Artificial Intelligence in Team Dynamics: Who Gets Replaced and Why?

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Abstract

This study investigates the effects of artificial intelligence (AI) adoption in organizations. We ask: (1) How should a principal optimally deploy limited AI resources to replace workers in a team? (2) In a sequential workflow, which workers face the highest risk of AI replacement? (3) How does substitution with AI affect both the replaced and non-replaced workers' wages? We develop a sequential team production model in which a principal can use peer monitoring—where each worker observes the effort of their predecessor—to discipline team members. The principal may replace some workers with AI agents, whose actions are not subject to moral hazard. Our analysis yields four key results. First, the optimal AI strategy stochastically replaces workers rather than fixating on a single position. Second, the principal replaces workers at the beginning and at the end of the workflow, but does not replace the middle worker, since this worker is crucial for sustaining the flow of information obtained by peer monitoring. Third, the principal may optimally underutilize available AI capacity. Fourth, the optimal AI adoption increases average wages and reduces intra-team wage inequality.

Keywords: *Artificial intelligence (AI), automation, technology, peer monitoring, teams, organizational structure*
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1 Introduction

Over the past decade, artificial intelligence (AI) has profoundly changed how organizations work and how tasks are assigned to workers. Organizations worldwide are adopting AI at unprecedented scales, owing to benefits such as increased consistency of output and reduced production costs. According to a McKinsey survey, approximately 78% of respondents reported that their organizations utilize AI "in at least one business function" (Singla et al., 2025). Despite its rapid adoption and projected growth, integrating AI into existing organizational structures comes with challenges (Glynn et al., 2024). Specifically, traditional workflows are designed and optimized for human workers, typically operating in teams, working on connected tasks with linked incentives. Thus, when AI is introduced into existing workflows, its effects are unlikely to remain localized. Workers whose tasks are not directly impacted by AI are still likely to be indirectly impacted. At a time when AI is reshaping work and workflows (Bughin et al., 2018; Brynjolfsson et al., 2022) and organizations are thinking about how best to integrate AI into their existing systems, it is essential to ask what the implications of AI are for teams. Yet, the literature to date largely reported effects of AI focusing on individual workers, abstracting away from team dynamics.

In this study, we focus on this area and ask the following questions: How should a principal optimally deploy limited AI resources to replace workers in a team? How does the position of a worker in the production sequence impact his risk of being replaced with AI and his earnings? Would the principal always prefer to fully utilize all available AI resources, or are there any strategic benefits to keeping some slack AI capacity? What are the effects of optimal AI deployment on the intra-team wage inequality, i.e., the wage gap between the highest- and lowest-paid workers in a team?

To address these questions, we develop a model building on the framework of Winter (2010). A principal (*she*) manages a team of workers (*he*), each performing a single task for a project. The tasks are equally critical to the project's success and complementary to each other. Workers act in sequence, deciding whether to exert effort or shirk, and these choices determine the likelihood of project success. An AI agent (*it*) is available to the principal to replace a worker and perform the associated task, and we study how to deploy it optimally. We assume effort costs are the same for AI agent and human workers, so neither resource is inherently superior to the other. However, unlike its human counterparts, AI's actions are not subject to moral hazard, and if deployed, it always exerts effort.[1]

Against this backdrop, the informational environment faced by workers is such that, prior to making their effort decisions, workers can see the effort of their predecessor but cannot tell whether it is a human

[1]The assumption that AI is not subject to moral hazard is a commonly expressed view. Foucault et al. (2025) write "[...] the nature of the 'moral hazard' differs significantly between human and AI agents. Unlike humans, AI does not shirk in effort, become sloppy when bored or fatigued, or pursue personal perks such as corporate jets, nepotism, or empire building (the recurring themes in [...] research involving agency problems). Instead, AI rigorously optimises programmed objectives, such as profit maximisation or trading efficiency. Nevertheless, dutiful AI brings [...] new (related) dimensions of agency problems" (p.115). Other studies also built on the moral hazard differences between human and technology resources (e.g, Dogan and Yildirim, 2022; Dogan et al., 2024).

or AI.[2] The principal's objective is to induce all workers to exert effort at minimal compensation cost. As shown in Winter (2010), in an all-human team, the optimal compensation scheme leverages peer monitoring by incentivizing workers to shirk if their predecessor shirks, creating a "domino effect" that propagates shirking to all subsequent workers and thereby effectively deters shirking. Introducing AI into teamwork may interrupt this domino effect and alter the structure of wages, creating trade-offs for the principal.

Specifically, there are three trade-offs that a manager needs to consider when deciding *whether* to replace a human worker. The first and most intuitive trade-off is the *direct cost savings* achieved when replacing a high-wage worker with an AI agent, fixing everything else. However, this benefit may be offset by other counter effects. A second effect, a *direct incentive cost*, arises when the likelihood of a worker being replaced with AI increases and the worker is not replaced. In this case, the worker infers that workers who succeed him are more likely to be replaced by AI and his temptation to shirk is higher, requiring a higher compensation to sustain his effort. The third tradeoff, an *indirect incentive cost*, occurs because a higher replacement probability for a worker also weakens the incentives of those who precede him, making their effort costlier to enforce. These effects manifest differently for team members based on their positions in the production sequence.

Considering the interplay of these three effects, our study yields four key insights. First, the principal prefers a mixed strategy in which she *randomizes* the deployment of AI to replace human workers. Put differently, teams with randomized AI replacement are preferred over deterministic team compositions where some workers are replaced with certainty. Such randomization can be implemented in real life by probabilistically replacing workers with AI across different projects or shifts. So, when deployed optimally, AI affects human workers at the intensive margin, by altering the intensity or frequency of their work, rather than at the extensive margin, or by displacing them (Jiang et al., 2025). This finding tempers some widespread concerns regarding labor displacement effects of AI (e.g., OECD, 2023; Smith, 2025).

Second, we address which team members face the highest and the lowest risk of AI replacement. For clarity, we focus on a three-worker team, where members are differentiated by position as *front-most*, *middle*, and *end-most*. We find that, in the optimal replacement strategy, the middle worker faces the lowest (zero) risk of replacement, so that the information flow among the members of the team can be maintained. By contrast, both the front-most and end-most workers face a positive risk of replacement, with the end-most worker being most at risk.

Third, the optimal strategy may leave some AI capacity unused. The principal may benefit strategically from keeping some slack AI resources, which generates an additional layer of uncertainty—not only about which workers are replaced, but also about whether any replacement occurs at all. This finding implies that in some cases, a manager will choose to maintain an all-human team, despite having unused

[2]Alternatively, one can interpret this as workers observing whether the predecessor's task is completed, which happens if and only if the predecessor exerts effort.

AI capacity at her disposal to create a human-AI team.

Fourth, we examine how optimal AI adoption impacts workers' wages and how the impact varies by position within the team members. Without AI adoption, the wages of workers increase monotonically along the production sequence, with the end-most worker earning the highest wage. Our results show that optimal AI deployment maintains this wage hierarchy, but reduces the wage gap between team members. Specifically, the front-most and middle workers see their wages increase due to AI adoption, whereas the wage of the end-most worker (who earns the highest wage) remains unchanged. This leads to decreased intra-team wage inequality, aligning with Bessen et al. (2025), who finds minimal wage scarring and even wage gains after the introduction of automation into an organization.

In Section 4, we introduce several extensions to the main model. Section 4.1 focuses on a critical characteristic of team production: synergy among workers (Che and Yoo, 2001). We proxy synergies by the degree of complementarity between the tasks workers carry out. We propose a specific production function that parameterizes this complementarity and find that greater task complementarity enhances the principal's ability to leverage peer monitoring, reducing the wage incentives necessary to deter shirking. However, higher complementarity also implies that a worker's shirking is more detrimental, and this implies the risk of replacing the front-most worker increases and that of the end-most worker decreases. We find that AI's potential to mitigate wage inequality is more pronounced in teams with low task complementarity. In Section 4.2, we focus on task-based automation (Acemoglu and Restrepo, 2018) and introduce an alternate model where AI substitutes for a fraction of a worker's tasks, rather than substituting the worker. We find that replacing a fraction of the tasks of a worker is never optimal, and the principal prefers to replace either all or none of the tasks of a worker. Moreover, as in the main model, only the front-most and the end-most workers face risks of task replacement. In Section 4.3, we examine how the optimal deployment of AI varies with the underlying network structure of the team. We compare the baseline chain network—whose optimality for human teams is established in Winter (2010)—to a star configuration. In the star network, the central worker—the worker who facilitates the team's information flow—again faces the lowest (i.e., zero) risk of AI replacement, while that for the peripheral workers may be positive. These findings highlight how the network structure among the team members may shape the principal's AI adoption strategy. Section 4.4 extends our model to consider the possibility that, similar to humans, AI can be programmed to shirk. We find that, if a principal could choose, she would choose to adopt an AI with reduced efficiency: one that can shirk. Finally, in Section 4.5, we discuss the implications of relaxing principal's AI capacity constraint; allowing workers to have partial or full observability by allowing them to tell if the task of their predecessor is completed by a human or AI; and introducing heterogeneity among workers to differentiate their contributions to the project.

For practitioners considering the deployment of AI technologies and their impact on the workforce, we highlight several key strategic considerations. First, short-sighted AI replacement strategies, particularly

those primarily driven by cost-cutting motives such as replacing the highest-paid workers, can backfire. A focus on direct costs of replacing workers alone overlooks the *indirect costs* AI introduces in the form of moral hazard. Our findings suggest that, in some cases, it may be optimal to replace a lower-paid worker if doing so minimizes the combined direct and indirect costs. Second, we find that a stochastic AI-human teaming strategy, where work is assigned to AI on a randomized basis, can outperform deterministic assignment strategies. This implies that retaining workers while reallocating their work to AI in a stochastic manner may be more effective than full replacement of the workers. Such strategies not only preserve human capital, but may enhance productivity within teams. Third, managers should be prepared to adjust wages for all team members, including those who are not directly impacted by AI. The wages of all workers in a team can be impacted by AI adoption, even when a worker himself is not substituted by AI. The principal may find herself having to pay a higher wage for the remaining workers after some team members are substituted with AI, despite benefiting from some savings in the form of foregone wages. This suggests that it is imperative for managers to understand that even when AI adoption is localized (i.e., replacing a small set of workers or tasks), its spillover effects can permeate the broader team.

Our research contributes to the literature on the role of peer monitoring in incentivizing effort within teams (e.g., Che and Yoo, 2001; Gibbons and Roberts, 2013; Villas-Boas, 2020; Upton, 2024), as well as the literature modeling moral hazard in production settings (e.g., Sun and Tian, 2018; Tian et al., 2023). We extend this body of work by investigating how the introduction of technology in general, and AI more specifically, reshapes the information structure within teams, with an emphasis on the risk of undermining peer monitoring. We demonstrate that AI can alter the incentives and the compensation of workers. In this sense, our work also complements the recent studies that endogenize information flow within teams when designing incentive structures (e.g., Zhou, 2016; Au and Chen, 2021; Lu and Song, 2025).

This study is also relevant to the literature studying AI effects on worker and firm productivity. A growing number of studies experimentally estimate the effect of AI adoption on worker and business productivity (Dell'Acqua et al., 2023a,b; Otis et al., 2024; Brynjolfsson et al., 2025b), with a particular focus on the adoption of generative AI (GenAI) tools. Overall, these studies demonstrate heterogeneous effects of AI adoption on productivity. For instance, while novice workers typically show a higher improvement in productivity compared to experienced workers (Brynjolfsson et al., 2025b), these effects may be reversed for complex tasks (Dell'Acqua et al., 2023b) or for businesses with unique needs (Otis et al., 2024). Workers may also strategically shift their focus to tasks that cannot be carried out by AI (Yiu et al., 2025). What is common between these studies and ours is the focus on productivity. Similar to these studies, we recognize that AI—either as a substitute or a complementary production technology—may alter a worker's effort decision. We provide a theoretical lens to explain the mixed findings from the earlier studies. In particular, our study shows two factors which may play a role: (i) the effects of AI do not remain localized—adopting AI to replace a worker may generate negative externalities on other workers;

(ii) AI may be deployed sub-optimally—e.g., AI may be used indiscriminately to replace (the tasks of) the wrong workers. Our paper highlights that, given AI's negative externalities, studies collecting data from environments where AI is deployed suboptimally may falsely conclude that AI fails to improve worker or organizational productivity.

Another stream of the literature focuses on estimating the macro effects of technology adoption, such as effects on employment and wages. A substantial body of research suggests that effects of automation on employment and wages have been nonuniform, where lower-skilled and less-educated workers have been disproportionately impacted (Acemoglu and Restrepo, 2019, 2020; Petrova et al., 2024). In contrast, the documented displacement stemming from AI thus far has been more specific to occupations and tasks (Acemoglu et al., 2022) and impacts skilled and educated workers as well (Brynjolfsson et al., 2025a). On wages, the evidence is similarly mixed: while some studies report declines due to automation (Acemoglu and Restrepo, 2020; Petrova et al., 2024), others find little to no wage scarring—or even wage gains—associated with automation and AI adoption (Barth et al., 2020; Domini et al., 2022; Bessen et al., 2025). For generative AI, specifically, recent work by Humlum and Vestergaard (2025) finds no significant changes in wages and employment.

Overall, our study bridges two important strands of research: the literature on the optimal design of incentives in teams and the emerging literature on the organizational implications of AI adoption (e.g., Agrawal et al., 2024). Even though most firms operate in team-based structures, much of the existing research on AI abstracts away from explicit consideration of incentives and interactions between members in teams.[3] Recent experimental evidence further underscores the importance of the team perspective. For example, Dell'Acqua et al. (2023a) find that AI integration can interfere with a team's ability to coordinate, and thus can decrease individual effort and overall team performance. These findings highlight the need for a more nuanced understanding of human-AI interactions within teams, explicitly considering the externalities that arise when some workers are replaced by AI on the workers who are not replaced. Our study addresses this gap by developing a formal model that captures both the benefits and costs of AI integration in team settings.

The rest of the paper is organized as follows. In Section 2, we set up the model, and in Section 3 we lay out the direct and indirect costs and benefits of AI adoption and describe the optimal AI adoption strategy. We offer several extensions in Section 4, and we provide a discussion of additional considerations and limitations. Finally, in Section 5, we conclude with a brief discussion of our key findings and takeaways for practice.

[3] A few exceptions include Athey et al. (2020), Dogan and Yildirim (2022), and Dogan et al. (2024), which begin to explore how technological change affects organizational design and coordination.

2 Model

A team is undertaking a project with $n \geq 3$ workers.[4] Each worker (he) $i \in \{1, \ldots, n\}$ performs a task and makes a binary effort decision $e_i \in \{0, 1\}$, where $e_i = 1$ indicates that worker i exerts effort; and $e_i = 0$ indicates he shirks. The cost of effort for worker i is $c(e_i) = ce_i$, where $c > 0$. Workers $1, \ldots, n$ act in sequence, and each observes their immediate predecessor's effort when making their own effort decision.[5] We denote the strategy of worker $i \in \{1, \ldots, n\}$ by σ_i, which maps the information available to him—the effort decision of any predecessor he may have—into an effort choice. Specifically,

$$\sigma_i : \{0, 1\} \to \{0, 1\}, \text{ for each worker } i = \{2, \ldots, n\},$$
$$\sigma_1 \in \{0, 1\}, \text{ for worker 1, who has no predecessor.}$$

The project's success depends on the number of workers exerting effort. If k out of n workers exert effort, the project succeeds with probability p_k, where p_k strictly increases in k. Workers' efforts are assumed to be complementary: the probability of success increases at an increasing rate as more workers exert effort, i.e., the marginal change in the probability of success from adding one additional worker is higher when more workers are already contributing effort. Formally, for each $k \leq n - 2$, we have: $p_{k+2} - p_{k+1} > p_{k+1} - p_k$.

The manager of the organization (principal, *she*) can observe only the outcome of the project, not the workers' individual effort choices. Since the project's success is highly valuable to her, she aims to incentivize each worker to exert effort by offering a contract $w \equiv (w_1, \ldots, w_n)$, where w_i specifies the payment worker i receives if the project succeeds. The workers are risk-neutral and seek to maximize their expected compensation net of the cost of effort.[6]

AI Replacement The principal has access to an AI agent which can carry out the tasks of a worker. The AI agent always exerts effort and AI's effort is just as effective as that of a worker in helping the project succeed. AI's cost of effort is also identical to that of a human, c, and is incurred by the principal.[7] The principal decides (i) whether to replace a worker with AI, and if so, (ii) which of the n workers to replace, paying attention to the position of the worker in the production process. We allow the principal to use a mixed strategy for both decisions. Specifically, her *replacement strategy* is:

$$x \equiv (x_1, x_2, \ldots, x_n), \quad \text{with } \bar{x} \equiv \sum_{i=1}^{n} x_i \leq 1,$$

[4] Throughout the paper, we will use the terms team and network interchangeably.

[5] While we adopt this sequential *chain* structure as given, Winter (2010) demonstrates that such a structure naturally emerges among the considered alternatives as the optimal arrangement. In Section 4.3, we will revisit this assumption.

