

# Financial Incentives in Multi-layered Organizations: An Experiment in the Public Sector\*

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## Abstract

A classic problem faced by organizations is to decide how to distribute incentives among their different layers. By means of a field experiment with a large public-health organization in Sierra Leone, we show that financial incentives maximize output when they are equally shared between frontline workers and their supervisor. The impact of this intervention on completed health visits is 61% larger than the impact of incentive schemes that target exclusively the worker or the supervisor. Also, the shared incentives uniquely improve overall health-service provision and health outcomes. We use these experimental results to structurally estimate a model of service provision and find that shared incentives are effective because worker and supervisor effort are strong strategic complements, and because side payments across layers are limited. Finally, through the use of counterfactual model experiments, we highlight the importance of effort complementarities across the different layers of an organization for optimal policy design.

**JEL Codes:** O15, O55, I15, J31, M52. **Keywords:** Financial incentives, multi-layered organizations, effort complementarities, side payments

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# 1 Introduction

Complementarity between the effort of workers in the workplace is one of the key reasons for the existence of organizations (Alchian and Demsetz 1972). These complementarities are particularly salient in vertical organizations, where workers and managers jointly contribute to production. Without good management, workers are often ineffective, and similarly, the efforts of managers can only pay off if workers are motivated to do their job. How to design incentives to best leverage these effort complementarities fundamentally depends on whether workers and managers can influence each other through side transfers. If transfers are easy and costless, agents will optimally redistribute financial rewards among themselves and the organization should only worry about the total level of incentives provided. In contrast, if transfers are constrained, the allocation of incentives across the different layers of an organization becomes crucial. Surprisingly, empirical evidence on how should incentives be divided among the different layers of a vertical organization is scarce.

In this paper, we show that the allocation of financial incentives within a large public-health organization has substantial impacts on the provision of health care services in poor communities across Sierra Leone. In particular, we document experimentally that equally sharing a piece-rate incentive between a worker and a supervisor generates an increase in health visits – the main output of the organization – that is 61% larger than the gain in visits achieved when offering the entire piece rate either to the worker or to the supervisor. Through a structural model and novel empirical evidence, we then shed light on the key factors that underpin these results — (i) the strong complementarity in worker and supervisor effort and (ii) the limited redistribution of the incentive — and explore their quantitative implications for optimal policy design.

The program we study is a large community-based health initiative designed to improve health-service provision in Sierra Leone, with a focus on pre- and post-natal care. Community-health services play a crucial role in reducing the burden of common diseases and child mortality (Nyqvist et al. 2019; Deserranno, Nansamba, and Qian 2020). Yet, access to primary health care is still a major issue in rural areas of developing countries and the expansion of community health worker programs is an important part of the global strategy to ensure universal health-care access (Campbell et al. 2013). Finding ways of optimizing the performance of community health workers is hence a first-order policy priority.

We introduce a new piece-rate scheme that pays 2,000 Sierra Leone Leones (SSL) per completed health visit, and creates random variation in its recipient in a sample of 372 health units across the country. Each unit is composed of an average of 8 health workers, who directly carry out health visits, and one supervisor, who provides training, support and advice. The incentive is either paid (i) only to the health worker who carried out the visit, (ii) only to the supervisor of this worker, or (iii) is shared equally between the worker and the

supervisor. In all these treatments, the organization relies on workers’ reports to determine the amount of incentive to be paid. Importantly, we also collect an independent measure of completed health visits by interviewing a random sample of households in each village. This independent measure is the main outcome variable in the study.

To guide our empirical analysis, we propose a simple model of service provision that illustrates the trade offs involved in the choice of how to allocate the incentive. In the model, a supervisor and a worker interact over two time periods. In the first period, the supervisor chooses how much effort to invest in training and advising the worker, and offers her a side payment conditional on the amount of services delivered at the end of the game. In the second period, the worker chooses how much effort to exert to provide services. A key intuition is that the optimal share of the incentive to be offered to each agent depends on: (i) the strategic complementarity of worker and supervisor effort, and (ii) the extent to which side payments offset the initial allocation of the incentive. In our setting, strategic complementarities are likely to be strong as supervisors play a key “enabling” role: they raise the health workers’ ability to conduct household visits by training and advising them, providing the necessary skills to perform their tasks, and by helping them build trust in the community. In contrast, supervisors’ role as “monitors” is much more limited. Further, workers and supervisors’ ability to offer side payments to each other is constrained by different contractual frictions.<sup>1</sup> Our model highlights how, in a setting with these features, sharing the piece rate is an optimal policy.

