between agents i and j, in any time period t. Define the following one-period $(M \times M)$ transition matrices $\mathbf{P} = [p_{kl}]_{k,l}$, and $\tilde{\mathbf{P}} = [\tilde{p}_{kl}]_{k,l}$ as follows:

$$p_{kl} \equiv \Pr(w^i_{1,t+1} = \mathsf{w}^l \,|\, w^j_{1,t} = \mathsf{w}^k), \tag{5}$$

$$\tilde{p}_{kl} \equiv \Pr(w^i_{1,t+1} = \mathsf{w}^l \,|\, w^j_{1,t} = \phi). \tag{6}$$

Hence, $\mathbf{P}$ and $\tilde{\mathbf{P}}$ are the transition matrices for the wages of the young population, at the end of their first work period, under inter- and intra-generational teams respectively. Elements of $\mathbf{P}$, and $\tilde{\mathbf{P}}$ are computed using the second column of Table 1.

Let s^m represent the share of old agents who received a wage equal to w^m at the end of their first employment period, with $\mathbf{S} = [s^m]_m$ being the $(1 \times M)$ vector of shares, under the inter-generational team arrangement. This wage w^m also represents the reputation of old agents in their second employment period. Under intra-generational teams the corresponding shares are $\tilde{\mathbf{S}} = [\tilde{s}^m]_m$. Using $\mathbf{S}$ and $\mathbf{P}$ for inter-generational teams, and $\tilde{\mathbf{S}}$ and $\tilde{\mathbf{P}}$ for intra-generational teams, we define a steady state under each team arrangement as follows:

Definition 1 (Steady state) *Let ι be a $(M \times 1)$ unit vector. The steady-state distributions of wages $\mathbf{S}^*$, and $\tilde{\mathbf{S}}^*$ satisfy*

$$\mathbf{S}^*\mathbf{P} = \mathbf{S}^*, \quad \mathbf{S}^*\iota = 1 \tag{7}$$

for inter-generational teams, and

$$\tilde{\mathbf{S}}^*\mathbf{P} = \tilde{\mathbf{S}}^*, \quad \tilde{\mathbf{S}}^*\iota = 1 \tag{8}$$

for intra-generational teams.

We can now substitute the steady-state distribution of wages given in Definition 1 in (3) and (4) to compute a worker's lifetime utility recursively, under either one of the two team arrangements. In both cases, the relevant probabilities used to compute expected utilities are given in Table 1. To simplify the exposition, the rest of the analysis drops the t subscript.

Inter-generational teams Under teams composed of two different-age workers, agent i's expected utility is given by:

$$v^i_1 = \sum_{m \in M} s^{m*} \sum_{y \in Y} \left\{ w^i_1(\phi, \mathrm{w}^m, y) + \beta v^i_2\left(w^i_1(\phi, \mathrm{w}^m, y)\right)\right\} \Pr(y \,|\, \eta^i_1, \mathrm{w^m}), \tag{9}$$

$$v^i_2(w^i_1) = \sum_{y \in Y} w^i_2(w^i_1, \phi, y) \Pr(y \,|\, \eta^i_1, \phi), \tag{10}$$

where the steady-state share of old workers' reputations, s^{m*}, is computed using (7).

[2] This assumption can be interpreted as wages being rounded off to some precision corresponding to a discretized grid W.

Intra-generational teams Under teams composed of two same-age workers, agent i's expected utility is given by:

$$\tilde{v}_1^i = \sum_{y \in Y} \left\{ w_1^i(\phi, \phi, y) + \beta \tilde{v}_2^i \left(w_1^i(\phi, \phi, y) \right) \right\} \Pr(y, \mid \eta_1^i, \phi), \quad (11)$$

$$\tilde{v}_2^i(w_1^i) = \sum_{m \in M} \tilde{s}^{m*} \sum_{y \in Y} w_2^i(w_1^i, \mathrm{w}^m, y) \Pr(y \mid \eta_1^i, \mathrm{w}^m). \quad (12)$$

where the steady-state share, $\tilde{s}^{m*}$, is computed using (8).