[6] Because workers have limited liability, the optimal contract grants each worker a positive payment if the project succeeds, and no payment in the event of failure.

[7] We purposely keep the effort costs the AI and worker identical. This allows us to focus on moral hazard and peer monitoring as drivers of technology adoption, rather than cost reduction.

where x_i represents the probability of replacing worker i with AI, and $\bar{x}$ is the aggregate probability of deploying AI. The constraint $\bar{x} \leq 1$ allows us to treat AI as a limited resource, closely capturing financial resource constraints managers face in reality, which forces them to prioritize which worker to replace. As we will show later, the principal may set $\bar{x}$ strictly less than 1 and choose not to fully utilize this capacity.

The principal commits to replacement strategy x publicly. The workers cannot observe the realized outcome of x, i.e., they cannot tell whether a worker is replaced, as well as which worker is replaced. They only observe their predecessor's effort, from which they can tell that shirking implies a human predecessor. This setup can be interpreted as a setting where worker i can tell whether the task completed immediately before his own $(i-1)$ will make a contribution to the overall project success or not, rather than directly observing the effort of his predecessor. Because workers and AI make equal contributions, worker i cannot tell whether a positive contribution comes from an AI or a worker.

Timing The sequence of events unfolds as follows. First, the principal chooses a replacement strategy and a compensation scheme, (x, w), which jointly determine the game faced by the workers. After observing (x, w) and, where applicable, the effort of their predecessors, workers decide whether to exert effort. The project outcome is then realized, and finally, workers are paid based on the outcome and the compensation scheme w.

2.1 Discussion of Model Setup

When introducing AI into the production environment, we make deliberate modeling choices that require further discussion. This section clarifies the reasoning behind them.

AI does not shirk. In our setting, the key distinction between AI and human workers lies in the risk of moral hazard: humans may shirk, whereas AI never does. We intentionally abstract away from any other differences between the two production sources. Put differently, the absence of shirking is a feature of our model, not a limitation. Empirical evidence further supports this assumption, and scholars recognize AI's consistent effort as an important factor in adoption decision (Foucault et al., 2025). Nonetheless, one may ask whether AI could be programmed to condition its decisions on the actions of its predecessor, as humans do. We explore this possibility formally in Section 4.4.

Full vs partial replacement of worker tasks. Our baseline model assumes a unit task is carried out by each worker, AI carrying out a task is equivalent to AI fully replacing a worker, performing his entire task. However, AI may only partially replace workers in some applications, handling specific task components. We consider such a partial replacement model in Section 4.2.

Limited capacity for AI replacement. We assume the principal has limited AI resources, requiring her to prioritize which workers to replace. This assumption can be micro-founded by introducing utilization costs for AI. In practice, such costs are a major obstacle to scaling: executives frequently cite expenses for computing and cloud infrastructure as barriers to expanding AI capacity (IBM, 2025b). A recent survey reports that every executive interviewed had canceled or postponed at least one GenAI initiative due to compute costs, with 15% of projects on hold and 21% failing to scale for this reason (IBM, 2025a). Thus, managers face real trade-offs in deploying limited AI capacity. We relax this assumption in Section 4.5. In addition, the extension in Section 4.2, which allows AI to perform part of a worker's task, accommodates more flexible capacity constraints.

Imperfect Observability. Our baseline model assumes workers cannot observe whether their coworkers are human or AI, reflecting scenarios where tasks are temporally separated or workers are not physically proximate. Put differently, we assume that the outcome that workers produce passes the Turing test and the output of the previous task cannot be fully attributed to a human or an AI. In Section 4.5, we explore the alternative case where workers can observe whether their coworkers are AI or human. Analysis shows that this scenario produces a weaker outcome for the principal compared to our baseline, suggesting that concealing whether a task is performed by a human or AI from the workers benefits the principal.

3 Analysis

Our objective is to characterize the optimal AI replacement strategy and compensation scheme as defined below.

Definition 1. *A replacement strategy and compensation scheme pair (x, w) is optimal if*

(i) it induces an equilibrium in which all workers exert effort, i.e., $(e_1, \ldots, e_n) = (1, \ldots, 1)$ on the equilibrium path;

(ii) among all pairs inducing such an equilibrium, it minimizes the expected cost of compensation for the principal:

$$W_{x,w} \equiv \sum_{i=1}^{n} \left[x_i c + (1 - x_i) p_n w_i \right]. \tag{1}$$

Two factors shape the expected cost of compensation: (i) the principal bears the AI's cost, c, regardless of the project outcome when deployed, and (ii) each worker (if not replaced) is compensated only upon the success of the project, which occurs with probability p_n if all workers exert effort.

Optimal Compensation for a Fixed Replacement Strategy. We begin our analysis by fixing the replacement strategy x and characterizing the optimal compensation scheme conditional on x, which we denote by w^x. The following proposition characterizes w^x and shows that it induces a trigger strategy profile $\sigma^* = (\sigma_1^*, \ldots, \sigma_n^*)$ as an equilibrium, where each worker exerts effort as long as no deviation is observed, and shirks otherwise. Formally,

$$\sigma_1^* = 1, \quad \sigma_i^*(e_{i-1}) = \begin{cases} 1 & \text{if } e_{i-1} = 1, \\ 0 & \text{if } e_{i-1} = 0, \end{cases} \quad \text{for all } i \in \{2, \ldots, n\}.$$

Proposition 1. *Fix a replacement strategy $x = (x_1, \ldots, x_n)$. The optimal compensation scheme conditional on x, denoted by $w^x = (w_1^x, \ldots, w_n^x)$, satisfies the following for each worker $i \in \{1, \ldots, n\}$ with $x_i < 1$:*

$$w_i^x = \frac{c}{p_n - \zeta_i^x}, \tag{2}$$

where ζ_i^x is the resulting success rate when worker i shirks:

$$\zeta_i^x = p_{i-1} \sum_{k=1}^{i-1} \frac{x_k}{1 - x_i} + \sum_{k=i+1}^{n} \frac{x_k}{1 - x_i} p_{n-k+i} + p_{i-1} \frac{1 - \bar{x}}{1 - x_i}. \tag{3}$$

Proposition 1 characterizes the optimal compensation for each worker who is not fully replaced ($x_i < 1$). If he is fully replaced ($x_i = 1$), then his compensation is irrelevant. We denote by W_x the principal's expected compensation cost under the *optimal* scheme w^x, obtained by substituting $w = w^x$ into the general expression of $W_{x,w}$ given in (1):

$$W_x \equiv W_{x,w^x} = \sum_{i=1}^{n} \left[x_i c + (1 - x_i) p_n w_i^x \right]. \tag{4}$$

The proof of Proposition 1 proceeds in three steps. First, we show that under w^x, the trigger strategy profile σ^* constitutes an equilibrium. Second, we show that no alternative compensation scheme with a lower expected cost can support σ^* as an equilibrium. Third, we show that inducing joint effort through another strategy profile apart from the trigger strategy necessarily incurs a higher expected compensation cost for the principal.

In the trigger strategy equilibrium induced by the compensation scheme w^x, the workers are indifferent between exerting effort and shirking upon observing the immediate predecessor exert effort. Then, due to effort complementarity, shirking becomes the optimal choice when a worker observes his immediate predecessor shirk. This generates a *domino effect*: Following a worker's deviation, all successive workers

choose to shirk as well. This domino effect, serving as the strongest possible deterrent to deviations, enables the principal to fully leverage the workers' peer monitoring. Replacing a middle worker with AI disrupts the domino effect, as AI does not condition its effort on the actions of other workers. This, in turn, alters the incentives and compensation of the workers. As we shall see shortly, the principal accounts for this disruption when determining her replacement strategy.

Worker i's indifference condition on the equilibrium path, which pins down w_i^x, is given by:

$$p_n w_i^x - c = \zeta_i^x w_i^x,$$

where ζ_i^x is the resulting success rate under the trigger strategy profile from worker i's perspective, when he shirks. Therefore, the payment that worker i receives (if not replaced) upon project success is $w_i^x = \frac{c}{p_n - \zeta_i^x}$. A higher ζ_i^x leads to a higher payment w_i^x, as a higher ζ_i^x makes shirking less consequential in terms of success, and therefore more appealing for worker i, requiring the principal to offer greater compensation to offset this temptation.

Since ζ_i^x depends on worker i's position in the production sequence, so does his compensation. In the absence of AI, as is also noted by Winter (2010), worker compensation increases monotonically, with the end-most worker receiving the highest compensation. This follows from the fact that under the trigger strategy, the end-most worker's shirking results in the smallest decline in the success rate, as it does not induce subsequent shirking.

To understand how a worker's incentive to shirk depends on the AI strategy, we examine ζ_i^x and its components closely. As shown in equation (3), ζ_i^x is a weighted sum of three success probabilities, each corresponding to a different replacement outcome when worker i deviates.

- If a predecessor of worker i is replaced, all of i's successors shirk, and the project succeeds with probability p_{i-1}.
- If a successor of worker i, say worker k, is replaced, worker i and all his successors up to $k-1$ shirk, while AI at position k and all later workers exert effort, yielding success probability p_{n-k+i}.
- If no workers are replaced, all of i's successors shirk, resulting in success probability p_{i-1}.

The weights on these outcomes reflect worker i's belief about the replacement outcomes, conditional on not being replaced himself. Specifically, he assigns probability $\frac{x_k}{1-x_i}$ to worker $k \neq i$ being replaced, and probability $\frac{1-\bar{x}}{1-x_i}$ to no replacement at all.

With this understanding, we now examine how the choice of AI adoption affects ζ_i^x. Rewriting equation (3) highlights its dependence on the replacement strategy:

$$\zeta_i^x = p_{i-1} + \sum_{k=i+1}^{n} \frac{x_k}{1-x_i} \left(p_{n-k+i} - p_{i-1}\right). \tag{5}$$

As seen, ζ_i^x, the temptation to shirk for worker $i < n$, increases with (i) the likelihood of replacing worker i, and (ii) the likelihood of replacing any of i's successors. For the end-most worker, ζ_n^x is independent of the replacement strategy x.

Tradeoffs of Replacement. We analyze the tradeoffs that arise from replacing a worker with AI by examining the partial derivative of the principal's expected cost with respect to x_i:

$$\frac{\partial W_x}{\partial x_i} = -\underbrace{(p_n w_i^x - c)}_{\substack{\text{direct} \\ \text{cost saving}}} + \underbrace{(1 - x_i) p_n \frac{\partial w_i^x}{\partial x_i}}_{\substack{\text{direct} \\ \text{incentive cost}}} + \underbrace{\sum_{k=1}^{i-1} (1 - x_k) p_n \frac{\partial w_k^x}{\partial x_i}}_{\substack{\text{indirect} \\ \text{incentive cost}}}. \tag{6}$$

Equation (6) demonstrates that the principal needs to balance trade-offs coming from three distinct effects to make the optimal replacement decision. The first effect is *the direct cost savings*. This benefit arises because the expected compensation for worker i is $p_n w_i^x$, while the cost of an AI is c. Since $p_n w_i^x \geq c$, replacing a worker with AI reduces the principal's expected compensation cost. This benefit is the highest for the end-most worker.

The second effect is *the direct incentive cost*. As discussed in the paragraph following Equation (5), all else being equal, increasing the likelihood of replacing worker i amplifies his incentive to shirk, in the event he is not replaced. This is because a higher x_i increases the posterior belief that other workers are replaced whenever he himself is not. In this case, shirking appears less consequential and therefore more appealing, which raises the compensation the principal must provide to induce effort.

The third effect is *the indirect incentive cost,* arises through the changes in compensation paid to other workers. If the probability of replacing worker i increases, then the compensation required to incentivize his predecessors also rises, because shirking becomes less consequential for them as well. Importantly, the magnitude of this indirect cost depends on the worker's position in the sequence: the closer a worker is to the end, the more predecessors are affected, and hence the larger the number of workers whose compensation is distorted.

The principal needs to balance these three effects when designing the optimal replacement strategy. For instance, replacing the end-most (and highest-paid) worker yields the largest direct cost saving, but also generates the greatest indirect incentive cost, since all predecessors' incentives are weakened. At the other extreme, replacing the front-most worker creates no indirect incentive cost, as he has no predecessors, but the direct cost saving is smaller because his compensation is relatively low. The direct incentive cost is zero for the end-most worker, while for other workers it depends on both their position and the AI replacement strategy. In what follows, we analyze how these trade-offs between direct cost savings, direct incentive costs, and indirect incentive costs shape the principal's optimal replacement policy.

3.1 Optimal Replacement Strategy

In this section, we characterize the optimal strategy for replacing workers with AI, denoted by x^*. As an initial step, the following proposition and the subsequent discussion highlight a key property of this strategy: randomization. We also explore the trade-offs that the principal faces while deciding her AI strategy.

Proposition 2. *The principal's optimal AI adoption strategy necessarily involves randomization:*

- *no worker is replaced with certainty, i.e.,* $x_i^* < 1$ *for all* i*; and*
- *at least one worker is replaced with positive probability, i.e.,* $x_i^* > 0$ *for some* i*.*

Proposition 2 shows that the principal adopts a randomized replacement strategy, ruling out both full replacement of any worker ($x_i = 1$ for some i) and no replacement at all ($x_i = 0$ for all i). We explain this finding by highlighting the trade-offs in the principal's replacement strategy, which encompasses two critical aspects: *whether* to replace any worker, and, if so, *which* worker(s) to replace.

To see why randomization is optimal, first consider a pure replacement strategy, where the principal replaces one worker with certainty or does not replace any workers at all. Within the set of pure strategies, replacing either the front-most or the end-most worker is among the optimal decisions.[8] Both options result in the same expected compensation, as they create an identical team network structure: $n-1$ sequentially connected workers and one isolated AI agent. This configuration preserves information flow among the non-replaced workers, allowing the principal to fully leverage peer monitoring. Replacing a middle worker, however, results in a disconnected network and a disrupted flow of information, increasing the compensation cost incurred by the principal.

Now consider a class of replacement strategies where the principal replaces the front-most and end-most workers with probabilities ρ and $1-\rho$, respectively, for some $\rho \in [0,1]$. The extreme points of this class, with $\rho = 0$ and $\rho = 1$, correspond to the two optimal pure replacement strategies. We show that all interior values of $\rho \in (0,1)$ outperform these pure strategies. Hence, the optimal replacement strategy necessarily involves randomization.

To explain why an interior value of ρ outperforms the optimal pure strategies, consider decreasing ρ, or gradually shifting the replacement probability from the front-most to the end-most worker. Since the end-most worker is compensated more than the front-most worker, this change results in higher direct cost savings for the principal. However, since the compensation of both workers is independent of ρ, the magnitude of these savings remains constant as ρ varies. This is because, in this class of strategies, the principal fully exhausts the AI capacity, and the end-most (front-most) worker knows that the front-most

[8] This is formally stated and proved in Appendix A (Lemma 2).

(end-most) worker is replaced with certainty when he himself is not replaced. As a result, ζ_1 and ζ_n (and therefore w_1 and w_n) remain fixed as ρ varies.

Yet, this shift also increases the indirect incentive cost. Specifically, as the replacement probability of the end-most worker $(1-\rho)$ increases, shirking becomes less consequential for all his predecessors (except the front-most worker), prompting the principal to raise their compensation. Importantly, this indirect cost is convex in ρ. The following observations together imply that an interior $\rho \in (0,1)$ is optimal within this class of strategies: (i) both extreme values $\rho = 1$ and $\rho = 0$ yield the same compensation cost, (ii) reducing ρ increases the direct cost savings at a constant rate, and (iii) reducing ρ increases the indirect incentive cost at an increasing rate. Therefore, all randomized replacement strategies with an interior ρ dominate the pure strategies.

Discussion of Randomization. There are a few points of discussion to bring forward related to Proposition 2. First is the optimality of randomization over the pure strategy replacement decisions, and whether the implementation of this strategy may pose challenges in real life. Since human resources may not be easily fungible, randomization can be achieved in other ways. For instance, a common application involves randomizing the assignment of AI to replace workers across projects, where a given task would be carried out by an AI some of the time and by a worker at other times. A randomization schedule may be achieved more easily if workers rotate across different divisions of the organization, and AI can replace them as they rotate out of a division. The schedule may also be carried out via rotating workers across different work shifts (e.g., day/night) or across days of work. Companies like Dmall specialize in offering such technology solutions to rotate workers with AI across shifts. One application, for instance, replaces daytime security staff at grocery stores with AI surveillance agents during nighttime shifts.[9]

An implication of randomization is the emergence of hybrid (human-AI) teams, where the same task can be carried out by a human worker and an AI. In this outcome, workers are not fully displaced, but see a reduction in their workload, as they are occasionally substituted with AI. While, in line with earlier studies, this finding implies labor displacement effects of new technologies (e.g., Acemoglu and Restrepo, 2020; Chen et al., 2025), they also provide a more mitigated and perhaps a more optimistic perspective. Despite some scholars and pundits expressing fear of sweeping labor displacement effects from AI adoption (Runciman, 2023; OECD, 2023), our findings suggest that permanently replacing workers with AI may be suboptimal and replacing them with AI in a way that varies their participation (e.g, across different projects or work shifts) may be more profitable for an organization.