In the first part of the paper, we present the causal effects of our treatments on the number of visits carried out by the health workers, as reported by the households. Our central empirical finding is that the shared incentives treatment maximizes the number of completed health visits. Workers in the control group without performance-based incentives (status quo) carried out 5.3 visits per household in the six months prior to our endline survey. This number significantly increases to 7.1 visits (a 40% increase over the control condition) when the incentive is only offered either to the worker or to the supervisor, and to 8.7 visits (a 63% increase over the control condition) when the incentive is shared between the worker and supervisor. Overall, the shared incentives generate an increase in health visits that is 61% larger than the increase caused by either of the one-sided incentives treatments. We rule out concerns related to quantity-quality trade-offs. The observed increase in the quantity of household visits provided in the shared incentives treatment is not compensated by a reduction in visit length, nor by changes in the targeting of poor and deserving households.

The large positive impact of the shared incentives treatment on household visits translates

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<sup>1</sup>Contractual frictions can derive from the limited observability and predictability of worker effort (Duflo, Hanna, and Ryan 2012), the difficulty of making binding commitments (Casaburi and Macchiavello 2019), social norms on the appropriateness of side payments or institutional rules that limit managerial autonomy (Banerjee et al. 2020; Bandiera et al. 2021), or flypaper effects whereby payments are expected to stay in the layer of the organization to which they are originally allocated (Hines and Thaler 1995).

into better access to pre- and post-natal care and lower disease incidence. Pregnant or expecting women are more likely to report having received at least four pre-natal visits from any provider and having delivered in a health facility (rather than at home) in the shared incentives treatment than in the one-sided incentives treatments or the control. Households also report fewer instances of fever among children below the age of five.

Importantly, shared incentives outperform both one-sided incentives also in terms of cost-effectiveness. The incentive is only paid when a visit is *reported* by the health worker. Thanks to a system of extensive back-checks, we find that over-reporting is minimal. Instead, health visits are generally under-reported, plausibly due to the reporting costs which we discuss in Section 2. Crucially, under-reporting decreases with the share of the incentive offered to the worker. This makes shared incentives particularly cost effective: we find that each 2,000 SLL spent on the program generate 16.1 visits in the shared incentive treatment, 9.6 visits in the supervisor incentive treatment, and 6.5 visits in the worker incentive treatment.

In the second part of the paper, we study the mechanisms explaining the large boost in output generated by shared incentives. In line with our model, we show that both effort complementarity and limited side payments play an important role. Three key results point to the presence of large effort complementarities. First, shared incentives generate the same increase in supervisor effort as supervisor incentives. This could seem surprising, since the *direct* incentive offered to the supervisor is lower in the shared incentives treatment. However, as predicted by our model, shared incentives compensate for this by providing a strong boost to worker effort, which raises the return to supervisor effort and hence *indirectly* incentivizes the supervisor to raise effort. Second, shared incentives generate a larger increase in visits and supervisor effort when effort complementarity is plausibly higher due to the low level of experience of the worker. Third, we carry out a formal mediation analysis which shows that the boost in visits due to worker effort increases with the level of supervisor effort.

Next, we turn to the role of side payments. We leverage unique data on inter-personal transfers to show that, on average, net transfers from the supervisor to the worker are positive, but very small: less than 10 percent of the overall incentive payment of the average supervisor. Why are transfers limited? One possibility is that the poor observability of worker effort makes contracting hard. In line with this, we show that supervisors who plausibly cannot observe worker output accurately make lower transfers. Additionally, as we argue below, in many cases the worker may have a higher stake in the production of output than the supervisor. Transfers from workers to supervisors, however, are almost never observed in the data, suggesting that frictions may also prevent bottom-up transfers.