In equation (9), for an inter-generational team, a young worker of reputation ϕ is matched with a reputation-w^m old worker with steady-state probability s^{m*}. Both her reputation and that of her teammate, as well as the team output determine her wages $w_1(\phi, \mathrm{w}^m, y)$. Given that agent i privately observes her productivity η_1^i, this wage is received with probability $\Pr(y \mid \eta_1^i, \mathrm{w}^m)$ using either the 4^{th} (HP worker) or the 5^{th} column (LP worker) in Table 1. Her next-period utility, (10), is her expected wage when old, given that she is matched with a reputation-ϕ young worker, and that her own reputation is w_1^i. In the case of intra-generational teams, two young workers are matched in the first period, (11), and two old workers are matched in the second period, (12).

Equations (9) and (10), for the inter-generational case, as well as (11) and (12) for intra-generational teams are solved using the corresponding steady-state distribution of wages given in (7) and (8) respectively. No analytical solution exists for this class of problem, and we resort to the following numerical method.[3] For example, in the inter-generational case, the algorithm is:

1. Compute the steady-state distribution of wages in the young-agent population. Starting from any initial share vector (say, a uniform distribution), iteratively multiply this vector by $\mathbf{P}$ until two successive share vectors differ by less than a given convergence threshold (we used 10^{-8}).
2. Evaluate the function $v_2^i(\cdot)$ at all points on the discretized wage grid using equation (10).
3. Using v_2^i, compute

$$\sum_{y \in Y} \{ w_1^i(\phi, \mathrm{w}^m, y) + \beta v_2^i(w_1^i(\phi, \mathrm{w}^m, y)) \} \Pr(y \mid \eta_1^i, \mathrm{w}^m),$$

the expected wage of a young worker, matched with an old worker who received w^m when young, for all w^m on the grid.
4. We weigh these values by the steady-state distribution of old workers' reputations to obtain the expected utility of a young worker v_1^i (equation (9)).

Until now, we have maintained that the employer is indifferent between the two team arrangements. We now formally prove that this is the case.

[3] The steady-state wage distributions depend on the discretization grid, which we set to 1,000 points. We use $\beta = 0.5$, which corresponds to an annual subjective discount factor of 0.98, over a 40-year generation period. We span the parameter space determined by ϕ and μ. The GAUSS code is available upon request.

Proposition 1 *The principal earns $2n\mu$ expected profits under both inter- and intra-generational teams.*

The intuition for Proposition 1 is as follows. First, technology (1) assumes that productivities and shocks from nature are i.i.d. and enter additively in the production function. Hence, the unconditional expected aggregate output is $2n(\phi + \mu)$, independent of team composition. Second, on the one hand, in the absence of conditioning information, each worker is paid ϕ, such that the unconditional expected aggregate wage outlay is $2n\phi$. On the other hand, under full information, HP workers receive 1, whereas LP workers receive 0. Once again, total wage outlay is $2n\phi$. Any partial information environment may be interpreted as a convex combination of the no- and full-information cases, such that the aggregate wage outlay remains unchanged. The team arrangement can only alter the information set used by the principal. Since aggregate wage bill is independent of information, and output is independent of team composition, it follows that the principal earns the (uncompensated) contribution from nature under both arrangements.

Therefore, the principal is *ex-ante* indifferent between inter- and intra-generational teams. Moving from one team arrangement to another can only involve redistributive shifts between wages of HP and LP workers. These shifts occur because the conditioning set used by the principal is affected by the age composition of the team. The next section discusses these effects.

4 Results

This section presents the numerical results for the complete parameter space determined by ϕ and μ. We first discuss the steady-state distribution of wages. Then, we present the utility levels under each team composition for HP and LP agents. Finally, we focus on workers' benefits (or losses) from moving from intra- to inter-generational teams. Our results are robust to changes in the only other remaining free parameter, the subjective discount factor, β.

4.1 Steady-state shares of wages

Figure 2 in Appendix C presents the steady-state shares of wages under inter- (upper panels) and intra-generational teams (lower panels) respectively. The left-hand side panels highlight the effect of the probability of a positive shock, μ, with the probability of an HP worker, ϕ, held fixed, while the right-hand side panels vary ϕ and hold μ fixed.