Heterogeneous Replacement Risk Based on Worker Position. In presenting the next set of results, to deliver sharper outcomes, we will focus on the case where $n = 3$. This three-worker structure captures the distinct incentives of workers within a team. Specifically:

[9]See `http://www.dmall.com/product/5641.html` for more information.

- the *front-most* worker (worker 1) does not have any predecessors, but his contributions will be observed by his successors,
- the *middle* worker (worker 2) both observes the actions of his predecessor and is also observed by his successors, thereby acting as a connector within the team, and
- the *end-most* worker (worker 3) observes his predecessor, but is not observed by a successor, making his effort choice less consequential for the project's success.

With this structure in mind, we proceed to discuss key properties of the optimal randomization scheme outlined in Proposition 2.

Proposition 3. *In the optimal replacement strategy, the middle worker is never replaced with AI. The end-most worker is replaced with a strictly positive probability, and this probability is weakly higher than that of the front-most worker. Formally,* $x_2^* = 0$, $x_3^* > 0$, *and* $x_3^* \geq x_1^* \geq x_2^*$.

Proposition 3 highlights that workers' risk of being replaced by AI varies by their position in the production sequence.

First, the middle worker, who is essential for the connectivity of the information network, does not face the risk of AI replacement. To understand why, consider an arbitrary replacement strategy (x_1, x_2, x_3) in which the middle worker is replaced with positive probability, i.e., $x_2 > 0$. Then consider deviating from this strategy by reallocating more AI resources from the middle to the end-most worker, yielding $(x_1, 0, x_3 + x_2)$. This shift (i) increases the direct cost savings, as the end-most worker has the highest wage; (ii) reduces the direct incentive costs, as replacing the end-most worker incurs none; but (iii) raises the indirect incentive costs, as the end-most worker has more predecessors. The combined positive effects of (i) and (ii) outweigh the negative effect of (iii), making the principal better off.

Second, the end-most worker's risk of replacement is strictly positive; and while the front-most worker also faces a risk of replacement, this risk is lower than that of the end-most worker. To see why, consider deviating from a given replacement strategy where $x_1 = x_3 + \Delta$ by reallocating an additional Δ amount of resources from the front-most to the end-most worker, yielding $(x_1 - \Delta, x_2, x_3 + \Delta)$. This reallocation generates the same outcomes (i), (ii), and (iii) discussed in the previous paragraph, and the combined positive effects from (i) and (ii) once again outweigh the negative effect from (iii). Thus, any strategy where the front-most worker is replaced at a greater rate than the end-most worker cannot be an optimal AI replacement strategy. This, together with the optimality of randomization (Proposition 2), implies that the risk of replacement the end-most worker faces is always strictly positive, i.e., $x_3^* > 0$.

From a practical perspective, these findings imply that managers wishing to integrate AI optimally into their existing organizational structures need to take into account factors beyond considerations such as costs and technological feasibility of AI. It is essential that managers consider how the integration of

AI will disrupt the information flow between workers in a team and follow an AI strategy that preserves the information flow. In our setting, this is equivalent to not replacing the middle agent. Moreover, AI adoption strategy should go beyond the naive replacement strategies, i.e., those that focus on replacing the high-compensation workers, and also focus on reducing the negative externalities of replacement on other workers. This consideration, in our setting, corresponds to the possibility of replacing the front-most worker, rather than focusing on the end-most worker alone.

Utilization of AI Capacity. So far, we have described some key aspects of the optimal AI replacement strategy in an organization, assuming the principal has sufficient resources that she can optimally allocate. An important question is whether the principal would always choose to exhaust these resources available to her.

If AI adoption decisions were purely driven by direct cost savings, a principal should choose to exhaust AI resources. But in Proposition 4, we will find a seemingly counterintuitive result: the principal may choose not to fully utilize the AI capacity available to her. Put differently, replacing workers with technology is *not* always the most preferred, or the most profitable, managerial strategy, and underutilization of AI resources is possible.

Proposition 4. *The principal chooses to underutilize AI capacity, setting* $\bar{x}^* < 1$*, if and only if the condition* $p_1^2 - p_3\, p_0 > 0$ *is satisfied.*

Proposition 4 establishes that the principal does not always fully utilize the available AI capacity. It provides a necessary and sufficient condition for when underutilization is optimal. Given that we have already established the absence of middle replacement (i.e., $x_2 = 0$), the key implication of Proposition 4 is that, despite having the option to increase the replacement probability of the front-most and the end-most workers, the principal may choose not to do so. The condition $p_1^2 - p_3 p_0 > 0$ is equivalent to $\frac{p_1}{p_0} > \frac{p_3}{p_1}$, implying that the proportional gain from securing the first unit of effort (moving from p_0 to p_1) exceeds the proportional gain from adding the remaining units of effort (moving from p_1 to p_3). Put differently, when the condition is satisfied, the first unit of effort is pivotal, as it contributes disproportionately more to success. With full utilization, ($\bar{x} = 1$), as there is always an AI in deployment, this pivotal unit effort will be exerted regardless of the workers' actions. This increases the project's success probability after any worker i shirks (ζ_i), making shirking less consequential. Thus, stronger incentives (i.e., higher payments) are required to deter shirking. To avoid these higher pay, the principal may optimally underutilize AI capacity, i.e., $\bar{x} < 1$.

To see what drives the underutilization result in greater detail, consider the replacement likelihood of the front-most worker. A marginal decline in the front-most worker's replacement likelihood results in the following two effects: (i) a direct cost saving of $c\frac{\zeta_1^x}{p_3 - \zeta_1^x}$, and (ii) a direct incentive cost of $c\frac{p_3(\zeta_1^x - p_0)}{(p_3 - \zeta_1^x)^2}$.

Under full utilization, the front-most worker knows that, if he is not replaced, the end-most worker will be replaced with certainty, implying a success rate $\zeta_1^x = p_1$ if he shirks. Plugging in $\zeta_1^x = p_1$ and comparing these two expressions, when the production function satisfies the condition $p_1^2 > p_0 p_3$. The direct incentive cost effect dominates the former effect, therefore, a marginal reduction in replacement of the front-most worker (x_1) benefits the principal. This implies that the principal prefers not to utilize the full AI capacity.

An important implication of whether the principal fully utilizes or underutilizes the available AI capacity is how utilization shapes the beliefs of workers about the presence and position of the AI agent in the production sequence. Moving from full to underutilization alters the uncertainty workers face, which can be used as a strategic tool that benefits the principal. With full utilization of AI resources, only the middle worker is facing uncertainty about which worker is replaced. The front-most (the end-most) worker knows that it must be the end-most (the front-most) worker replaced, if he is not replaced. Underutilization introduces an additional layer of uncertainty. All workers are now unsure whether a replacement has taken place.

To see how this uncertainty may benefit the principal, consider moving from full to under utilization by reducing x_1, while keeping $x_2 = 0$ and x_3 constant. Reducing x_1 lowers w_1 while leaving w_2 and w_3 unchanged, which can benefit the principal. At the same time, since x_1 is reduced, now the principal needs to pay the front-most worker more frequently. When the former effect outweighs the latter, underutilization, and the resulting environment of uncertainty, can make the principal better off. A similar strategic use of uncertainty by a principal in organizations has been the focus of several theoretical studies recently (e.g., Halac et al., 2021; Halac, 2025).

Impact of AI adoption on Wages by Worker's Team Position. Having demonstrated that the optimal AI adoption strategy in a team setting involves randomization, we next investigate how, as the principal adopts AI, the wages and the expected payoffs of the workers change, and do so conditional on their position in the production sequence. Let w_i^0 be the optimal compensation of worker i in the absence of AI adoption, and $w_i^{x^*}$ be the optimal compensation following optimal AI replacement. The following proposition shows that, while wages of some workers may increase, the intra-team wage hierarchy of all-human teams is maintained under optimal AI adoption.

Proposition 5. *Optimal AI adoption preserves the order of the wages based on the position of the workers ($w_3^{x^*} > w_2^{x^*} > w_1^{x^*}$). Moreover, after optimal AI adoption, worker 1 and worker 2's wages increase ($w_1^{x^*} > w_1^0, w_2^{x^*} > w_2^0$) and worker 3's wage remains identical ($w_3^{x^*} = w_3^0$).*

Proposition 5 provides two key insights. First, optimal AI adoption increases the wages of the front-most and the middle workers, but not the wage of the end-most worker, for whom the wage remains unchanged. The wage increase for the first two workers is due to the positive replacement probability of

their successor workers, which makes shirking more appealing for them. Since the end-most worker does not have a successor, the likelihood of success following his shirking does not depend on the AI adoption strategy; thus, his wage remains unchanged.

A second insight concerns the potential impact of AI replacement on the intra-team wage hierarchy. Proposition 1 and the findings from Winter (2010) imply that with all-human teams, optimal wages increase monotonically in the worker's position in the production sequence. A suboptimal adoption of AI can, in principle, disrupt this hierarchy–as we formally establish in Appendix A.3 (Lemma 3). Proposition 5 shows that under the optimal AI strategy, the wage hierarchy of all-human teams is preserved, despite the upward pressure on the wages.

Next, we investigate how the intra-team wage gap (i.e., the dispersion between the highest and the lowest wage) changes following AI adoption. For a given replacement strategy x, we denote this wage gap by Gap^x:

$$Gap^x = \max_i\{w_i^x\} - \min_i\{w_i^x\}.$$

Note that, in a team with three workers, $\max_i\{w_i^x\} = w_3^{x^*}$, and $\min_i\{w_i^x\} = w_1^{x^*}$, therefore $Gap^{x^*} = w_3^{x^*} - w_1^{x^*}$. A comparison of the wages indicates that following optimal AI adoption, the intra-team wage gap declines. Corollary 1 states this finding formally.

Corollary 1. *Intra-team wage gap decreases following optimal AI adoption:* $Gap^{x^*} < Gap^0$.

Our finding that highlights the decline in the intra-team wage gap following technology adoption can be contrasted with those from earlier studies. While several studies point to a widening in pay inequality as a result of technology, depending on the skill level of workers (Acemoglu and Loebbing, 2024) or the job of the worker within a firm (Barth et al., 2020), the extent to which these workers' tasks are exposed to technology may be vastly different. Focusing on a narrow context where the workers are, aside from their position in the production sequence, identical and make the same contributions to the success of their firms, we show a decline in the intra-team wage gap. While this finding may seem contradictory, it is not; as the contradiction can be explained by how competitive market forces influence workers of different skill and education levels. In our setting, we are able to abstract away from these confounds and demonstrate a declining wage gap that is directly attributable to how AI adoption alters the incentives in a team.

The findings thus far may paint an optimistic picture about the effects of new technologies on organizations, with only partial job losses and wages weakly increasing. It is important to consider the potential effects on workers' overall earnings, particularly if workers face income losses during their "off" time. To this end, Proposition 6 summarizes the change in workers' payoffs, defined as $(1 - x_i)(p_3 w_i^x - c)$ for worker i, comparing them before and after the optimal deployment of AI.

Proposition 6. *Following the optimal AI strategy, the middle worker's payoff increases, the end-most worker's payoff decreases, and the front-most worker's payoff may increase or decrease relative to the payoffs in the absence of AI.*

Given the probabilistic nature of work following optimal AI adoption, it is useful to think about the expected payoffs, in addition to the wages earned when workers are not displaced. Proposition 6 completes this picture and underscores that even in homogeneous teams, AI adoption creates winners and losers. Depending on their position, some workers are better off and some are worse off. Recall that the front-most and the middle workers' wages increase, whereas that of the end-most worker remains identical to the wages before AI adoption. Moreover, the front-most and the end-most workers experience partial replacement, while the middle worker does not. Combining these effects, the end-most worker, who is the highest earner, loses payoff. The middle worker, who is essential for maintaining the information flow in the network and thus is not replaced, faces higher payoffs. The front-most worker may experience an increase or decrease in his payoff depending on his extent of replacement and wage increase. Following these changes, the payoffs may no longer follow the hierarchy that the wages follow; and we discuss these changes in more detail in the context of a specific production function in Appendix C.

4 Extensions

4.1 Team Synergies and Task Complementarity

A key aspect of teamwork is the idea that the tasks, or the effort carried out by individuals in the team, build on each other to result in the success of the project. Our main model assumes such complementarity, but how does the degree of task complementarity alter the likelihood of AI replacement and wage outcomes of workers? In this subsection, we will explore these questions. To facilitate the analysis, we will adopt a production function that incorporates a parameter to capture the degree of complementarity of tasks, the *O-ring* production function, as known and well cited in the literature (Kremer, 1993; Winter, 2004). Let $p_k = \alpha^{n-k}$, where $\alpha \in (0, 1)$ calibrates the degree of complementarity.[10] The smaller the α, the more complementary the efforts are. Put differently, α indicates how consequential the effort of a worker is to success. Proposition 7 provides the optimal replacement strategy and wages with this production function.

Proposition 7. *When $p_k = \alpha^{n-k}$, the optimal replacement strategy is as follows:*

$$x_1^* = \frac{\sqrt{1+\alpha} - 1}{\alpha}, \quad x_2^* = 0, \quad x_3^* = 1 - x_1^*.$$

[10] One may interpret this functional form as a task structure, where each worker is responsible for a task that succeeds with probability 1 if the worker exerts effort or α if he shirks. The project succeeds only if all tasks succeed.

As the degree of complementarity increases (α becomes smaller), the likelihood of the front-most (end-most) worker being replaced increases (decreases). Moreover, the workers' compensations satisfy

$$w_1^{x^*} = \frac{c}{1-\alpha^2}, \quad w_2^{x^*} = \frac{c}{(1-\alpha)\sqrt{1+\alpha}}, \quad w_3^{x^*} = \frac{c}{1-\alpha}.$$

Proposition 7, while characterizing the optimal replacement strategy under the O-ring production function, also affirms our earlier results. Specifically, it confirms that (i) the optimal strategy involves randomization (Proposition 2), (ii) there is no middle replacement (Proposition 3). At the same time, the principal chooses to always fully utilize the AI capacity because, under this functional form, the necessary and sufficient condition for full utilization (stated in Proposition 4) is satisfied; $p_1^2 \leq p_0\, p_3$ is satisfied as $p_1^2 = \alpha^4$, and $p_0 p_3 = \alpha^3$.

The proposition indicates that as worker efforts become more complementary, i.e., when α gets smaller, the likelihood of replacing the front-most worker increases and that of the end-most worker decreases. In fact, in the extreme case when $\alpha \to 0$, both x_1 and x_3 converge to 0.5. This is intuitive, because when team efforts are highly complementary, a single worker's shirking is enough to compromise the success of the project. In consequence, the extent to which the domino effect discussed in Section 3 deters shirking is limited, and it does not play a significant role in disciplining the workers. When the domino effect is less potent, the wages of workers vary less by position, thus the direct cost savings are similar whether the principal replaces the front-most or the end-most worker. At the same time, the direct and indirect incentive costs are negligible, once again implying that replacing these two workers will yield similar outcomes for the principal. Taken together, higher task complementarity results in more homogeneous forms of replacement, moving both the front-most and the end-most worker's replacement probabilities closer to 0.5.

When we turn to wages, we see that as task complementarity increases (as α gets smaller), the wages of all workers decline. This is intuitive: with a higher degree of task complementarity, workers are motivated to work, which reduces the need for the principal to incentivize them through higher wages.

Recall from Corollary 1 that, optimal AI adoption reduces the intra-team wage gap. Thus, a natural question to ask is, how does this inequality reducing effect of AI vary across teams with high- and low-complementarity tasks? Under the O-ring production function, in the absence of AI adoption, the wage gap is $Gap^0 = \frac{c\alpha(1+\alpha)}{1-\alpha^3}$, and that under the optimal AI strategy is $Gap^{x^*} = \frac{\alpha c}{1-\alpha^2}$. Then

$$\frac{Gap^{x^*}}{Gap^0} = 1 - \frac{\alpha}{(1+\alpha)^2}.$$

It is easy to see that the ratio is always lower than 1, indicating a reduction in intra-team wage inequality with the adoption of AI. At the same time, as task complementarity increases (as $\alpha \to 0$), the potency

of AI in reducing this gap is lower. Put differently, AI makes a bigger difference for wage inequality for teams where tasks are highly independent of each other, and the shirking of a single team member is less consequential to the project's success.

In Appendix C, we also extend the analysis to compare payoffs between workers, in addition to comparing payoffs of workers before and after AI adoption. The analysis provides a robustness check and shows that the payoffs change in identical directions to those discussed in Proposition 6.

4.2 Task-Based AI Substitution

Our analysis thus far focused on a scheme in which a worker is replaced by an AI for his entire task. However, in real-world applications, AI systems often complement human labor by taking over only a subset of tasks, resulting in substitution at the task level rather than complete worker replacement. To capture this possibility, we extend the model to allow AI to substitute for a fraction of a worker's tasks. We show that, in equilibrium, the principal prefers full worker-level replacement over partial task-level replacement.