We present several pieces of evidence which are inconsistent with two alternative explanations of our results. First, one-sided incentives treatments could be ineffective due to a negative morale effect arising from pay inequality (Breza, Kaur, and Shamdasani 2018). Our experimental design minimizes this concern, as workers are not informed of the presence of

supervisor incentives (if any) and only few seem learn about it from the supervisors. Moreover, we find no evidence suggesting that workers in the supervisor incentives treatment are less satisfied with their payment or their job compared to the control group. Second, we consider the possibility of sharp discontinuities in the utility function. Shared incentives could be highly effective in the absence of effort complementarities if, for both agents, the marginal utility generated by the incentive declines rapidly after 1,000 SLL (the size of the incentives paid in the shared incentives scheme) or the marginal cost of effort increases steeply after the level of effort generated by a 1,000 SLL incentive. However, when we analyze non-parametrically the relationship between treatment effects and proxies of utility (wealth) and costs (distance between the worker and her patients, or between the supervisor and the worker), we do not observe any sharp discontinuities.

In the final part of the paper, we leverage the experimental variation to structurally estimate our model of service provision and perform different counterfactual simulations. For the estimation, we use moments capturing household visits and supervisor effort in the three treatment conditions and in the control group. The model is able to match these moments with great precision. Further, the model correctly predicts that side-payments are close to zero — a key non-targeted moment that is central to our empirical setting. The estimated model parameters confirm that our results are driven by a strong complementarity of effort. In particular, we estimate that the marginal return to worker effort is up to 36% higher due to the complementarity with supervisor effort. Second, we find that, in the absence of the intervention, supervisors have weaker incentives to provide effort than workers. This means that it would be optimal for side-transfers to flow from workers to supervisors, but contractual frictions likely prevent this from happening.

We derive three lessons on optimal policy based on the structural model. First, given the estimated parameters, we calculate that the optimal policy would offer 54% of the value of the incentive to the worker, and 46% to the supervisor. Second, we study how the optimal policy changes for different levels of effort complementarity. We find that the optimal allocation of the incentive is quite sensitive to the exact value of this parameter, which emphasizes the importance of re-calibrating the policy in new contexts. Third, the strong complementarity determines a large positive external effect of individual effort, which the agents fail to internalize. This makes interventions that tie incentives to joint output more effective than interventions that incentivize effort directly, even in settings where effort is perfectly observable. This result has broad implications for optimal pay structure in organizations where workers at different layers complement each other in the production of output.

This paper contributes to four strands of the literature. First, we show that the allocation of incentives in an organization with multiple tiers is highly consequential due to a combination of strong effort complementarities and a limited redistribution of incentives. The existing empirical literature has largely been unable to shed light on this important

point since most studies to date have explored the effects of raising incentives in one layer of the organization, while holding incentives in the other layer fixed. These include papers focusing on the bottom layer — e.g., frontline workers (Glewwe, Ilias, and Kremer 2010; Muralidharan and Sundararaman 2011; Duflo, Hanna, and Ryan 2012; Ashraf, Bandiera, and Jack 2014), sales associates (e.g., Lazear, 2000) — and papers focusing on the top layer — e.g., high-level public sector officials (Rasul and Rogger 2018; Luo et al. 2019), private sector CEOs/managers (Bandiera, Barankay, and Rasul 2007; Bertrand 2009; Frydman and Jenter 2010) — with Behrman et al. (2015) as an exception.<sup>2</sup> Our results have two implications for organizations working in contexts similar to ours. First, agents engage in very limited fine-tuning of the allocation of incentives through transfers. Thus, there are large returns from picking the optimal allocation from the start. Second, when the interests of principals and agents are not aligned, the ability of one layer of the organization to distort behavior in other layers through transfers is likely to be limited.