Result 1 *Inter-generational teams produce more heterogeneity in old workers' reputations than intra-generational teams.*

Inter-generational teams distribute the probability mass on a large number of wages in the support, whereas intra-generational teams concentrate the mass around at most 5 points. Intra-generational teams start with 2 young workers with identical reputations. Since the principal cannot discriminate between the two, they therefore receive the same wage. The feasible *ex-post* wages are limited by the feasible output set Y. These wages become their reputation when old. Following a random match, two old workers will likely have different reputations, leading to different *ex-post* wages. However these different 'third-period reputations' do not feed back into the wage schedule since workers live only for two periods. In comparison, inter-generational teams continuously feed old workers' reputations into a young worker's wage equation (see Table 1). This creates an information chain across generations. As a result, a continuum of wages are observed under inter- but not intra-generational teams.

Result 2 *Inter-generational teams generate a greater share of wages that are close to workers' theoretical productivities, compared to intra-generational teams.*

Reputations close to 0.5 correspond to the least informative region of feasible wages. In Figure 2, intra-generational teams maintain a large share of wages around the 0.5 level. This is not the case for inter-generational teams that shift the mass away from the center and towards the extremes. Indeed, we can evaluate the sum of the wage shares less than 0.05 and greater 0.95 under each team arrangement. We then calculate the difference of those two sums. This difference captures the informational gain of inter-generational teams in generating wages that are close to the theoretical productivities. Figure 3 shows that inter-generational teams *always* outperform intra-generational teams in assigning wages that are close to the theoretical productivities. The difference is particularly important when the difference between ϕ and μ is large.[4]

To understand this result, recall that the principal uses Bayes' rule (2) to update her priors on a worker's productivity. Result 1 arises because inter-generational teams create a continuous information chain across generations, whereas this is not the case for intra-generational teams. Consequently, the information set is richer under inter- than under intra-generational teams. The conjunction of Bayes' rule and a richer conditioning set implies that in the aggregate, wages should be closer to workers' theoretical productivities under inter- than intra-generational teams. Result 2 establishes that this is what we observe.

Note, however, that although wages are closer to the theoretical productivities under inter- than under intra-generational teams, this does not imply that those who receive a wage close to 1 (0) are HP (LP) workers. We verify whether this holds by computing the expected utility of HP and LP workers under both arrangements.

4.2 Expected utilities of HP and LP workers

Figure 4 presents the steady-state expected utility for young HP agents (left-hand side) and LP agents (right-hand side), under the inter-generational (top panel) and intra-generational (bottom panel) arrangements.

First, we find that the expected utility of an HP young agent is greater than that of an LP young agent. This result is obtained by taking the difference of the expected utilities of an HP and an LP agent for all points in the parameter space.[5] On average, an HP agent is better off than an LP worker by 82% in an inter-generational team, and by 68% in an

[4] Result 2 is robust to changes in the cutoff points.

[5] This corresponds to the row differences of the levels in Figure 4.

intra-generational team. This occurs because attainable outputs, and therefore wages, are higher for an HP than an LP worker, regardless of the team arrangement.

Second, as anticipated, Figure 4 reveals that a young worker's expected utility is monotone increasing in ϕ, which is a consequence of the principal paying expected marginal product which is itself increasing in self reputation. Moreover, a higher ϕ also implies a higher probability of being matched with an HP agent. Better co-workers allow for higher output, such that a higher wage can be anticipated.

Third, we also find in Figure 4 that a worker's expected utility is convex (concave) in μ for HP (LP) agents. When μ is close to 0 or 1, there is less uncertainty regarding the contribution of technological shocks to output. This benefits an HP worker, but penalizes an LP agent, by reducing the uncertainty concerning her contribution. Conversely, when μ is close to 0.5, the contribution of technological shocks is less certain, which penalizes HP workers and benefits LP agents. Consequently, an HP agent's expected utility is high when μ is close to 0 or 1, and low otherwise, whereas it is high for an LP agent when μ is close to 0.5, and low otherwise.

4.3 Inter-generational team premium

We now compute the inter-generational team premium as a young worker's steady-state expected utility under inter-generational teams minus that obtained under intra-generational teams.[6] Figure 5 graphs that difference for an HP agent in the left panel, and for an LP agent in the right panel.