Let x_i denote the fraction of worker i's tasks performed by the AI, thereby proportionally reducing his effort cost to $(1 - x_i)c$. For consistency with our main analysis, we assume an AI capacity of 1:

$$\bar{x} = \sum_{i=1}^{n} x_i \leq 1.$$

With this modification, each position in the network is occupied by a worker-AI pair. As in the main model, the success of the project depends on the number of positions *effectively* exerting effort. If worker i exerts effort, the entire pair is considered to exert effort. If the worker shirks, only the AI, which performed a fraction x_i of tasks, remains functional. Thus, the pair contributes to effective effort with probability x_i. When k worker-AI pairs are effectively exerting effort, the project succeeds with probability p_k. This adjustment allows the success probability to reflect partial AI substitution within each position.

We also modify the peer monitoring structure. A shirking worker is detected by his successor only if the worker-AI pair appears to be shirking, which occurs with probability $1 - x_i$. Because the AI handles a fraction x_i of worker i's tasks, this partially conceals the worker's shirking, lowering the probability of detection.

Finally, we reconfigure the compensation structure. Under this task-based AI adoption scheme, compensation is no longer tied to a worker's entire role, but is instead determined per unit of task performed. To make this distinction clear, we now use w_i to denote the compensation per task carried out by worker i. If a fraction x_i of his tasks is handled by AI, his total compensation upon successful project completion becomes $(1 - x_i)w_i$. For any pair (w, x) that induces joint effort among workers, the principal's expected compensation cost remains the same as in Equation (1).

Worker Incentives and Optimal Compensation. The following result, a counterpart to Proposition 1, characterizes the optimal compensation scheme for a given task-based AI adoption strategy x.

Proposition 8. *Fix a task-based AI adoption strategy $x = (x_1, \ldots, x_n)$. The optimal compensation scheme conditional on x, denoted by $w^x = (w_1^x, \ldots, w_n^x)$, satisfies:*

$$w_i^x = \frac{c}{p_n - \zeta_i^x}, \text{ for each } i \in \{1, \ldots, n\} \text{ with } x_i < 1,$$

where

$$\zeta_i^x = x_i p_n + \sum_{k=1}^{n-i} \left[p_{n-k}\, x_{i+k} \prod_{j=i}^{i+k-1} (1 - x_j) \right] + p_{i-1} \prod_{j=i}^{n} (1 - x_j)\,.$$

Proposition 8 characterizes the optimal compensation for workers whose tasks are not entirely performed by the AI, as otherwise compensation is irrelevant. As in the main model, the optimal compensation scheme induces effort by supporting a trigger strategy profile as an equilibrium, and ensures that workers remain indifferent on the equilibrium path. The compensation of worker i decreases with $p_n - \zeta_i^x$, the difference in the probability of success when he exerts effort versus when he shirks. The explicit value of this difference is:

$$\begin{aligned} p_n - \zeta_i^x &= (1 - x_i) p_n - \sum_{k=1}^{n-i} \left[p_{n-k}\, x_{i+k} \prod_{j=i}^{i+k-1} (1 - x_j) \right] - p_{i-1} \prod_{j=i}^{n} (1 - x_j) \\ &= (1 - x_i) \left(p_n - \sum_{k=1}^{n-i} \left[p_{n-k}\, x_{i+k} \prod_{j=i+1}^{i+k-1} (1 - x_j) \right] - p_{i-1} \prod_{j=i+1}^{n} (1 - x_j) \right) \end{aligned}$$

The key insight here is that worker i's per-task compensation decreases proportionally with $1 - x_i$, so his total compensation, $(1 - x_i) w_i^x$, remains unchanged regardless of how many tasks he retains. This is because AI replacement affects both production and monitoring in parallel: while it lowers the worker's effort cost by offloading tasks, it also reduces the detectability of shirking. As a result, unless a worker's entire task is replaced, partial replacement—where AI handles only a fraction of his tasks—offers no clear advantage to the principal. This intuition motivates the formal analysis that follows.

Optimal task-based AI substitution. For conciseness, we provide expressions for the wages for a three-worker sequential production team, or the front-most, middle, and end-most workers, respectively:

$$\begin{aligned} w_1^x &= \frac{c}{(1 - x_1)\left(p_3 - [x_2 p_2 + (1 - x_2) x_3 p_1 + (1 - x_2)(1 - x_3) p_0]\right)}, \\ w_2^x &= \frac{c}{(1 - x_2)\left(p_3 - [x_3 p_2 + (1 - x_3) p_1]\right)}, \\ w_3^x &= \frac{c}{(1 - x_3)\left(p_3 - p_2\right)}. \end{aligned}$$

Then, by focusing on a replacement strategy where no worker is fully replaced ($x_i < 1$ for each i) we can formulate the principal's problem of minimizing the expected compensation cost as:

$$\min_{\substack{x_1,x_2,x_3\in[0,1)\\ x_1+x_2+x_3\leq 1}} \quad (x_1+x_2+x_3)\,c + \frac{p_3 c}{p_3 - [x_2 p_2 + (1-x_2)x_3 p_1 + (1-x_2)(1-x_3)p_0]} + \frac{p_3 c}{p_3 - [x_3 p_2 + (1-x_3)p_1]} + \frac{p_3 c}{p_3 - p_2}.$$

It is clear that the solution to this restricted problem ($x_i < 1$ for each i) yields $(x_1, x_2, x_3) = (0, 0, 0)$, as x_1, x_2, and x_3 all have strictly positive partial derivatives. Then, to determine the globally optimal strategy, we compare the solution $(x_1, x_2, x_3) = (0, 0, 0)$ with the strategies that involve full replacement of a worker: $(x_1, x_2, x_3) \in \{(1, 0, 0), (0, 1, 0), (0, 0, 1)\}$. This means that the optimal solution in this task-based setting reduces to selecting the best full-replacement strategy, which aligns with the optimal pure-replacement strategy from the main model. As established earlier, this optimal strategy involves fully replacing either the front-most or the end-most worker as long as $p_0 > 0$. If $p_0 = 0$, then not replacing anyone, $x = (0, 0, 0)$, is equally optimal: the front-most worker can be induced to exert effort with no information rent (his expected payment equals the effort cost c), because if he shirks, all subsequent workers also shirk and the success probability becomes at $p_0 = 0$. Proposition 9 formalizes this result.

Proposition 9. *The optimal task-based AI adoption strategy involves fully replacing either the entire task of the front-most or the entire task of the end-most worker, when $p_0 > 0$. If instead $p_0 = 0$, then replacing no one, $(0, 0, \ldots, 0)$, is also optimal.*

Interestingly, while this alternative model allows the AI to handle a fraction of a worker's tasks, this possibility does not materialize in equilibrium and full replacement of workers' tasks is preferred by the principal. This outcome is closer to the observations from reality, where, workers' tasks are displaced in their entirety, which is equivalent to replacing a worker, connecting our findings to the lay observations from reality.

Finally, we turn our attention to the utilization of AI capacity, and question what is different in a task-based replacement relative to the benchmark model. To this end, we inquire a scenario where $n \geq \mathcal{A} > 0$ denotes the total AI capacity available to the principal, and the replacement strategy $x = (x_1, \ldots, x_n)$ satisfies $\sum_{i=1}^{n} x_i \leq \mathcal{A}$. Similar to what we noted for the main model, a fractional task-based replacement weakens peer monitoring and raises compensation costs. Consequently, with task-based substitution, the principal prefers to replace the entire task of some workers, while letting the other workers carry out their tasks in their entirety, but does not facilitate fractional AI allocation. Corollary 2 provides the solution for a general AI capacity, following the same approach as in Proposition 9.

Corollary 2. *The optimal AI adoption strategy allows for no fractional task allocation and replaces the entire tasks of $\lfloor \mathcal{A} \rfloor$ workers. The replacement is done in a way that ensures the remaining workers, whose*

tasks are not replaced, are consecutive to each other. If $p_0 = 0$ *and* $\lfloor \mathcal{A} \rfloor = 1$*, then not replacing anyone,* $(0, 0, \ldots, 0)$*, is also optimal.*

An immediate implication of the corollary is the possibility of underutilization of the AI capacity. For example, if $\mathcal{A} < 1$, the optimal strategy is to refrain from adopting AI altogether. This finding bolsters the idea that even under a limited AI capacity, the principal may, under some circumstances, choose not to exhaust it.

4.3 Network Structure

In the main part of the paper, we focus on an organization with a chain network structure, as its optimality is proven in Winter (2010). The chain structure well represents organizations where tasks are carried out sequentially among team members. Naturally, for reasons we abstract away from in this paper, teams may be organized in other structures than the chain structure. Another commonly observed structure is the *star* network, where some team members first simultaneously carry out their tasks, followed by a central, possibly higher level, executive carrying out his own. In this section, we will extend our framework to the star network and summarize the insights identical to and different from a chain environment.

Consider a team where $n-1$ *peripheral* workers (denoted by $1, \cdots, n-1$) are observed by a *central* worker, who may be a manager (denoted by n). Proposition 10 demonstrates the robustness of two of our earlier insights: (i) a team member who is essential to maintaining information flow between team members is less likely to be replaced, and (ii) a randomized replacement strategy may still be optimal.

Proposition 10. *In a star structure, all AI replacement strategies satisfying* $\sum_{i=1}^{n-1} x_i = 1$ *and* $x_n = 0$ *are optimal, if the condition* $p_{n-1}^2 - p_n p_{n-2} \leq 0$ *is satisfied.*

The proposition suggests that, the manager—the team member who is essential for maintaining the information flow—is never replaced, and the peripheral workers face a higher risk of being replaced with AI. Since these peripheral workers are identical, any AI replacement strategy, where the probability of replacement sums up to the AI capacity, is optimal when the sufficient condition $p_{n-1}^2 - p_n p_{n-2} \leq 0$ is met. This implies that the key insights we derive in our benchmark model, while shaped by the characteristics of the network, are not specific to the chain network assumption, and carry forward to a star organizational structure as well.

4.4 Strategic AI

So far, we have considered AI agents that, when deployed, automatically exert effort. We now extend the analysis to a setting in which AI's behavior can be programmed to condition its action on the actions of its predecessor, like human workers do. In other words, rather than exerting effort unconditionally,

a programmable AI can follow a strategy that maps its predecessor's action into its own effort decision. This extension allows us to study the implications of introducing AI that can replicate not only the productivity but also the strategic responsiveness of human agents within the sequential chain structure.

The strategy of an AI agent placed at position i, $\sigma_i^{AI} : \{0,1\} \mapsto \{0,1\}$, $i \in \{2,\ldots,n\}$ specifies its effort decision based on the observed decision e_{i-1} of its predecessor. Since there is no predecessor to position 1, the AI strategy in this position is $\sigma_1^{AI} \in \{0,1\}$. In this environment, the principal's AI deployment decision has two dimensions: (i) deciding which human worker to replace, and (ii) determining how to program the AI to act strategically, depending on its position in the sequence. We solve for the principal's decision, starting with the assumption that she can costlessly program AI.

Note that the principal's objective is to induce all workers to exert effort while keeping compensation costs as low as possible. For each worker i, the required compensation depends on ζ_i, the project's success probability from worker i's perspective if he chooses to shirk. Minimizing compensation therefore requires minimizing ζ_i. This is achieved by programming the AI agent to shirk whenever it observes its predecessor shirking, regardless of its position in the sequence. Hence, the principal's optimal programming of AI actions is:

$$\sigma_1^{*AI} = 1, \quad \sigma_i^{*AI}(e_{i-1}) = \begin{cases} 1 & \text{if } e_{i-1} = 1, \\ 0 & \text{if } e_{i-1} = 0, \end{cases} \quad \text{for all } i \in \{2,\ldots,n\}.$$

Given this optimal programming strategy, the principal then determines which agent to replace. We provide the optimal replacement strategy in Proposition 11.

Proposition 11. *When the principal can strategically program AI to condition its effort on the actions of its predecessor, the optimal deployment of AI is such that $x = (0,0,\ldots,1)$. In words, the principal replaces the end-most worker with certainty.*

As Proposition 11 argues, with a strategic AI, the principal no longer deploys a randomization strategy and strictly chooses to replace the end-most worker. She does so since, in this environment, she is no longer subject to the indirect and direct incentive costs, but is only concerned with direct cost savings, thus focusing on replacing the agent with the highest compensation. This result follows trivially in a world where AI can perfectly and costlessly mimic human behavior. Given these advantages of AI, the principal will always use AI. However, in real life, programming AI to mimic humans may not be costless. Doing so amounts to introducing both a monitoring and decision-making capacity to AI, requiring upfront and continuous investments. If the costs of programming AI were prohibitively high, we would go back to our benchmark setting, with the benchmark deployment strategy.

These findings yield two key managerial insights. First, the optimal deployment of AI in human-AI teams requires attention to the strategic programming of AI–specifically, how it should respond to shirking by humans (or other AI agents). To our knowledge, such monitoring and adaptive response mechanisms are not yet embedded in existing AI systems. Second, and perhaps counterintuitively, our results show

that a principal may sometimes prefer an AI that shirks occasionally–and is therefore less efficient–over one that always works unconditionally. For managers, this suggests that evaluating the benefits of automation requires accounting for such strategic shirking, since it reduces the total productive capacity of these technologies.

4.5 Additional Discussions

Limited Capacity of AI In the main model, we assume AI capacity is limited. This is a realistic assumption that captures the resource constraints of any organization. Adoption of AI technologies and their use are both costly, therefore, while organizations are trying to integrate AI into multiple aspects of their work, they care to prioritize the use of AI for the tasks where the returns to the system will be the highest (Stackpole, 2024).

In our main model, we purposely abstracted away from the costs of AI adoption and use to focus on the deployment strategy. We prefer not to add unnecessary overhead to the decision due to costs of adopting AI. We also wanted to sharpen the question of how to prioritize among nearly identical workers when deploying AI.

These said, in some distant future costs of adopting and using AI may no longer be a significant constraint to achieve AI capacity, and a principal may deploy AI in a way to replace all workers. We also introduced a version of this scenario when we investigated task-based replacement in Section 4.2 by relaxing the capacity to take an arbitrary value $\bar{x} \leq n$.

If we follow our benchmark model, in the absence of a capacity constraint and AI adoption/use costs, trivially, the principal would choose to replace all workers. In this setting, all other insights we deliver—from wages, pay inequality, randomization of work—are no longer relevant.

Imperfect observability of AI utilization. In the baseline model, workers are unable to observe the realized outcome of the AI replacement strategy. This scenario is analogous to an AI system successfully passing a Turing test, where a worker cannot tell whether the effort in a preceding task was produced by a human or by an AI. Recent evidence indicates that AI can today indeed generate outputs that are "statistically indistinguishable from a random human" (Mei et al., 2024, abstract). Thus, in many instances of AI integration into organizational workflows, workers may fail to identify whether the task-relevant inputs they receive are from human colleagues or from AI systems. For example, call center agents increasingly rely on written guidance generated by AI (Li et al., 2024b), yet call center workers often cannot determine whether the instructions were produced by a more experienced employee or by an algorithm. Likewise, software developers frequently collaborate with AI systems (Hoffmann et al., 2025), receiving code suggestions and feedback that are not readily distinguishable from those produced by human peers.

While both the literature and the practice highlight that it is nearly impossible to distinguish a

human input from an AI input, the setting we study can also arise optimally. This is because if the principal could choose the work setting, she would optimally design a work environment with imperfect observability. Thus, imperfect observability is a feature of the environment that arises optimally.

To see this, consider a setting where the timeline of the game is altered to facilitate observability. Specifically, the principal first chooses a (potentially mixed) AI replacement strategy, and then the realized replacement is publicly observed. Second, then the principal chooses a compensation strategy. Finally, workers choose their efforts and the outcome of the project is realized.

In this setting, the principal's payoff associated with any replacement strategy x will be linear in pure strategies. Moreover, we know that there are two optimal pure strategies when $p_0 > 0$: replacing the front-most and the end-most worker. Therefore, any randomization between replacing these two workers will be optimal. When $p_0 = 0$, not replacing any worker is equally optimal, making randomization among the two replacement strategies and no replacement optimal as well. Since payoffs from randomization are equivalent to those from pure replacement strategies, the principal does not have a strict preference for randomization. These observations together suggest that imperfect observability benefits the principal.

Another important observation here is that, in the perfect observability setting, strategic uncertainty or shaping the worker's beliefs about replacement is no longer feasible. Thus, underutilization of AI resources is no longer optimal, and the principal utilizes the full AI capacity as long as $p_0 > 0$. When $p_0 = 0$, not replacing any worker is also optimal, alongside fully utilizing AI capacity to replace the front-most or end-most worker, so underutilization of AI capacity may arise in equilibrium.

Heterogeneity of Team Members In the main model, we purposefully abstract away from creating asymmetries among workers other than their position in the network. We also assume that each task contributes identically to the success of the project. We do so to demonstrate that informational position alone is sufficient to generate differential risks of AI replacement and wage outcomes. Team members may, however, vary in other ways than their position, for instance in their skills, or the cost of effort. Moreover, the contributions of tasks to the project success may vary by their position. Without building a full-fledged model, we can argue that the replacement probability of the workers may look different from what our propositions suggest, and the middle worker may face a non-zero probability of replacement if he is more costly or lower-skilled than his peers in the team.

5 Conclusion

Owing to the rapid growth of robotization and AI, organizations are going through a profound transformation about what work is and how work is done. New AI technologies have transformed how employees interact with each other as well, as their tasks are partially or fully carried out by the AI agents. Given the scale and scope of this transformation, it is essential to ask how work and groups of employees should

be re-optimized around these new technologies.