Second, we provide key evidence on the *productive* role of middle managers in hierarchical organizations. A long-standing literature — which spans seminal theoretical contributions (e.g., Tirole 1986, 1992) and a number of recent empirical papers (Dodge et al. 2018; Cilliers et al. 2018; Bandiera et al. 2021; Dal Bó et al. 2021) — focuses instead on the *monitoring* role of managers. This literature studies how to optimally delegate authority and how to avoid harmful collusion between workers and supervisors, but it typically ignores the enabling (and thus productive) role of supervisors, and therefore remains silent on how effort complementarities can be best leveraged. In our experiment, we explicitly minimize the scope for collusion through frequent back-checks of worker reports. This enables us to shed light on how the top layer of the hierarchy enables the frontline layer to be productive, and on the implications of this complementarity for the design of incentives.

Third, we advance the literature on effort complementarities in organizations. Seminal theoretical work by Alchian and Demsetz (1972); Itoh (1991); Ray, Baland, and Dagnelie (2007) has suggested that effort complementarities are a key rationale for the existence of organizations, and has reflected on the implications of complementarities for incentive design. Empirically, a number of papers have demonstrated that group incentives that reward joint output are effective in increasing output in “horizontal” teams — composed of workers from the *same* layer of the organization — even if at the potential cost of increasing free-riding (Muralidharan and Sundararaman 2011; Babcock et al. 2015; Friebe et al. 2017). A key distinction between these papers and ours is that we focus on “vertical” teams composed

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<sup>2</sup>Behrman et al. (2015) evaluate the effectiveness of three alternative performance incentive schemes on mathematics tests scores in Mexican schools: (1) individual incentives for students only, (2) individual incentives for teachers only, and (3) individual and group incentives for students, teachers, and administrators. Program impact estimates reveal the largest average effects for (3). The paper cannot assess whether this is because of complementarities across layers or because of the different incentives structure (e.g., individual vs. group).

of workers in *different* layers of the organization. This is an important distinction because the high-level workers in a “vertical” team (in our case, the supervisors) typically do not produce output (health visits) directly. Yet, they have a crucial role in enabling bottom-tier workers (health workers) to produce output, thus resulting in large effort complementarities across layers. Moreover, contractual frictions may be particularly strong between higher- and lower-tier workers, who are more distant within the hierarchy. Finally, the question of how to allocate incentives is particularly relevant in vertical teams, where roles and responsibilities differ across layers. In horizontal teams, where workers have the exact same job, asymmetry in the incentives contract across workers is hardly defensible due to ethical and fairness concerns (Breza, Kaur, and Shamdasani 2018).

Fourth, we highlight the importance of contractual frictions within *within an organization* (Adhvaryu et al. 2020). Most of the literature has instead focused on contractual frictions *across organizations or firms* (Coase 1937; Gibbons 2005; Lafontaine and Slade 2007; Lee, Whinston, and Yurukoglu 2021). Our results highlight that frictions such as the limited observability of subordinates’ effort limit the scope for Coasian bargaining within the firm, and make the allocation of incentives central to organizational performance.

The paper is structured as follows. Section 2 discusses the context and research design. Section 3 presents a simple model of service delivery with effort complementarity across layers and contractual frictions. Section 4 studies the effect of our incentives treatments on output and reporting, and their cost-effectiveness. Section 5 explores the mechanisms underlying our main output results. Section 6 presents the structure model and performs a number of relevant counterfactual policies. Section 7 concludes. The Appendix presents further results and discusses key aspects of research ethics.

## 2 Context and Research Design

### 2.1 The Community Health Program

Sierra Leone is one of the poorest countries in the world, with the third-highest maternal mortality rate and the fourth-highest child mortality rate in 2017 (World Health Organization 2017). Such elevated mortality rates have been attributed to the slow post-civil war recovery, the 2014 Ebola outbreak, and a critical shortage of health workers, together with limited access to health facilities throughout the country (World Health Organization 2016). In order to strengthen the provision of primary health care, Sierra Leone’s Ministry of Health and Sanitation (MoHS) created a national Community Health Program in 2017. The program is organized around Peripheral Health Units (PHUs), small health facilities staffed with doctors (when available), nurses, and midwives. Each PHU has typically a catchment area of seven to ten villages with one community health worker per village and one supervisor per PHU,

for a total of approximately 15,000 health workers and 1,500 supervisors nationwide.