Result 3 *A high-productivity agent always prefers inter- to intra-generational teams, whereas the opposite holds for a low-productivity agent.*

Figure 5 reveals that the inter-generational team premium is always positive for an HP agent, and always negative for a LP agent. The average inter-generational team premium for an HP worker is 3%, and attains 34% for low ϕ and high μ.

This preference of HP workers for inter-generational teams is a direct consequence of our earlier results. Result 1 and 2 establish that the principal has access to a richer information set under inter- than intra-generational teams. Consequently, wages are closer to a workers' theoretical productivity under inter- than intra-generational teams. We find that this benefits HP agents who obtain a wage close to 1, and penalizes LP workers who receive a wage close to 0. In comparison, agents' productivities are less clearly identified under intra-generational teams. Intra-generational teams benefit an LP worker who earns high informational rent, and is detrimental to the HP agent who earns a low wage.

Result 3 would still hold if we were to replace the i.i.d. technological shock assumption by perfectly correlated shocks. Breton et al. (2002) use a similar OLG team setup where young and old agents are randomly matched in inter-generational teams. They show that when assuming common technological shocks to both workers, i.e. $\epsilon^i = \epsilon^j$ in (1), inter-generational teams lead to a perfectly separating steady-state equilibrium. In comparison, when young agents work by themselves (an arrangement that is informationally equivalent

[6]This corresponds to the column differences of the levels in Figure 4.

to intra-generational teams) some uncertainty on agents' productivities persists. It follows that HP workers would again prefer inter- to intra-generational teams.

In addition, Figure 5 shows that the inter-generational team premium is convex in μ for HP agents, while it is concave for LP agents. This occurs for the same reasons as discussed in Section 4.2. Finally, when μ differs from 0.5, and ϕ is high, we find that the inter-generational team premium to an HP worker is low, whereas the loss to an LP worker is high. Conversely, at low ϕ, the inter-generational team premium to the HP worker is high, whereas the loss to the LP worker is low.[7] A high ϕ is equivalent to a high reputation for young workers. An LP agent stands to lose more informational rent by being identified as such, and loses more under inter-generational teams. However, since an HP worker has a reputation that is already close to her true productivity, the marginal benefit of the additional information is small. Conversely, for low ϕ, an LP agent has less informational rent to lose if she is identified as such. However, an HP agent loses more from a low reputation, and has more to gain from the incremental information conveyed by inter-generational teams.

5 Conclusion

We ask whether young workers prefer to work in inter- or intra-generational production teams when wages are reputation-based. To answer this question, we consider an agency problem in a dynamic OLG framework. Agents who differ in age (young-old), productive ability (high-low), and work experience are randomly matched in production pairs. Wages summarize past employment histories and any new information revealed by current output.

We numerically compute the steady-state distribution of wages, and the expected utility of young workers, under the two alternative team compositions. Our main results are:

i. Inter-generational teams produce more heterogeneous old workers' reputations.

ii. Inter-generational teams generate a greater share of wages that are close to workers' theoretical productivities, compared to intra-generational teams.

iii. A high-productivity agent always prefers inter- to intra-generational teams, whereas the opposite holds for a low-productivity agent.

The last result is probably the most interesting, and should be a concern for employers if there are additional benefits in attracting high-productivity workers. These benefits are voluntarily omitted here for us to focus on informational issues only. Different-age teams imply differences in reputation. This allows output to be more informative on each agent's true productivity. Consequently inter-generational teams shift the steady-state wage distribution away from the un-informative segment towards the more informative extremes. This benefits high-productivity workers at the expense of low-productivity agents.

[7] Note that a corollary of Proposition 1 is that the aggregate net effect is zero, i.e.:

$$\sum_{i=1}^{n} \phi(v_1^i - \tilde{v}_1^i)\Big|_{\eta_1^i=1} + (1-\phi)(v_1^i - \tilde{v}_1^i)\Big|_{\eta_1^i=0} = 0$$