There is a growing literature on how machines alter worker and business performance (Otis et al., 2024) and human decision-making (De Véricourt and Gurkan, 2023; Boyacı et al., 2024; Li et al., 2024a; Burtch et al., 2025). Much of the existing literature focuses on individual-level performance effects of the workers who adopt AI (e.g., Dell'Acqua et al., 2023a) or the labor displacement and wage changes due to AI (e.g., Chen et al., 2025; Humlum and Vestergaard, 2025). We contribute to these understudied areas by focusing on the effects of AI agents on worker productivity from a team perspective, explicitly modeling how adoption of AI alters the motivation of the workers and the incentives set by the principal. We demonstrate how a principal integrates AI in a team previously optimized for human employees, and characterize the replacement risk and resulting wage changes for each team in the production sequence based on their position.

First, our analysis reveals that optimal AI adoption involves stochastic rather than deterministic labor force replacement. AI resources are best utilized to complement the workers' roles, possibly in a way that alters or reduces the workload, while maintaining the critical benefits of human worker input. This finding aligns with recent theoretical work emphasizing the importance of human-AI complementarity in maximizing organizational productivity (Brynjolfsson and Mitchell, 2017).

Second, we demonstrate that the likelihood of AI replacement varies by a worker's position within the team's information network. To maintain essential information flows and leverage peer monitoring effectively, it is optimal to minimize the replacement risk for the middle worker, while setting positive replacement probabilities for the front-most and end-most team members. The organizational position relates to the recent literature emphasizing the critical role of information and communication in teams for organizational efficiency (Garicano, 2000; Angelucci, 2017; Matouschek et al., 2025).

Third, we investigate the wage implications of optimal AI integration within production teams. In his analysis of the AI effects on wages and pay inequality, Acemoglu (2025) states that while theoretically it is possible for AI to reduce wages and exacerbate inequality, there is little evidence in practice for these predictions. Our findings provide additional theoretical predictions relevant to this domain; by suggesting that the strategic adoption of AI does not necessitate wage reductions; instead, managers should anticipate comparable or higher wages post AI adoption relative to the wages before AI adoption. Importantly, while existing wage hierarchies remain unchanged following AI adoption, the intra-team wage gap is significantly reduced as lower-paid workers receive wage increases. Collectively, these insights challenge prevailing assumptions and provide practical managerial guidance for navigating AI integration. Table 1 summarizes these key managerial prescriptions.

While AI stands to offer productivity gains, our findings highlight that its integration of AI to human systems must be carefully designed to maintain the information flows between the team members. By doing so, organizations can benefit from replacing workers with AI while minimizing the negative

Table 1: Summary of Key Managerial Insights

Question	Findings from our setting
How should a manager optimally integrate AI to a human team?	AI deployment to replace workers should be randomized, e.g., across different projects or work shifts.
Which workers in the team are more likely to be replaced with AI?	The front-most and the end-most workers face higher replacement risk. The middle worker should not be replaced.
How does AI adoption affect worker wages?	Wages increase for all except the end-most worker, whose wage remains unchanged.
How does the optimal deployment of AI impact intra-team wage inequality?	Intra-team wage gap declines following optimal AI adoption.
When is AI's wage inequality reducing effect more potent?	AI's wage inequality reducing effect is more potent in teams with lower complementarity.
Is it better for AI to carry out a fraction of a worker's tasks, rather than fully substituting him?	No, the principal prefers to replace a worker rather than a fraction of tasks.

externalities on the non-replaced members of the team.

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Appendix

Appendix A Supporting Statements

This appendix section presents supporting statements omitted from the main text for brevity, along with their corresponding proofs.

A.1 Existence

We first establish the existence of the optimal AI replacement.

Lemma 1. *The optimal replacement strategy exists.*

Proof of Lemma 1.
We first prove that the principal's payoff is continuous with respect to x. If $x_i < 1$ for all i, then

$$\frac{W_x}{c} = \sum_{i=1}^{n} x_i + \sum_{i=1}^{n} \frac{(1-x_i)\,p_n}{p_n - \zeta_i^x}.$$

Let $\vec{x}_j$ be a vector whose jth element is 1 and all other elements are zeros, then

$$\lim_{x\to\vec{x}_j} \frac{W_x}{c} = 1 + \sum_{i\neq j} \frac{p_n}{p_n - \zeta_i^{\vec{x}_j}} + \lim_{x\to\vec{x}_j} \frac{(1-x_j)\,p_n}{p_n - \zeta_j^x}.$$

As can be seen in equation (3) when $x_j = 1$, the zero denominator makes ζ_j^x not well-defined. (3) implies

$$p_{j-1} \leq \zeta_j^x \leq p_{n-1}$$

and thus

$$\frac{(1-x_j)\,p_n}{p_n - p_{j-1}} \leq \frac{(1-x_j)\,p_n}{p_n - \zeta_j^x} \leq \frac{(1-x_j)\,p_n}{p_n - p_{n-1}}.$$

Note that

$$\lim_{x\to\vec{x}_j} \frac{(1-x_j)\,p_n}{p_n - p_{j-1}} = 0$$
$$\lim_{x\to\vec{x}_j} \frac{(1-x_j)\,p_n}{p_n - p_{n-1}} = 0.$$

By squeeze theorem,

$$\lim_{x\to\vec{x}_j} \frac{(1-x_j)\,p_n}{p_n - \zeta_j^x} = 0.$$

So

$$\lim_{x\to\vec{x}_j} \frac{W_x}{c} = 1 + \sum_{i\neq j} \frac{p_n}{p_n - \zeta_i^{\vec{x}_j}},$$

which is indeed the principal's payment when $x = \vec{x}_j$.

Moreover, note that the set of feasible replacement strategies,

$$\left\{(x_1,\cdots,x_n)\,|x_i\geq 0,\forall i=1,\cdots,n,\sum_{i=1}^{n}x_i\leq 1\right\},$$

is a compact set. Therefore minimum of a continuous function on a compact set exists. □

A.2 The Optimal Pure Replacement Strategy

The next statement characterizes the optimal pure replacement strategy.

Lemma 2. *The optimal pure replacement strategies involve replacing either the front-most or the end-most worker. That is,* $(1,0,\ldots,0)$ *and* $(0,\ldots,0,1)$ *are optimal when* $p_0>0$*. If instead* $p_0=0$*, then replacing no one,* $(0,0,\ldots,0)$*, is also optimal.*

Proof of Lemma 2.
With slight abuse of notation, denote the principal's expected compensation cost under the pure replacement strategy in which worker $i\in\{1,\cdots,n\}$ is replaced with probability 1 by W_i and that under the pure replacement strategy in which no worker is replaced by $W_\emptyset$. We will show that:

$$W_1=W_n=min\{W_\emptyset,W_1,W_2,\cdots,W_n\}.$$

We have:

$$\begin{aligned}\frac{W_\emptyset}{c}&=\sum_{i=1}^{n}\frac{p_n}{p_n-p_{i-1}}\\ \frac{W_i}{c}&=1+\sum_{k=1}^{i-1}\frac{p_n}{p_n-p_{n+k-i}}+\sum_{k=i+1}^{n}\frac{p_n}{p_n-p_{k-1}},\ \text{for each } i\in\{1,\cdots,n\}.\end{aligned}$$

Then:

$$\frac{W_{i+1}-W_i}{c}=\frac{p_n}{p_n-p_{n-i}}-\frac{p_n}{p_n-p_i},\ \text{for each } i\in\{1,\cdots,n-1\}.$$

Therefore:

$$W_{i+1}\begin{cases}>W_i, & \text{if } i<n/2,\\ =W_i, & \text{if } i=n/2,\\ <W_i, & \text{if } i>n/2,\end{cases}\ \text{for each } i\in\{1,\cdots,n-1\}.$$

Note that

$$\begin{aligned}\frac{W_{n+1-i}}{c}&=1+\sum_{k=1}^{n+1-i-1}\frac{p_n}{p_n-p_{n+k-(n+1-i)}}+\sum_{k=n+1-i+1}^{n}\frac{p_n}{p_n-p_{k-1}}\\ &=1+\sum_{k=i+1}^{n}\frac{p_n}{p_n-p_{k-1}}+\sum_{k=1}^{i-1}\frac{p_n}{p_n-p_{n+k-i}}.\end{aligned}$$

$$= \frac{W_i}{c}$$

This implies that $W_1 = W_n$. Moreover, when $p_0 > 0$ we have

$$\frac{W_1}{c} = 1 + \sum_{i=2}^{n} \frac{p_n}{p_n - p_{i-1}} < \frac{p_n}{p_n - p_0} + \sum_{i=2}^{n} \frac{p_n}{p_n - p_{i-1}} = \frac{W_\emptyset}{c}.$$

and when $p_0 = 0$, we have:

$$\frac{W_1}{c} = 1 + \sum_{i=2}^{n} \frac{p_n}{p_n - p_{i-1}} = \frac{p_n}{p_n - p_0} + \sum_{i=2}^{n} \frac{p_n}{p_n - p_{i-1}} = \frac{W_\emptyset}{c}.$$

This concludes the proof. □

A.3 Possibility of Altering Wage Hierarchy

The next result shows that (suboptimal) AI replacement can alter the wage hierarchy within the production team compared to the case where no replacement occurs.

Lemma 3. *For any $i < j < n$, there exists a replacement strategy x such that $w_i^x > w_j^x$.*

Proof of Lemma 3.
Consider the replacement strategy with $x_i + x_{i+1} = 1$ and $x_i \in (0, 1)$. Then from equation (5) we have $\zeta_i^x = p_{n-1}$ and $\zeta_j^x = p_{j-1}$, which implies $w_i^x > w_j^x$. □

Appendix B Proofs of Results

This appendix section provides the proofs of the results stated in Section 3 and Section 4.

B.1 Proofs of Section 3

Proof of Proposition 1.
The proof proceeds in three steps. We show the following in sequence:

1. Trigger strategy profile σ^* constitutes an equilibrium under w^x.
2. No alternative compensation scheme with a lower expected cost can support σ^* as an equilibrium.
3. Supporting any other strategy profile, apart from the trigger strategy profile, that results in joint effort, as an equilibrium necessarily incurs a higher expected compensation cost for the principal.

Step 1. We will prove that, under the compensation scheme w^x, the trigger strategy is a best response for each worker $i \in \{1, \ldots, n\}$ given that all other workers follow the trigger strategy.

If worker i observes $e_{i-1} = 1$, he believes that nobody has deviated. In this case, choosing effort is a best response for worker i if and only if:

$$p_n\, w_i - c \geq \zeta_i^x\, w_i. \tag{7}$$

The left-hand side is the expected payoff for worker i when he exerts effort, which leads all subsequent workers to exert effort, resulting in a p_n probability of success. The right-hand side is his expected payoff when he shirks, where ζ_i^x is the probability of success from his perspective given that the other workers follow the trigger strategy profile.

Note that w_i^x is defined so that condition (7), a necessary condition for the trigger strategy to comprise an equilibrium, holds with equality: $w_i^x = \frac{c}{p_n - \zeta_i}$ (equation (2)). Therefore worker i has no incentive to deviate from the trigger strategy after observing $e_{i-1} = 1$.

If worker i observes $e_{i-1} = 0$, we are off the equilibrium path. Worker i then believes that all the predecessors of worker $i-1$ exerted effort and worker $i-1$ is the first to shirk.[11] In this case, shirking ($e_i = 0$) is a best response for worker i if and only if:

$$p_{n-1} w_i^x - c \leq \hat{\zeta}_i^x\, w_i^x. \tag{8}$$

The left-hand side is the expected payoff of worker i when he exerts effort. By exerting effort, worker i ensures that all his successors will also exert effort, resulting in a probability of success of p_{n-1}, as all workers other than $i-1$ have exerted effort. The right-hand side denotes the expected payoff for worker i when he shirks, where $\hat{\zeta}_i^x$ is the probability of success when worker i shirks, given that he has observed $e_{i-1} = 0$ and believes that all workers preceding $i-1$ have exerted effort, and all his successors will adhere to trigger strategies. That is:

$$\begin{aligned}
\hat{\zeta}_i^x &= p_{i-2} \sum_{k=1}^{i-2} \frac{x_k}{1 - x_i - x_{i-1}} + \sum_{k=i+1}^{n} \frac{x_k}{1 - x_i - x_{i-1}} p_{n-1-k+i} + p_{i-2}\, \frac{1 - \bar{x}}{1 - x_i - x_{i-1}} \\
&= p_{i-2} \frac{1 - \sum_{k=i-1}^{n} x_k}{1 - x_i - x_{i-1}} + \sum_{k=i+1}^{n} \frac{x_k}{1 - x_i - x_{i-1}} p_{n-1-k+i}
\end{aligned}$$

More precisely, after observing $e_{i-1} = 0$, worker i knows that neither he nor worker $i-1$ has been replaced. Therefore, the probability of worker k being replaced (for $k \neq i, i-1$) is given by $\frac{x_k}{1 - x_i - x_{i-1}}$, while the probability of no replacement from worker i's perspective is $\frac{1 - \bar{x}}{1 - x_i - x_{i-1}}$. When the replaced worker is a predecessor of worker i (and $i-1$) (i.e., when $k < i-1$), or when there is no AI replacement, all the successors of worker i will shirk upon observing that worker i shirks, resulting in a success probability of p_{i-2}. When the replaced worker is a successor of worker i (i.e., when $k > i$), all the workers between i and k will shirk, and all the successors of k will exert effort, resulting in a success probability of $p_{n-1-k+i}$.

[11] All subsequent arguments would analogously hold even if worker i has different out-of-path beliefs regarding the behavior of his predecessors.

We already know that $w_i^x(p_n - \zeta_i^x) = c$. Therefore showing that $p_n - \zeta_i^x \geq p_{n-1} - \hat{\zeta}_i^x$ would suffice to show that condition (8) holds, and hence each worker finds it optimal to shirk upon observing that his immediate predecessor shirks. Therefore, we would like to show that

$$p_n - p_{n-1} \geq \zeta_i^x - \hat{\zeta}_i^x$$

Note that

$$\zeta_i^x - \hat{\zeta}_i^x = \underbrace{\left(p_{i-1} \frac{1 - \sum_{k=i}^{n} x_k}{1 - x_i} + \sum_{k=i+1}^{n} \frac{x_k}{1 - x_i} p_{n-k+i} \right)}_{\zeta_i^x} - \underbrace{\left(p_{i-2} \frac{1 - \sum_{k=i-1}^{n} x_k}{1 - x_i - x_{i-1}} + \sum_{k=i+1}^{n} \frac{x_k}{1 - x_i - x_{i-1}} p_{n-1-k+i} \right)}_{\hat{\zeta}_i^x}$$

After some algebra, we get:

$$\begin{aligned} \zeta_i^x - \hat{\zeta}_i^x = (p_{i-1} - p_{i-2}) \frac{1 - \sum_{k=i-1}^{n} x_k}{1 - x_i - x_{i-1}} + \sum_{k=i+1}^{n} \frac{x_k}{1 - x_i} (p_{n-k+i} - p_{n-1-k+i}) \\ + p_{i-1} \frac{x_{i-1} \sum_{k=i+1}^{n} x_k}{(1 - x_i)(1 - x_i - x_{i-1})} - \sum_{k=i+1}^{n} \frac{x_{i-1} x_k}{(1 - x_i)(1 - x_i - x_{i-1})} p_{n-1-k+i}. \end{aligned}$$

Simplifying further, we get:

$$\begin{aligned} \zeta_i^x - \hat{\zeta}_i = (p_{i-1} - p_{i-2}) \frac{1 - \sum_{k=i-1}^{n} x_k}{1 - x_i - x_{i-1}} + \sum_{k=i+1}^{n} \frac{x_k}{1 - x_i} (p_{n-k+i} - p_{n-1-k+i}) \\ + \sum_{k=i+1}^{n} \frac{x_{i-1} x_k}{(1 - x_i)(1 - x_i - x_{i-1})} (p_{i-1} - p_{n-1-k+i}). \end{aligned}$$

However, the term on the second line of this equality is negative as $p_{i-1} \leq p_{n-1-k+i}$ for each $k \geq i+1$. Then we can write

$$\zeta_i^x - \hat{\zeta}_i^x \leq (p_{i-1} - p_{i-2}) \frac{1 - \sum_{k=i-1}^{n} x_k}{1 - x_i - x_{i-1}} + \sum_{k=i+1}^{n} \frac{x_k}{1 - x_i} (p_{n-k+i} - p_{n-1-k+i}).$$

The right hand side of this inequality is a weighted average of incremental increase in the probabilities,

and the sum of the weights is less than 1. Then by using the fact that $p_n - p_{n-1}$ is the largest incremental increase in the probability, we get:

$$\zeta_i^x - \hat{\zeta}_i^x \leq p_n - p_{n-1}.$$

Therefore, condition (8) is satisfied, and worker i finds it optimal to shirk upon observing $e_{i-1} = 0$. Therefore, the trigger strategy profile comprises an equilibrium under compensation scheme w^x.