Health workers are hired locally and typically have no experience in the health sector prior to joining the program. They work part-time and are paid a fixed monthly allowance of 150,000 SLL (\$17.5) by the MoHS. Supervisors are often former health workers. They also work part-time and are paid a fixed monthly allowance of 250,000 SLL (\$29.2) by the MoHS. In what follows, we describe in detail the roles played by workers and supervisors. In Appendix B.1, we provide additional information about hours worked and earnings from secondary activities.

**Health workers (bottom layer)** – The role of the health workers is to provide a package of basic healthcare services in their community. They do so by making home visits to expecting mothers or mothers who recently gave birth, during which they provide: (i) health education (e.g., about the benefits of a hospital delivery); (ii) timely pre- and post-natal check-ups, and (iii) accompany women for birth to the health facility. They also conduct visits to households with young children in which they: (i) educate them on how to prevent and recognize symptoms of malaria, diarrhea, and pneumonia, (ii) treat non-severe cases of malaria and diarrhea, (iii) screen for danger signs and refer for further treatment at an health facility when necessary. Workers are expected to follow a checklist when they provide each of these services. We describe the checklists in Appendix B.1.

**Supervisors (top layer)** – The role of the supervisors is to train and advise health workers located in their PHU (typically, seven to ten health workers per supervisor). They do so in three ways. First, they organize monthly one-day “general trainings” at the local health facility which cover key health topics, such as diagnosing, treating and recognizing danger signs for referral to health facilities. Second, supervisors organize “one-to-one trainings” with health workers on a monthly basis in their respective villages. Third, supervisors provide “in-the-field supervision” by accompanying health workers on household visits (continuous on-site training). Supervisors are not tasked to provide services themselves to the households, but rather to provide health workers with concrete feedback on how to improve service delivery. Supervisor’s presence during these household visits also helps build trust towards the health worker in the community and reinforces the demand for her services. This is particularly important, since community members may initially have doubts about the expertise of the health worker — who is typically known by the community as a farmer or shopkeeper — and the supervisor can play a key role in legitimizing their position in the eyes of the community. Thus, overall, a substantial share of the support offered to the worker is personalized, which limits the potential for economies of scale in supervisor effort. Finally, note that supervisors do not take any personnel decisions (hiring, firing, promotions, etc.). These are taken by the head of the PHU. We provide details on the supervisors’ tasks in Appendix B.1.



**Complementarities across layers** – In the setting we study, supervisors are mostly engaged in supporting front-line workers. This is a common arrangement in many organizations, and sets our paper apart from a recent literature that focuses on the monitoring role played by middle managers (Dodge et al. 2018; Callen et al. 2020; Muralidharan et al. 2021; Bandiera et al. 2021; Dal Bó et al. 2021). In our context, supervisors generate demand for the workers’ services by training the workers and by building trust towards them in the community. This can create a strategic complementarity between worker and supervisor effort. When a supervisor increases her effort, the worker is able to generate more visits for the same amount of time spent in the community. Similarly, the efforts of the supervisors have a larger return when the worker is motivated and makes the most of the stronger demand for their services created by the supervisor.

## 2.2 Intervention and Research Design

We study the introduction of new incentive scheme that pays a piece-rate of 2,000 SLL (\$0.23) for each reported household visit. We have four experimental conditions. In the *worker incentives treatment* ( $T_{worker}$ ), the incentive of 2,000 SLL is paid entirely to the health worker who provides the visit.<sup>3</sup> In the *supervisor incentives treatment* ( $T_{supv}$ ), the incentive of 2,000 SLL is paid entirely to the supervisor of the health worker who provides the visit. In the *shared incentives treatment* ( $T_{shared}$ ), the incentive is equally shared between the health worker and the supervisor (1,000 SLL each). In the *control* group (status quo), the incentive is paid neither to the health worker nor to the supervisor.<sup>4</sup>

Our experiment takes place in 372 PHUs throughout Sierra Leone, with the intervention running from May 2018 to August 2019. Appendix B.2 provides details on the location of the 372 PHUs, and Appendix C.1 discusses research ethics (IRB approval and AEA pre-registration).