A Tables

Table 1: Output probabilities and *ex-post* wages for agent i

Current-period team's output, y	$\Pr(\eta^i = 1, y \mid w^i, w^j)$	$\Pr(y \mid w^i, w^j)$	$\Pr(y \mid \eta^i, w^j)$ $\eta^i = 1$	$\Pr(y \mid \eta^i, w^j)$ $\eta^i = 0$
0	0	$\bar{\mu}^2 \bar{w}^i \bar{w}^j$	0	$\bar{\mu}^2 \bar{w}^j$
1	$\bar{\mu}^2 w^i \bar{w}^j$	$\bar{\mu}^2[\bar{w}^i w^j + w^i \bar{w}^j] + 2\mu\bar{\mu}\bar{w}^i \bar{w}^j$	$\bar{\mu}^2 \bar{w}^j$	$\bar{\mu}^2 w^j + 2\mu\bar{\mu}\bar{w}^j$
2	$\bar{\mu}^2 w^i w^j + 2\mu\bar{\mu} w^i \bar{w}^j$	$\bar{\mu}^2 w^i w^j + 2\mu\bar{\mu}[w^j \bar{w}^i + w^i \bar{w}^j] + \mu^2 \bar{w}^i \bar{w}^j$	$\bar{\mu}^2 w^j$	$2\mu\bar{\mu} w^j + \mu^2 \bar{w}^j$
3	$2\mu\bar{\mu} w^i w^j + \mu^2 w^i \bar{w}^j$	$2\mu\bar{\mu} w^i w^j + \mu^2[\bar{w}^i w^j + w^i \bar{w}^j]$	$2\mu\bar{\mu} w^j + \mu^2 \bar{w}^j$	$\mu^2 w^j$
4	$\mu^2 w^i w^j$	$\mu^2 w^i w^j$	$\mu^2 w^j$	0

Note: The current-period worker of interest i's reputation is $w^i \in [0,1]$ while her teammate j's is $w^j \in [0,1]$. We define $\bar{w}^k \equiv 1 - w^k$, $k = i, j$, and $\bar{\mu} \equiv 1 - \mu$. The production technology is given by (1), where y is the team's output. Worker i's *ex-post* wages in (2) for each y, are given by the ratio of the second to the third columns. Columns 4 and 5 correspond to the probability of output y, given that agent i is HP or LP respectively.

B Proof of Proposition 1

First, recall that productivities and shocks are i.i.d. Under technology (1), this implies that aggregate expected output

$$\begin{aligned} E(y) &= \sum_{y\in Y} \Pr(y) \sum_{k=1}^{2n} \left(\eta_a^k + \epsilon^k\right), \\ &= 2n(\phi+\mu), \end{aligned} \tag{13}$$

is independent of the age composition of the team.

Second, we show that expected wage outlays are also unaffected by the team arrangement. From the principal's perspective, using wages (2), the *ex-ante* expected wage of agent i is:

$$\begin{aligned} E(w_a^i \,|\, w_{a-1}^i, w_b^j) &= \sum_{y\in Y} w_a^i(w_{a-1}^i, w_b^j, y) \Pr(y \,|\, w_{a-1}^i, w_b^j) \\ &= \sum_{y\in Y} \frac{\Pr(\eta_a^i = 1, y \,|\, w_{a-1}^i, w_b^j)}{\Pr(y \,|\, w_{a-1}^i, w_b^j)} \Pr(y \,|\, w_{a-1}^i, w_b^j) \\ &= \sum_{y\in Y} \Pr(\eta_a^i = 1, y \,|\, w_{a-1}^i, w_b^j) \\ &= w_{a-1}^i(\mu+\bar{\mu})^2(w_b^j + \bar{w}_b^j) \\ &= w_{a-1}^i, \end{aligned} \tag{14}$$

using the second column of Table 1. Note that the principal uses a different conditional distribution, $\Pr(y \,|\, w_{a-1}^i, w_b^j)$, than the agent in (9)–(12) since the employer cannot condition on the agent's productivity. Equation (14) shows that the expected wage of agent i, before output is observed, is simply her self reputation, and is independent of her teammate j's reputation. It then follows that it is also independent of her teammate's age. Consequently, expected wages are independent of the age composition of the team:

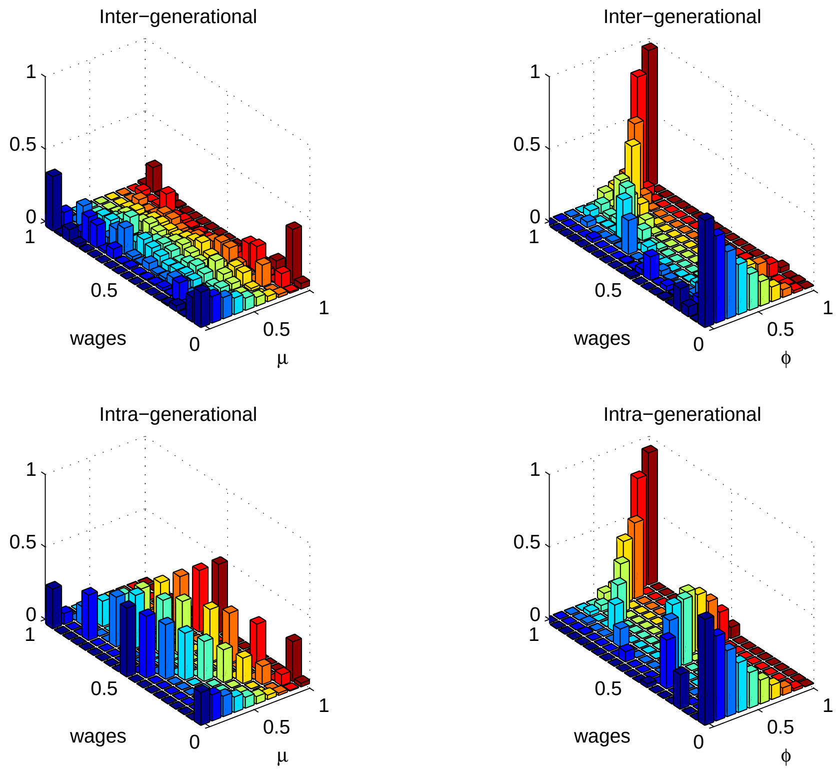
$$E(w_1^i \,|\, \phi, w_a^j) = \phi, \tag{15}$$

$$E\left(w_2^i \,|\, E(w_1^i \,|\, \phi, w_a^j), w_b^h\right) = \phi, \tag{16}$$

such that total unconditional expected wage outlay is $2n\phi$ (i.e. ϕ per generation), independent of the team composition. Expected profits are obtained by (13) minus the unconditional wage outlay, $2n\phi$, which yields $2n\mu$. ■

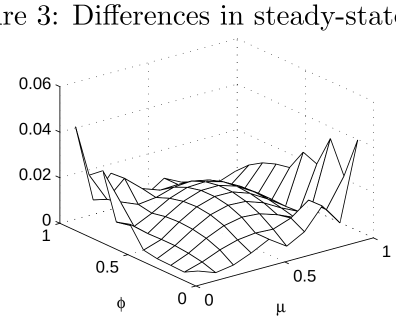
C Other Figures

Figure 2: Steady-state distribution of wages: Effect of μ and ϕ



Note: Steady-state distribution of wages for inter-generational teams, $\mathbf{S}^*$ from (7), and for intra-generational teams, $\tilde{\mathbf{S}}^*$ from (8). $\phi = \Pr(\eta = 1)$ is the HP probability, $\mu = \Pr(\epsilon = 1)$ is the probability of a positive shock, $\beta = 0.5$ is the discount factor. For left-hand side (right-hand side) panels, ϕ (μ) is held fixed at 0.10.