Step 2. Moreover, we know that w^x is the least costly compensation scheme to support the trigger strategy profile as an equilibrium. This is because w^x satisfies condition (7), a necessary condition to support the trigger strategy as an equilibrium, with equality. Any compensation scheme with a lower expected cost to the principal would violate this condition.

Step 3. Finally, in any alternative equilibrium strategy profile with joint effort as the equilibrium outcome, the probability of success following worker i's deviation (from his perspective) is (weakly) higher than that under the trigger strategy profile, ζ_i^x. This imposes a (weakly) stronger version of the above constraint and thus requires a (weakly) higher payment to each worker. Consequently, w^x must also be the optimal compensation scheme conditional on replacement strategy x. □

Proof of Proposition 2.

Consider a replacement strategy x of the form:

$$x = (\rho, 0, \ldots, 0, 1-\rho), \quad \text{for } \rho \in [0,1].$$

The two extreme points within this class, which are obtained by setting $\rho = 0$ and $\rho = 1$, correspond to the optimal pure replacement strategies. We will show that choosing any interior value $\rho \in (0,1)$ outperforms these pure strategies. Therefore, the optimal replacement strategy necessarily involves randomization.

With a slight abuse of notation, for $x = (\rho, 0, \ldots, 0, 1-\rho)$, we denote ζ_i^x as ζ_i^ρ, w_i^x as w_i^ρ, and W_x as W_ρ. It is clear that:

$$\begin{aligned}
&\zeta_1^\rho = p_1, \\
&\zeta_n^\rho = p_{n-1}, \\
&\zeta_i^\rho = (1-\rho)\, p_i + \rho\, p_{i-1}, \ \forall i \in \{2, \ldots, n-1\}.
\end{aligned}$$

Moreover,

$$\frac{W_\rho}{c} = \sum_{i=2}^{n-1} \frac{p_n}{p_n - (1-\rho)\, p_i - \rho p_{i-1}} + \frac{p_n}{p_n - p_1}(1-\rho) + \rho \frac{p_n}{p_n - p_{n-1}} + 1.$$

Note this holds even when $\rho = 0$ or $\rho = 1$. The second order derivative of the W_ρ with respect to ρ satisfies:

$$\frac{\partial^2 W_\rho}{\partial \rho^2}\frac{1}{c} = 2p_n\left(\sum_{i=2}^{n-1}\frac{(p_i - p_{i-1})^2}{(p_n - (1-\rho)\,p_i - \rho p_{i-1})^3}\right).$$

With $n \geq 3$, the summation contains at least one strictly positive term, as $(p_i - p_{i-1})^2 > 0$ and $(p_n - (1-\rho)\,p_i - \rho p_{i-1})^3 > 0$. Therefore:

$$\frac{W_\rho}{\partial \rho^2} > 0,$$

implying that W_ρ is strictly convex in ρ. But we know that $\rho = 0$ and $\rho = 1$ corresponds to the optimal pure replacement strategies. That is, $W_\rho\big|_{\rho=0} = W_\rho\big|_{\rho=1}$. Then, from the convexity of W_ρ, there must exist a $\rho \in (0,1)$ minimizing W_ρ. This implies that, a replacement strategy with some interior ρ is better than the optimal pure replacement strategies. Therefore, the optimal scheme must involve randomization. □

Proof of Proposition 3.

Step 1. First we prove a stronger statement that implies $x_2^* = 0$ when $n = 3$.

Claim. *In the optimal replacement strategy, $x_{n-1}^* = 0$.*

Proof of the Claim. Let $x = (x_1, \cdots, x_n)$ be an optimal replacement strategy, and suppose that $x_{n-1} > 0$ to get a contradiction. Then we must also have $x_{n-1} < 1$ as the optimal replacement strategy involves randomization (Proposition 2).

Recall that the expected compensation cost for the principal satisfies:

$$\frac{W_x}{c} = \sum_{i=1}^{n} x_i + \sum_{i=1}^{n}\frac{(1-x_i)^2\,p_n}{R_i},$$

where

$$R_i = (1-x_i)\,(p_n - p_{i-1}) - \sum_{k=i+1}^{n} x_k\,(p_{n+i-k} - p_{i-1})\,.$$

Now, given this optimal replacement strategy with $x_{n-1} > 0$, consider a deviation in which the probability of replacement for the $(n-1)$th worker is transferred to the nth worker. That is, the new replacement strategy x' obtained by this deviation from x is:

$$x' = (x_1, \cdots, x_{n-2}, 0, x_{n-1} + x_n).$$

Case 1: First consider the case where $x_{n-1} + x_n < 1$. The new expected cost is:

$$\frac{W_{x'}}{c} = \sum_{i=1}^{n} x_i + \sum_{i=1}^{n-2}\frac{(1-x_i)^2\,p_n}{R_i'} + \frac{p_n}{R_{n-1}'} + \frac{(1-x_{n-1}-x_n)^2\,p_n}{R_n'},$$

where

$$R_i' = R_i + x_{n-1}\,(p_{i+1} - p_i)\,,\ \text{if } i < n-1,$$

$$
\begin{aligned}
R'_{n-1} &= R_{n-1} + x_{n-1}\left(p_n - p_{n-1}\right), \\
R_n &= \left(1 - x_n\right)\left(p_n - p_{n-1}\right), \\
R'_n &= \left(1 - x_{n-1} - x_n\right)\left(p_n - p_{n-1}\right).
\end{aligned}
$$

We would like to show that $W_{x'} < W_x$ holds. Given $R_i < R'_i$ if $i < n-1$, it suffices to show that:

$$
\frac{\left(1 - x_n\right)^2}{R_n} - \frac{\left(1 - x_{n-1} - x_n\right)^2}{R'_n} + \frac{\left(1 - x_{n-1}\right)^2}{R_{n-1}} - \frac{1}{R'_{n-1}} \geq 0. \tag{9}
$$

The first two terms of (9) can be rewritten as:

$$
\begin{aligned}
\frac{\left(1 - x_n\right)^2}{R_n} - \frac{\left(1 - x_{n-1} - x_n\right)^2}{R'_n} =& \frac{\left(1 - x_n\right)^2}{\left(1 - x_n\right)\left(p_n - p_{n-1}\right)} - \frac{\left(1 - x_{n-1} - x_n\right)^2}{\left(1 - x_{n-1} - x_n\right)\left(p_n - p_{n-1}\right)} \\
=& \frac{1 - x_n}{p_n - p_{n-1}} - \frac{1 - x_{n-1} - x_n}{p_n - p_{n-1}} \\
=& \frac{x_{n-1}}{p_n - p_{n-1}}
\end{aligned} \tag{10}
$$

Moreover, by using the equality $R_{n-1} = R'_{n-1} - x_{n-1}\left(p_n - p_{n-1}\right)$, we can rewrite the third and fourth terms of (9) as:

$$
\begin{aligned}
\frac{\left(1 - x_{n-1}\right)^2}{R_{n-1}} - \frac{1}{R'_{n-1}} &= \frac{R'_{n-1}\left(1 - x_{n-1}\right)^2 - R'_{n-1} + x_{n-1}\left(p_n - p_{n-1}\right)}{R_{n-1}R'_{n-1}} \\
&= \frac{x_{n-1}\left[\left(p_n - p_{n-1}\right) - R'_{n-1}\left(2 - x_{n-1}\right)\right]}{R_{n-1}R'_{n-1}}.
\end{aligned}
$$

Therefore, inequality (9) holds if and only if

$$
\frac{1}{p_n - p_{n-1}} + \frac{\left(p_n - p_{n-1}\right) - R'_{n-1}(2 - x_{n-1})}{R_{n-1}R'_{n-1}} \geq 0.
$$

This inequality holds if and only if

$$
\left(p_n - p_{n-1}\right)^2 - R'_{n-1}(2 - x_{n-1})(p_n - p_{n-1}) + R_{n-1}R'_{n-1} \geq 0,
$$

which further simplifies to

$$
\left(p_n - p_{n-1}\right)^2 - R'_{n-1}(2 - x_{n-1})(p_n - p_{n-1}) + \left[R'_{n-1} - x_{n-1}(p_n - p_{n-1})\right] R'_{n-1} \geq 0.
$$

This can be rewritten as

$$
\left(p_n - p_{n-1}\right)^2 - 2(p_n - p_{n-1})R'_{n-1} + \left(R'_{n-1}\right)^2 \geq 0,
$$

which is equivalent to

$$\left(p_n - p_{n-1} - R'_{n-1}\right)^2 \geq 0.$$

Since the square of a real number is always non-negative, the inequality holds.

This implies that the deviation is profitable for the principal, which contradicts the optimality of the allocation $x = (x_1, \ldots, x_{n-1}, x_n)$. Therefore, the optimal replacement strategy x^* has to satisfy $x^*_{n-1} = 0$.
Case 2: Next consider the case where $x_{n-1} + x_n = 1$. The first two terms in (9) becomes $\frac{(1-x_n)^2}{R_n}$ in this case. Moreover, note that:

$$\frac{(1-x_n)^2}{R_n} = \frac{(1-x_n)^2}{(1-x_n)(p_n - p_{n-1})} = \frac{1-x_n}{p_n - p_{n-1}} = \frac{x_{n-1}}{p_n - p_{n-1}}$$

which coincides with (10). Therefore, the optimal replacement strategy x^* has to satisfy $x^*_{n-1} = 0$. This completes the proof of the claim.

Step 2. Next, we prove that the optimal replacement strategy x^* satisfies $x^*_3 > 0$. Suppose, for contradiction, that a replacement strategy $x = (x_1, x_2, x_3)$ with $x_3 = 0$ is optimal. Note that, the partial derivative of the principal's expected cost with respect to x_1 (as long as $x_1 < 1$) is:

$$\begin{aligned}
\frac{1}{c}\frac{\partial W_x}{\partial x_1} &= 1 - p_3\frac{w_1}{c} + p_3(1-x_1)\frac{1}{c}\frac{\partial w_1}{\partial x_1} \\
&= 1 - \frac{p_3}{p_3 - \zeta_1} + p_3(1-x_1)\frac{1}{(p_3-\zeta_1)^2}\frac{\partial \zeta_1}{\partial x_1} \\
&= -\frac{\zeta_1}{p_3 - \zeta_1} + p_3\frac{1}{(p_3-\zeta_1)^2}\frac{\sum_{k=2}^{3} x_k(p_{4-k} - p_0)}{1-x_1} \\
&= -\frac{\zeta_1}{p_3 - \zeta_1} + \frac{p_3(\zeta_1 - p_0)}{(p_3-\zeta_1)^2} \\
&= \frac{\zeta_1^2 - p_3 p_0}{(p_3-\zeta_1)^2}. \qquad (11)
\end{aligned}$$

From the previous step, we know that $x_2 = 0$. Then $x_2 = x_3 = 0$ implies that $\zeta_1 = p_0$. By substituting this into (11), we get $\frac{\partial W_x}{\partial x_1} \leq 0$. This, in turn, implies that $x_1, x_2, x_3) = (1, 0, 0)$ is an optimal replacement strategy, which contradicts Proposition 2. Therefore, the optimal replacement strategy x^* satisfies $x^*_3 > 0$.

Step 3. Now we prove that the optimal replacement strategy x^* satisfies $x^*_3 \geq x^*_1$. Suppose not for contradiction. Then, a replacement strategy $x = (x_1, 0, x_3)$ with $x_1 > x_3$ is optimal. This in turn requires $x_1 \in (0, 1)$.

The expected compensation cost of the principal under the scheme $(x_1, 0, x_3)$ is:

$$c\left(x_1 + x_3 + p_3\left[\frac{(1-x_1)^2}{(1-x_1)(p_3-p_0) - x_3(p_1-p_0)} + \frac{1}{(p_3-p_1) - x_3(p_2-p_1)} + \frac{1-x_3}{p_3-p_2}\right]\right).$$

The expected compensation cost of the principal under the scheme $(x_3, 0, x_1)$ is:

$$c\left(x_1 + x_3 + p_3\left[\frac{(1-x_3)^2}{(1-x_3)(p_3-p_0) - x_1(p_1-p_0)} + \frac{1}{(p_3-p_1) - x_1(p_2-p_1)} + \frac{1-x_1}{p_3-p_2}\right]\right).$$

In the subsequent analysis, we will show that the precedent is strictly larger than the latter, i.e., we will show that:

$$\left[\frac{(1-x_1)^2}{(1-x_1)(p_3-p_0)-x_3(p_1-p_0)}+\frac{1}{(p_3-p_1)-x_3(p_2-p_1)}+\frac{1-x_3}{p_3-p_2}\right]$$
$$-\left[\frac{(1-x_3)^2}{(1-x_3)(p_3-p_0)-x_1(p_1-p_0)}+\frac{1}{(p_3-p_1)-x_1(p_2-p_1)}+\frac{1-x_1}{p_3-p_2}\right]>0. \tag{12}$$

This, in turn, implies that the principal is better off under the allocation $(x_3, 0, x_1)$, which contradicts the optimality of $(x_1, 0, x_3)$.

To this end, note first that:

$$\frac{1-x_3}{p_3-p_2}-\frac{1-x_1}{p_3-p_2}=\frac{x_1-x_3}{p_3-p_2}.$$

Moreover, we have:

$$\frac{1}{(p_3-p_1)-x_3(p_2-p_1)}-\frac{1}{(p_3-p_1)-x_1(p_2-p_1)}=\frac{-(p_2-p_1)(x_1-x_3)}{[(p_3-p_1)-x_3(p_2-p_1)][(p_3-p_1)-x_1(p_2-p_1)]}.$$

Claim. *The following inequality holds:*

$$\frac{-(p_2-p_1)(x_1-x_3)}{[(p_3-p_1)-x_3(p_2-p_1)][(p_3-p_1)-x_1(p_2-p_1)]}>\frac{-(p_2-p_1)(x_1-x_3)}{(p_3-p_1)(p_3-p_2)}.$$

Proof of the Claim. The inequality holds if and only if:

$$[(p_3-p_1)-x_3(p_2-p_1)][(p_3-p_1)-x_1(p_2-p_1)]>(p_3-p_1)(p_3-p_2).$$

This is equivalent to:

$$(p_3-p_1)^2-x_1(p_2-p_1)(p_3-p_1)-x_3(p_2-p_1)(p_3-p_1)+x_1x_3(p_2-p_1)^2-(p_3-p_1)(p_3-p_2)>0,$$

which can be rewritten as:

$$(p_3-p_1)(p_2-p_1)-x_1(p_2-p_1)(p_3-p_1)-x_3(p_2-p_1)(p_3-p_1)+x_1x_3(p_2-p_1)^2>0.$$

Rearranging further, we obtain:

$$(p_3-p_1)(1-x_1-x_3)+x_1x_3(p_2-p_1)>0,$$

which is correct because $1-x_1-x_3\geq 0$, $x_1>0$, and $x_3>0$. □

Getting back to the inequality (12), note that:

$$\frac{x_1-x_3}{p_3-p_2}-\frac{(p_2-p_1)(x_1-x_3)}{(p_3-p_1)(p_3-p_2)}=\frac{x_1-x_3}{p_3-p_1}.$$

Define:

$$\frac{(1-x_1)^2}{(1-x_1)(p_3-p_0)-x_3(p_1-p_0)}-\frac{(1-x_3)^2}{(1-x_3)(p_3-p_0)-x_1(p_1-p_0)}=\frac{\Omega}{\Theta},$$

where

$$\Theta=\left[(1-x_1)(p_3-p_0)-x_3(p_1-p_0)\right]\left[(1-x_3)(p_3-p_0)-x_1(p_1-p_0)\right]$$

$$\begin{aligned}\Omega&=(p_3-p_0)\left[(1-x_1)^2(1-x_3)-(1-x_3)^2(1-x_1)\right]+(p_1-p_0)\left[(1-x_3)^2x_3-(1-x_1)^2x_1\right]\\&=-(x_1-x_3)\left[(p_3-p_0)(1-x_1)(1-x_3)+(p_1-p_0)\left(x_1^2+x_1x_3+x_3^2-2x_1-2x_3+1\right)\right].\end{aligned}$$

Also denote

$$\Lambda\equiv-\frac{\Omega}{x_1-x_3}.$$

To show that inequality (12) holds, it suffices to show:

$$\frac{x_1-x_3}{p_3-p_1}-\frac{(x_1-x_3)\Lambda}{\Theta}\geq 0.$$

This is equivalent to:

$$\Theta-(p_3-p_1)\Lambda\geq 0.$$

By rearranging it, we obtain:

$$\begin{aligned}&\underbrace{(1-x_1)(1-x_3)(p_3-p_0)^2}_{S_1}-\underbrace{(p_3-p_1)(p_3-p_0)(1-x_1)(1-x_3)}_{S_2}\\&-\underbrace{(1-x_1)x_1(p_3-p_0)(p_1-p_0)}_{S_3}-\underbrace{x_3(1-x_3)(p_1-p_0)(p_3-p_0)}_{S_4}\\&-\underbrace{(p_3-p_1)(p_1-p_0)\left(x_1^2+x_1x_3+x_3^2-2x_1-2x_3+1\right)}_{S_5}+\underbrace{x_1x_3(p_1-p_0)^2}_{S_6}\geq 0.\end{aligned}$$

However, note that:

$$S_1-S_2=(p_1-p_0)(p_3-p_0)(1-x_1)(1-x_3).$$

Thus, we obtain:

$$\underbrace{(p_1-p_0)(p_3-p_0)(1-x_1)(1-x_3)}_{S_1-S_2}-S_3-S_4=(p_3-p_0)(p_1-p_0)\left(x_1^2+x_1x_3+x_3^2-2x_1-2x_3+1\right).$$

Therefore, we further derive:

$$\underbrace{(p_3-p_0)(p_1-p_0)\left(x_1^2+x_1x_3+x_3^2-2x_1-2x_3+1\right)}_{S_1-S_2-S_3-S_4}-S_5+S_6=(1-x_1-x_3)^2(p_1-p_0)^2\geq 0.$$

Thus, inequality (12) holds, which contradicts with the optimality $(x_3, 0, x_1)$. Therefore, the optimal replacement strategy x^* satisfies $x_3^* \geq x_1^*$. □

Proof of Proposition 4.