Figure 3: Differences in steady-state tails

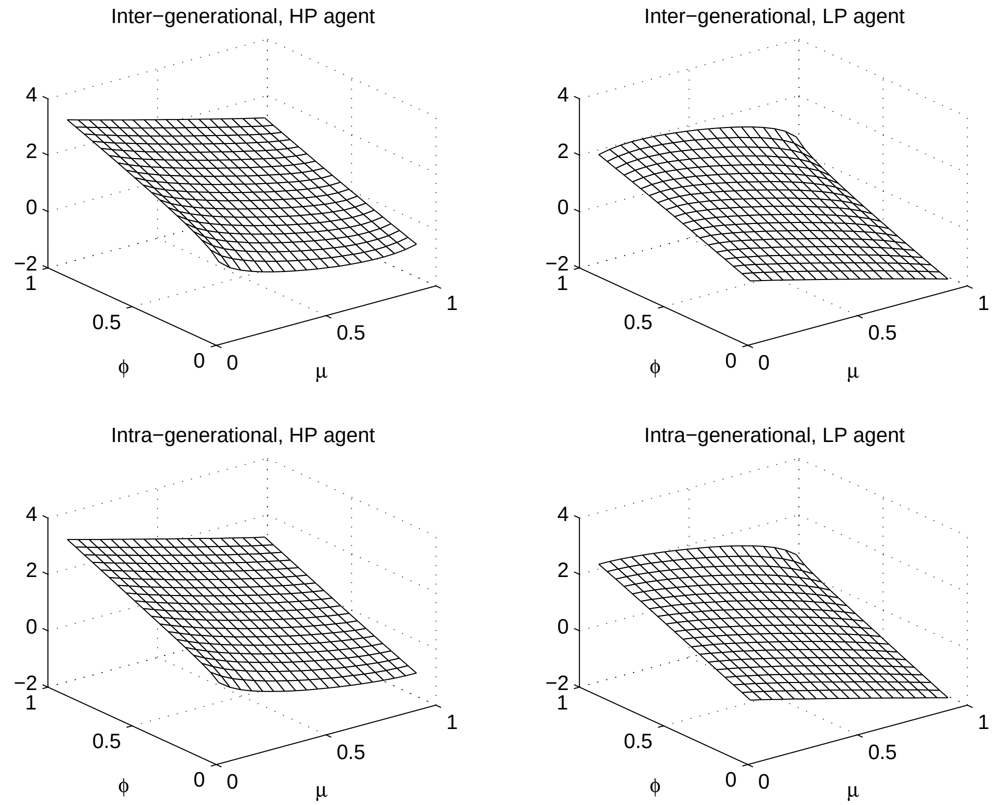


Note: We compute

$$\Delta S^*_{\text{tails}} \equiv \sum_{\substack{w^m \leq 0.05 \\ w^m \geq 0.95}} (s^{m*} - \tilde{s}^{m*}).$$

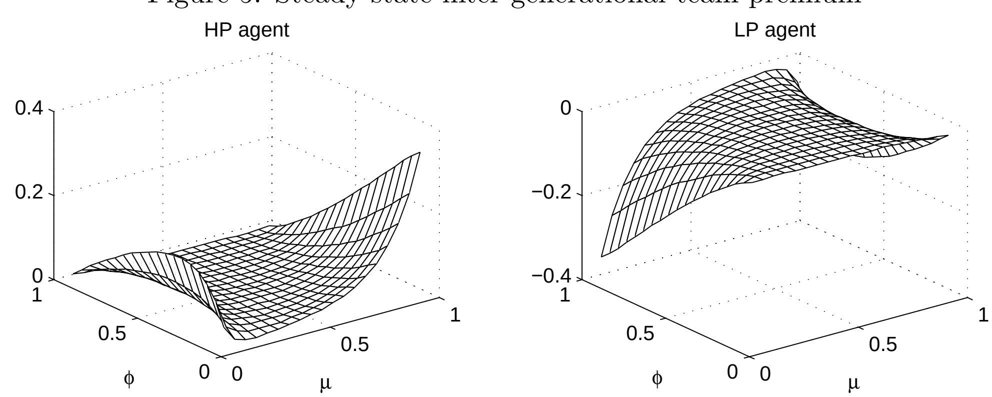
where s^{m*} and $\tilde{s}^{m*}$ are defined in (7) and (8), respectively. The discount factor is $\beta = 0.5$.

Figure 4: Steady-state expected utility



Note: Steady-state expected utility levels for HP and LP agents computed under inter-generational (9–10), and intra-generational (11–12) teams. $\phi = \Pr(\eta = 1)$ is the HP probability, $\mu = \Pr(\epsilon = 1)$ is the probability of a positive shock. The discount factor is $\beta = 0.5$.

Figure 5: Steady-state inter-generational team premium



Note: The inter-generational team premium equals the steady-state expected utility under inter-generational (9) minus that under intra-generational (11) teams. $\phi = \Pr(\eta = 1)$ is the HP probability, $\mu = \Pr(\epsilon = 1)$ is the probability of a positive shock. The discount factor is $\beta = 0.5$.

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