We prove Proposition 4 in two steps:

1. If $p_1^2 - p_3p_0 \leq 0$, the principal fully utilizes the AI capacity, i.e., $\bar{x}^* = 1$.
2. If $p_1^2 - p_3p_0 > 0$, the principal does not fully utilize the AI capacity, i.e., $\bar{x}^* < 1$.

Step 1. Assume that $p_1^2 - p_3p_0 \leq 0$. Suppose, for contradiction, that the principal does not fully utilize the AI capacity under the optimal replacement strategy, i.e., a strategy x with $\bar{x} < 1$ is optimal. Note that

$$\zeta_1 = p_0 + \sum_{k=2}^{3} \frac{x_k}{1-x_1}(p_{4-k} - p_0).$$

As we know from Proposition 3 that $x_2 = 0$, we obtain:

$$\zeta_1 = p_0 + \frac{x_3}{1-x_1}(p_1 - p_0).$$

Since $\bar{x} < 1$, we must have $x_3 < 1 - x_1$, so $\zeta_1 < p_1$. Therefore, we must have:

$$\zeta_1^2 - p_3p_0 < p_1^2 - p_3p_0 \leq 0.$$

Then, from equation (11), we know that:

$$\frac{1}{c}\frac{\partial W_x}{\partial x_1} = \frac{\zeta_1^2 - p_3p_0}{(p_3-\zeta_1)^2} \quad \Longrightarrow \quad \frac{\partial W_x}{\partial x_1} < 0.$$

Therefore, increasing x_1 slightly, which is feasible since $x_1 + x_3 < 1$, leads to an improvement in terms of the expected cost of compensation. This contradicts the optimality of x. Hence, under the optimal replacement strategy x^*, the principal fully utilizes the AI capacity, i.e., $\bar{x}^* = 1$.

Step 2. Assume $p_1^2 - p_3p_0 > 0$. Suppose, for contradiction, that the principal fully utilizes the AI capacity under the optimal replacement strategy, i.e., a replacement strategy x with $\bar{x} = 1$ is optimal. Then we must have $x_1 + x_3 = 1$, since Proposition 3 shows that $x_2 = 0$. Note that, $x_3 = 1 - x_1$ implies:

$$\zeta_1 = p_0 + \frac{x_3}{1-x_1}(p_1 - p_0) = p_1.$$

By substituting $\zeta_1 = p_1$, we obtain:

$$\zeta_1^2 - p_3 p_0 = p_1^2 - p_3 p_0 > 0.$$

Then, from equation (11), we know that:

$$\frac{1}{c}\frac{\partial W_x}{\partial x_1} = \frac{\zeta_1^2 - p_3 p_0}{(p_3 - \zeta_1)^2} \quad \Longrightarrow \quad \frac{\partial W_x}{\partial x_1} > 0.$$

This implies that decreasing x_1 slightly, which is feasible as $x_1 > 0$, leads to an improvement in terms of the expected compensation cost. This contradicts the optimality of x. Hence, under the optimal replacement strategy x^*, the principal under-utilizes the AI capacity, i.e., $\bar{x}^* < 1$, in this case. □

Proof of Proposition 5.

Recall that:

$$\begin{aligned}
\zeta_1^x &= p_2 \frac{x_2}{1 - x_1} + p_1 \frac{x_3}{1 - x_1} + p_0 \frac{1 - x_1 - x_2 - x_3}{1 - x_1}, \\
\zeta_2^x &= p_2 \frac{x_3}{1 - x_2} + p_1 \frac{1 - x_2 - x_3}{1 - x_2}, \\
\zeta_3^x &= p_2.
\end{aligned}$$

1. From earlier results, we know that $x_3^* \in (0, 1)$, and $x_2^* = 0$. First, $x_2^* = 0$ implies $\zeta_1^{x^*} \leq p_1$. Next, $x_3^* \in (0, 1)$ implies $\zeta_2^{x^*} \in (p_1, p_2)$. In consequence, we have $\zeta_3^{x^*} > \zeta_2^{x^*} > \zeta_1^{x^*}$, which implies that the wages are increasing in the position after the optimal automation: $w_3^{x^*} > w_2^{x^*} > w_1^{x^*}$.

2. As $x_3^* > 0$, we have $\zeta_1^{x^*} > p_0 = \zeta_1^0$. This implies that the wage of the front-end worker increases after the automation: $w_1^{x^*} > w_1^0$.

3. $x_3^* > 0$ also implies that $\zeta_2^{x^*} > p_1 = \zeta_2^0$. Therefore, the wage of the middle worker also increases after the automation: $w_2^{x^*} > w_2^0$.

4. Finally, note that, regardless of the replacement strategy, we have: $\zeta_3^{x^*} = p_2$. Therefore, the wage of the end-most worker remains the same after the automation: $w_3^{x^*} = w_3^0$.

□

Proof of Proposition 6.

From Proposition 5, we know that after AI replacement, the wages of the front-most and middle workers increase, while the wage of the end-most worker remains unchanged. Additionally, the end-most worker faces a risk of replacement, whereas the middle worker does not. Consequently, the middle worker's payoff increases, while the end-most worker's payoff decreases relative to their payoffs prior to AI replacement.

The front-most worker's payoff depends on his replacement probability—while his wage increases, his payoff may rise or fall. □

B.2 Proofs of Section 4.1

Proof of Proposition 7.

Step 1. First, we will derive the closed-form solution for the optimal replacement strategy. Note that this functional form satisfies the necessary and sufficient condition for full utilization given in Proposition 4, ensuring $\bar{x}^* = 1$. Moreover, Proposition 3 establishes that $x_2^* = 0$. Therefore, we have $x_1^* + x_3^* = 1$.

As the optimal replacement strategy must involve randomization (Proposition 2), we must have $x_1^*, x_3^* \in (0,1)$. Consider an arbitrary such strategy given by $x = (x_1, x_2, x_3) = (\rho, 0, 1-\rho)$ for some $\rho \in (0,1)$. Denoting, with a slight abuse of notation, the principal's expected compensation cost under this strategy by W_ρ, we obtain:

$$\frac{W_\rho}{c} = 1 + \frac{p_3}{p_3 - p_1}(1-\rho) + \frac{p_3}{p_3 - (1-\rho)p_2 - \rho p_1} + \rho\frac{p_3}{p_3 - p_2}.$$

Under the optimal replacement strategy, ρ must satisfy:

$$\frac{1}{c}\frac{\partial W_\rho}{\partial \rho} = -\frac{p_3(p_2 - p_1)}{\left(p_3 - (1-\rho)p_2 - \rho p_1\right)^2} - \frac{p_3}{p_3 - p_1} + \frac{p_3}{p_3 - p_2} = 0.$$

Rearranging, this simplifies to:

$$\frac{p_2 - p_1}{\left(p_3 - (1-\rho)p_2 - \rho p_1\right)^2} = \frac{1}{p_3 - p_2} - \frac{1}{p_3 - p_1} = \frac{p_2 - p_1}{(p_3 - p_2)(p_3 - p_1)}.$$

Solving for ρ yields:

$$p_3 - (1-\rho)p_2 - \rho p_1 = \sqrt{(p_3 - p_2)(p_3 - p_1)}.$$

From which we obtain:

$$\rho = \frac{\sqrt{p_3 - p_2}\left(\sqrt{p_3 - p_1} - \sqrt{p_3 - p_2}\right)}{p_2 - p_1} = \frac{\sqrt{1-\alpha}\left(\sqrt{1-\alpha^2} - \sqrt{1-\alpha}\right)}{\alpha - \alpha^2} = \frac{\sqrt{1+\alpha} - 1}{\alpha}.$$

This provides the closed-form solution for the optimal replacement strategy as stated.

Step 2. Next, we will show the comparative statics results. From the previous step, for a given α, the optimal replacement probability of the front-most worker satisfies:

$$x_1^* = \frac{\sqrt{1+\alpha} - 1}{\alpha}.$$

Taking the derivative of x_1^* with respect to α, we obtain:

$$\frac{\partial x_1^*}{\partial \alpha} = \frac{\frac{\alpha}{2\sqrt{1+\alpha}} - \sqrt{1+\alpha} + 1}{\alpha^2}.$$

The numerator of this expression is a decreasing function of α as:

$$\frac{\partial\left(\frac{\alpha}{2\sqrt{1+\alpha}}-\sqrt{1+\alpha}+1\right)}{\partial\alpha}=\frac{\sqrt{1+\alpha}-\frac{\alpha}{2}\frac{1}{\sqrt{1+\alpha}}}{1+\alpha}-\frac{1}{\sqrt{1+\alpha}}=-\frac{\alpha}{2(1+\alpha)^{3/2}}<0.$$

Moreover, the numerator evaluates to zero at $\alpha=0$, which implies that it remains strictly negative for all $\alpha\in(0,1)$. Thus, we obtain:

$$\frac{\partial x_1^*}{\partial\alpha}<0,$$

proving that as the degree of complementarity increases (α becomes smaller), the likelihood of the front-most (end-most) worker being replaced increases (decreases). □

B.3 Proofs of Section 4.2

Proof of Proposition 8.

By applying analogous arguments from the proof of Proposition 1, we can establish that under a given replacement strategy x: (i) the optimal compensation scheme sustains effort by inducing a trigger strategy equilibrium, and (ii) workers remain indifferent between exerting effort and shirking along the equilibrium path. For conciseness, we do not replicate these arguments here. Denote by ζ_i^x the probability of project success when worker i shirks, assuming all other workers follow the trigger strategy profile. Worker i's incentive constraint then becomes:

$$p_n(1-x_i)w_i-(1-x_i)c\geq\zeta_i^x w_i.$$

Under the optimal compensation scheme, this constraint binds, which yields:

$$w_i^x=\frac{c}{p_n-\zeta_i^x}.$$

To understand the expression ζ_i^x in the proposition statement, consider what happens when worker i chooses to shirk. Only a fraction $1-x_i$ of his tasks are unperformed. The overall project success rate then depends on how this shirking decision affects downstream behavior through peer monitoring.

- With probability x_i, the AI completes worker i's tasks, so the worker-AI unit contributes to the project. In this case, the project succeeds with probability p_n.
- With probability $(1-x_i)x_{i+1}$, worker i's shirking is noticed by worker $i+1$, who responds by shirking. However, the AI assigned to worker $i+1$ completes his share of tasks, so the unit at $i+1$ still contributes to the project. The project thus succeeds with probability p_{n-1}.
- With probability $(1-x_i)(1-x_{i+1})x_{i+2}$, shirking cascades further. Worker $i+1$ shirks, and $1-x_{i+1}$ fraction of the tasks performed by AI doesn't fully compensate, and worker $i+2$ observes this and also shirks. Yet, the AI at $i+2$ performs x_{i+2} of the tasks, allowing partial contribution. The project succeeds with probability p_{n-2}.

- This process continues recursively, with each successive worker potentially shirking in response, depending on how much of the previous worker's task is conducted by AI. Eventually, the entire downstream chain might shirk, in which case no further contribution comes from any of them.
- In the worst case, where all successors also shirk and none of their AI compensates, the project succeeds only with probability p_{i-1}, which reflects the effort of workers before position i.

Summing over all these possible outcomes gives us:

$$\zeta_i^x = x_i p_n + \sum_{k=1}^{n-i} \left[p_{n-k}\, x_{i+k} \prod_{j=i}^{i+k-1} (1 - x_j) \right] + p_{i-1} \prod_{j=i}^{n} (1 - x_j)\,.$$

This expression represents the expected project success probability when worker i shirks, accounting for the compensating effects of AI task completion and the induced monitoring response throughout the network. □

Proof of Proposition 9.

For the case where $x_i < 1$ for each worker $i \in \{1, \ldots, n\}$, we can write:

$$p_n - \zeta_i^x = (1 - x_i)\,(p_n - \Psi_i^x)$$

where

$$\Psi_i^x = x_{i+1}\, p_{n-1} + \sum_{k=1}^{n-i-1} \left[x_{i+1+k}\, p_{n-1-k} \prod_{j=i+1}^{i+k} (1 - x_j) \right] + p_{i-1} \prod_{j=i+1}^{n} (1 - x_j)\,.$$

Moreover, we can rewrite the principal's expected cost as:

$$\begin{aligned} \sum_{i=1}^{n} [x_i c + p_n(1 - x_i) w_i] &= \sum_{i=1}^{n} \left[x_i c + p_n(1 - x_i) \frac{c}{p_n - \zeta_i^x} \right] \\ &= \sum_{i=1}^{n} \left[x_i c + p_n \frac{c}{p_n - \Psi_i^x} \right]. \end{aligned}$$

First, note that Ψ_i^x depends on x_ℓ only if $\ell > i$. Moreover, the partial derivative $\frac{\partial \Psi_i^x}{\partial x_\ell}$ is proportional to the difference between $p_{n+i-\ell}$ and a weighted average of $p_{n+i-\ell-1}, \ldots, p_{i-1}$, and is therefore positive. Now consider increasing x_i. The principal's expected compensation cost increases due to the following strictly increasing components:

- the direct term $x_i c$, and
- the indirect terms of the form $p_n \frac{c}{p_n - \Psi_\ell^x}$ for $\ell < i$, each of which increases because Ψ_ℓ^x is strictly increasing in x_i.

Therefore, increasing x_i strictly increases the expected cost. It follows that setting all $x_i = 0$ minimizes the expected cost over all strategies satisfying $x_i < 1$ for each worker $i \in \{1, \ldots, n\}$. This proves that the strategy $(0, \ldots, 0)$ is optimal among such replacement strategies. Lemma 2 completes the proof. □

B.4 Proofs of Section 4.3

Proof of Proposition 10.

First, similar reasoning to that in Proposition 1 establishes, for a given replacement strategy, the optimal compensation scheme, and that this scheme induces a trigger strategy as an equilibrium. Moreover, analogous arguments to those in Lemma 1 ensure the existence of an optimal replacement strategy in this star network structure. To prove the proposition, we first state and prove two auxiliary claims.

Claim 1. *Given a fixed x_n, there exists a constrained optimal replacement strategy in which*

$$x_1 = x_2 = \cdots = x_{n-1}.$$

Proof of Claim 1.

– If $x_n = 1$, the claim trivially holds as we must have $x_1 = \cdots = x_{n-1} = 0$ in this case.

– If $x_n = 0$, then $\zeta_i^x = p_{n-2}$, for each $i \in \{1, \cdots, n-1\}$. The expected compensation cost of the principal under an arbitrary replacement strategy $(x_1, x_2, \cdots, x_{n-1}, 0)$ is:

$$\sum_{i=1}^{n-1} \left[x_i c + (1 - x_i)\, p_n \frac{c}{p_n - p_{n-2}} \right] + p_n \frac{c}{p_n - p_{n-1}}.$$

Consider modifying this replacement strategy into $(\tilde{x}, \cdots, \tilde{x}, 0)$ with:

$$\tilde{x} = \frac{x_1 + \cdots + x_{n-1}}{n-1}.$$

The expected compensation cost of the principal under this replacement strategy is:

$$(n-1) \left[\tilde{x} c + (1 - \tilde{x})\, p_n \frac{c}{p_n - p_{n-2}} \right] + p_n \frac{c}{p_n - p_{n-1}}.$$

Note that, this is equal to the expected compensation cost prior to modification. This implies that there exists a constrained optimal replacement strategy satisfying $x_1 = \cdots = x_{n-1}$.

– If $x_n \in (0, 1)$, we first show that $(1 - x_i)\, p_n \frac{w_i^x}{c}$ is a strictly convex function of x_i. Note that:

$$\begin{aligned}
\frac{\partial \left((1 - x_i)\, p_n \frac{w_i^x}{c} \right)}{\partial x_i} &= p_n \left(-\frac{w_i^x}{c} + \frac{1}{c} (1 - x_i) \frac{\partial w_i^x}{\partial x_i} \right) \\
&= p_n \left(-\frac{1}{p_n - \zeta_i^x} + \frac{1 - x_i}{(p_n - \zeta_i^x)^2} \frac{\partial \zeta_i^x}{\partial x_i} \right) \\
&= p_n \left(-\frac{1}{p_n - \zeta_i^x} + \frac{1}{(p_n - \zeta_i^x)^2} \frac{x_n (p_{n-1} - p_{n-2})}{1 - x_i} \right)
\end{aligned}$$

$$= p_n \left(-\frac{1}{p_n - \zeta_i^x} + \frac{\zeta_i^x - p_{n-2}}{\left(p_n - \zeta_i^x\right)^2} \right)$$
$$= p_n \left(\frac{2\zeta_i^x - p_n - p_{n-2}}{\left(p_n - \zeta_i^x\right)^2} \right).$$

Taking the second order derivative, we obtain:

$$\frac{\partial^2 \left((1 - x_i)\, p_n \frac{w_i^x}{c} \right)}{\partial x_i^2} = p_n \frac{\partial \zeta_i^x}{\partial x_i} \frac{2\left(p_n - \zeta_i^x\right)^2 + 2\left(p_n - \zeta_i^x\right)\left(2\zeta_i^x - p_n - p_{n-2}\right)}{\left(p_n - \zeta_i^x\right)^4}$$
$$= p_n \frac{\partial \zeta_i^x}{\partial x_i} \frac{2\left(p_n - \zeta_i^x\right)\left(\zeta_i^x - p_{n-2}\right)}{\left(p_n - \zeta_i^x\right)^4}.$$

But, $x_n > 0$ implies $\zeta_i^x - p_{n-2} > 0$ and $\frac{\partial \zeta_i^x}{\partial x_i} > 0$. Also, note that $p_n - \zeta_i^x > 0$. Therefore, the second order derivative of $(1 - x_i)\, p_n \frac{w_i^x}{c}$ with respect to x_i is positive, implying that $(1 - x_i)\, p_n \frac{w_i^x}{c}$ is a strictly convex function of x_i.

Now, denoting

$$\Gamma\left(x_i\right) \equiv \frac{\left(1 - x_i\right) p_n c}{p_n - p_{n-2}\left(1 - \frac{x_n}{1 - x_i}\right) - p_{n-1}\frac{x_n}{1 - x_i}},$$

we can write the expected compensation cost of the principal under the replacement strategy $(x_1, \cdots, x_n)$ as:

$$\sum_{k \neq i,j} \left[x_k c + \left(1 - x_k\right) p_n w_k^x \right] + x_i c + x_j c + \Gamma\left(x_i\right) + \Gamma\left(x_j\right).$$

Consider the following optimization problem:

$$\min_{\substack{x_i' \geq 0 \\ x_j' \geq 0}} \quad x_i' c + x_j' c + \Gamma\left(x_i'\right) + \Gamma\left(x_j'\right) \quad \text{s.t. } x_i' + x_j' = x_i + x_j.$$

We can equivalently write this optimization problem as:

$$\min_{x_i'} \quad \Gamma\left(x_i'\right) + \Gamma\left(x_i + x_j - x_i'\right) \quad \text{s.t. } 0 \leq x_i' \leq x_i + x_j.$$

Note that:

$$\frac{\partial^2 \left(\Gamma\left(x_i'\right) + \Gamma\left(x_i + x_j - x_i'\right) \right)}{\partial x_i'^2} = \Gamma''\left(x_i'\right) + \Gamma''\left(x_i + x_j - x_i'\right) > 0.$$

Thus, the first-order condition

$$\frac{\partial \left(\Gamma\left(x_i'\right) + \Gamma\left(x_i + x_j - x_i'\right) \right)}{\partial x_i'} = \Gamma'\left(x_i'\right) - \Gamma'\left(x_i + x_j - x_i'\right) = 0$$

is uniquely satisfied by $x_i' = \frac{x_i + x_j}{2}$, ensuring that the minimum is uniquely achieved. This implies that

for all $i, j \in \{1, \ldots, n-1\}$, we must have $x_i = x_j$ in the optimal replacement strategy. Consequently, it follows that $x_1 = \cdots = x_{n-1}$. □

Claim 2. *The principal chooses to fully utilize AI capacity, setting $\bar{x} = 1$, if the condition $p_{n-1}^2 - p_n p_{n-2} \leq 0$ is satisfied.*

Proof of Claim 2.
Suppose, for contradiction, that the condition $p_{n-1}^2 - p_n p_{n-2} \leq 0$ is satisfied, yet the principal does not fully utilize the AI capacity. From the previous claim, we know that for a given replacement probability x_n of the central worker, the rest of the optimal replacement strategy can, without loss of generality, be restricted to strategies where the replacement probability is identical for all the peripheral workers, i.e., $x_i = x$ for each worker $i \leq n-1$, whereby $x < \frac{1-x_n}{n-1}$.

Take such a replacement strategy $(x, x, \cdots, x, x_n)$ for some $x < \frac{1-x_n}{n-1}$. Ignoring the dependence on the specific values of x and x_n, let w denote the corresponding wage of a peripheral worker and let ζ represent a peripheral worker's belief about the project's success rate when deviating under the trigger strategy profile. These are given by:

$$\zeta = p_{n-2} + \frac{x_n}{1-x}(p_{n-1} - p_{n-2}), \quad w = \frac{c}{p_n - \zeta}.$$

The principal's expected cost for a peripheral node is:

$$xc + (1-x)p_n w.$$

Substituting the expression for w and differentiating with respect to x, we obtain:

$$\begin{aligned}
\frac{\partial\left(xc + (1-x)p_n w\right)}{\partial x} &= c\left(1 - \frac{p_n}{p_n - \zeta} + \frac{(1-x)p_n}{(p_n-\zeta)^2}\frac{\partial \zeta}{\partial x}\right) \\
&= c\left(-\frac{\zeta}{p_n - \zeta} + \frac{p_n}{(p_n-\zeta)^2}\frac{x_n(p_{n-1} - p_{n-2})}{1-x}\right) \\
&= c\left(-\frac{\zeta}{p_n - \zeta} + \frac{p_n(\zeta - p_{n-2})}{(p_n-\zeta)^2}\right) \\
&= c\left(\frac{\zeta^2 - p_n p_{n-2}}{(p_n-\zeta)^2}\right).
\end{aligned}$$

Since $\zeta < p_{n-1}$, the condition $p_{n-1}^2 - p_n p_{n-2} \leq 0$ ensures that the derivative above is negative. Thus, increasing x slightly—which is feasible since the capacity is not fully utilized—leads to a reduction in expected compensation cost. This contradicts optimality, implying that the principal must fully utilize the AI capacity. □

Claims 1 and 2 imply that given x_n, the optimal replacement strategy satisfies:

$$x_i = x = \frac{1 - x_n}{n-1}, \quad \forall i \leq n-1.$$

The principal's expected compensation cost for a given x_n, denoted by W_{x_n} (with a slight abuse of notation), satisfies:

$$\frac{W_{x_n}}{c} = 1 + (n-1)(1-x)p_n\frac{1}{p_n-\zeta} + (1-x_n)p_n\frac{1}{p_n-p_{n-1}}.$$

Differentiating with respect to x_n, we obtain:

$$\begin{aligned}\frac{\partial\frac{W_{x_n}}{c\,p_n}}{\partial x_n} =& -(n-1)\frac{1}{p_n-\zeta}\frac{\partial x}{\partial x_n} + (n-1)(1-x)\frac{1}{(p_n-\zeta)^2}\frac{\partial\zeta}{\partial x_n} - \frac{1}{p_n-p_{n-1}} \\ & -(n-1)\frac{1}{p_n-\zeta}\frac{\partial x}{\partial x_n} + (n-1)(1-x)\frac{1}{(p_n-\zeta)^2}\left[\frac{p_{n-1}-p_{n-2}}{1-x} + \frac{(p_{n-1}-p_{n-2})x_n}{(1-x)^2}\frac{\partial x}{\partial x_n}\right] - \frac{1}{p_n-p_{n-1}}.\end{aligned}$$

After simplifications, and defining $R \equiv p_n - \zeta$, this reduces to:

$$\frac{\partial\frac{W_{x_n}}{c\,p_n}}{\partial x_n} = \frac{1}{R} + \frac{(n-1)(p_{n-1}-p_{n-2})}{R^2} - \frac{(p_{n-1}-p_{n-2})x_n}{(1-x)R^2} - \frac{1}{p_n-p_{n-1}}.$$

Therefore, the sign of $\frac{\partial\frac{W_{x_n}}{c\,p_n}}{\partial x_n}$ matches the sign of:

$$(p_n-p_{n-1})(1-x)R + (n-1)(p_n-p_{n-1})(p_{n-1}-p_{n-2})(1-x) - (p_{n-1}-p_{n-2})(p_n-p_{n-1})x_n - (1-x)R^2,$$

which in turn has the same sign as:

$$-(1-x)R^2 + (p_n-p_{n-1})(1-x)R + (n-2)(p_{n-1}-p_{n-2})(p_n-p_{n-1}).$$

Moreover, note that

$$1-x = \frac{(n-2)(p_{n-1}-p_{n-2})}{R+(n-1)(p_{n-1}-p_{n-2})-(p_n-p_{n-2})}.$$

Thus, the sign of the above expression matches the sign of:

$$\begin{aligned}&-(n-2)(p_{n-1}-p_{n-2})R^2 + 2(n-2)(p_{n-1}-p_{n-2})(p_n-p_{n-1})R \\ &+(n-2)(p_{n-1}-p_{n-2})(p_n-p_{n-1})\left[(n-1)(p_{n-1}-p_{n-2})-(p_n-p_{n-2})\right].\end{aligned}$$

We know that $R \in [p_n-p_{n-1}, p_n-p_{n-2}]$ and that the expression above attains its minimum at $R = p_n - p_{n-2}$. Evaluating at $R = p_n - p_{n-2}$, we get:

$$\begin{aligned}&-(n-2)(p_{n-1}-p_{n-2})(p_n-p_{n-2})^2 + 2(n-2)(p_{n-1}-p_{n-2})(p_n-p_{n-1})(p_n-p_{n-2}) \\ &+(n-2)(p_{n-1}-p_{n-2})(p_n-p_{n-1})\left[(n-1)(p_{n-1}-p_{n-2})-(p_n-p_{n-2})\right].\end{aligned}$$

Dividing this expression by $(n-2)(p_{n-1}-p_{n-2})$, we obtain:

$$(p_{n-1}-p_{n-2})\left[(n-2)(p_n-p_{n-1})-(p_{n-1}-p_{n-2})\right],$$

which is positive.

Therefore, the derivative of the expected cost with respect to x_n is positive. As a result, the optimal strategy requires $x_n = 0$. Furthermore, as shown in the proof of Claim 1, all replacement strategies satisfying $\sum_{i=1}^{n-1} x_i = 1$ are optimal. □

Appendix C Complementary Analysis

This appendix section provides a complementary analysis to the main findings in the document. In what follows, we use *O-ring* production function and, for clarity and conciseness, continue with the setting of three workers.

AI's impact on intra-team hierarchy of payoffs. Proposition 12 presents additional results on how the optimal AI replacement affects the payoff hierarchy, showing that the middle worker receives the highest payoffs considering both wages and the frequency and the use of AI.

Proposition 12. *The optimal AI replacement reshapes the hierarchy of payoffs within the team: the middle worker receives the highest payoff, followed by the end-most worker, and then the front-most worker. Formally:*

$$(1-x_2^*)\left(p_3 w_2^{x^*}-c\right) > (1-x_3^*)\left(p_3 w_3^{x^*}-c\right) > (1-x_1^*)\left(p_3 w_1^{x^*}-c\right).$$

Proof of Proposition 12.
Denoting $\beta \equiv \sqrt{1+\alpha}$, we get:

$$\begin{aligned}
\frac{(1-x_1^*)\left(p_3 w_1^{x^*}-c\right)}{c} &= \frac{\left(\beta^2-1\right)^2}{\beta\left(\beta+1\right)\left(2-\beta^2\right)} \\
\frac{(1-x_2^*)\left(p_3 w_2^{x^*}-c\right)}{c} &= \frac{1}{\beta\left(2-\beta^2\right)} - 1 \\
\frac{(1-x_3^*)\left(p_3 w_3^{x^*}-c\right)}{c} &= \frac{\beta-1}{2-\beta^2}.
\end{aligned}$$

Therefore:

$$\frac{(1-x_2^*)\left(p_3 w_2^{x^*}-c\right)}{c} - \frac{(1-x_3^*)\left(p_3 w_3^{x^*}-c\right)}{c} = \frac{1}{\beta\left(2-\beta^2\right)} - 1 - \frac{\beta-1}{2-\beta^2} = \frac{\left(\beta+1\right)\left(\beta-1\right)^2}{\beta\left(2-\beta^2\right)} > 0,$$

and

$$\frac{(1-x_3^*)\left(p_3 w_3^{x^*}-c\right)}{c} - \frac{(1-x_1^*)\left(p_3 w_1^{x^*}-c\right)}{c} = \frac{\beta-1}{2-\beta^2} - \frac{\left(\beta^2-1\right)^2}{\beta\left(\beta+1\right)\left(2-\beta^2\right)} = \frac{\left(\beta^2-1\right)\left(-\beta^2+\beta+1\right)}{\beta\left(\beta+1\right)\left(2-\beta^2\right)},$$

which is positive as $\beta \in \left(1, \sqrt{2}\right)$. This concludes the proof. □

AI's impact on payoffs. Proposition 13 demonstrates that the front-most worker may experience a loss or gain in payoff, and provides the conditions for each outcome under the O-ring production function. Recall that, in the main text, we have already demonstrated that the optimal AI adoption always resulted in higher (lower) payoffs for the middle (end-most) worker. This proposition therefore completes the earlier payoff analysis.

Proposition 13. *The front-most worker's payoff declines following AI replacement,*

$$(1-x_1^*)\left(p_3 w_1^{x^*}-c\right) < p_3 w_1^0 - c,$$

if and only if effort complementarity is weak enough—that is, $\alpha \geq \bar{\alpha}$ for some threshold $\bar{\alpha} \in (0,1)$.

Proof of Proposition 13.
Note that:

$$\begin{aligned}\frac{p_3 w_1^0 - c}{c} - \frac{(1-x_1^*)\left(p_3 w_1^{x^*}-c\right)}{c} &= \frac{\left(\beta^2-1\right)^3}{(2-\beta^2)\left[\left(\beta^2-1\right)^2+\beta^2\right]} - \frac{\left(\beta^2-1\right)^2}{\beta(\beta+1)(2-\beta^2)} \\ &= \frac{\left(\beta^2-1\right)^2}{\beta(\beta+1)(2-\beta^2)\left[\left(\beta^2-1\right)^2+\beta^2\right]}\left(\beta(\beta+1)\left(\beta^2-1\right) - \left[\left(\beta^2-1\right)^2+\beta^2\right]\right).\end{aligned}$$

The second line is a positive value multiplied with $\beta^3-\beta-1$, which is positive if and only if β is larger than $\sqrt[3]{\frac{1}{2}+\sqrt{\frac{23}{108}}}+\sqrt[3]{\frac{1}{2}-\sqrt{\frac{23}{108}}} \approx 1.318$ (by Cardano's formula). □

As is indicated in Proposition 6, the optimal AI deployment on the one hand increases the wage of the front-most worker. On the other hand, he faces replacement. Proposition 13 implies that the latter effect dominates when α is large (tasks are highly independent of each other).

AI's impact on intra-team inequality of payoffs. Proposition 14 explores how AI alters intra-team payoff inequality and shows that, similarly to wage inequality, the inequality of payoffs also declines with optimal AI adoption.

Proposition 14. *The intra-team payoff inequality decreases with optimal AI adoption, relative to the intra-team inequality without AI adoption. That is:*

$$\left[(1-x_2^*)\left(p_3 w_2^{x^*}-c\right) - (1-x_1^*)\left(p_3 w_1^{x^*}-c\right)\right] < \left[\left(p_3 w_3^0 - c\right) - \left(p_3 w_1^0 - c\right)\right].$$

Proof of Proposition 14.

Note that:

$$\begin{aligned}
&\frac{1}{c}\left[\left(1-x_2\right)\left(p_3 w_2^x-c\right)-\left(1-x_1\right)\left(p_3 w_1^x-c\right)\right]-\frac{1}{c}\left[\left(p_3 w_3^0-c\right)-\left(p_3 w_1^0-c\right)\right] \\
&\quad=\left[\frac{1}{\beta\left(2-\beta^2\right)}-1-\frac{\left(\beta^2-1\right)^2}{\beta\left(\beta+1\right)\left(2-\beta^2\right)}\right]-\left[\frac{1}{2-\beta^2}-\frac{1}{\left(2-\beta^2\right)\left[\left(\beta^2-1\right)^2+\beta^2\right]}\right] \\
&\quad=\frac{\beta-1}{2-\beta^2}-\frac{\beta^2\left(\beta^2-1\right)}{\left(2-\beta^2\right)\left[\left(\beta^2-1\right)^2+\beta^2\right]} \\
&\quad=\frac{\beta-1}{\left(2-\beta^2\right)\left[\left(\beta^2-1\right)^2+\beta^2\right]}\left\{\left(\beta-1\right)\left[\left(\beta-1\right)\left(\beta^2+\beta-1\right)-3\right]-1\right\}
\end{aligned}$$

which is negative as $\beta \in \left(1, \sqrt{2}\right)$. This completes the proof. □