The 372 PHUs were randomly assigned to one of the four experimental groups, in equal proportions. Three features of the randomization are of note. First, the randomization was performed at the PHU level. This limits spillovers across treatments as staff interactions are minimal across PHUs. Second, the randomization was stratified by district, average distance between the residence of the supervisor and the health workers in the PHU, and by the number of health workers in the PHU. These variables are important predictors of our main outcome variables and will be controlled for in all our specifications. Third, a random sub-sample of the health workers in our study experienced a change in the promotion process

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<sup>3</sup>The size of the piece rate is substantial: a health worker who provides (and reports) one visit every other day can earn up to 14% of her monthly fixed allowance.

<sup>4</sup>We chose the three most natural splits in our context (100%-0%, 50%-50% or 0%-100%): see Appendix B.2 for more details. In Section 6, we will study the optimal split among the all the possible ones with a structural model.

six months after the start of the new incentive scheme, which is the focus of [Deserranno, Kastrau, and León-Ciliotta \(2021\)](#). The results of this paper are shown to be orthogonal to this variation.<sup>5</sup>

**Description of the intervention** – There are three features of the incentive scheme that should be highlighted. First, the incentives were disbursed by a reputable external organization independent from the government. Subjects were paid on a monthly basis through mobile money and without any delay. This enabled us to establish the credibility of the new incentive scheme in the eyes of all experimental participants.

Second, incentives were paid based on worker self-reports. This is a common arrangement for incentives schemes with decentralized delivery agents, as directly monitoring output is typically expensive and impractical (e.g., [Soeters and Griffiths 2003](#); [Shapira et al. 2017](#)). To report a visit, the worker has to send an SMS from their main phone number to a toll free number, including the date of the service and the contact number of the patient. To trigger a payment, the SMS needs to be complete and needs to be sent from the worker’s registered phone number.<sup>6</sup> All health workers of our study (including those in the control group) were asked to report their visits, but only those in the treatments were incentivized based on the SMSs. We present more information about the reporting system in [Appendix B.2](#).

Our set-up discourages over-reporting through extensive back-checks and strong penalties. A random 25% of reports are verified by contacting the household mentioned in the report, and a worker caught reporting a visit that did not take place would not be eligible for any further incentive payment and would be reported to the MoHS. Back-checks and penalties were discussed extensively during the training on the reporting system that workers received prior to the start of the intervention.<sup>7</sup> We will later show that the threat was credible and nearly eliminates over-reporting.

Our design, however, does not prevent under-reporting. Even though the SMS reporting tool is free to use, reporting is inherently costly, as it is usually the case. First, reporting takes time and requires gathering information on the patients’ name and phone number, which patients may not always be willing to share. Second, mobile phone coverage is unreliable and unpredictable in rural areas of Sierra Leone, thus limiting health workers’ ability to send the SMS on the spot. This can lead to under-reporting if the worker subsequently forgets to send the SMS and/or forgets to record the information needed for the SMS to be valid. We will

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<sup>5</sup>In [Appendix B.2.4](#), we describe the change in the promotion system in details and show that: (a) the results hold if we restrict the analysis to the sample of health workers who did not experience any change in the promotion system, (b) the treatment effects are orthogonal to whether the health worker experienced a change in the promotion system or not.

<sup>6</sup>This implies that supervisors or households are unable to report services for the workers.

<sup>7</sup>To keep things as comparable as possible across experimental groups, all workers received the same training and the same number of back-checks, including workers in the control and supervisor incentive groups.

later show that under-reporting is indeed frequent in our setting. This is not uncommon in organizations (e.g., [Agolia, Hatfield, and Lambert 2015](#); [Mendoza 2020](#)). [Karing \(2021\)](#), for example, shows that local health facilities in Sierra Leone under-report vaccination entries, despite the presence of financial incentives, likely due to hassle costs.

Third, the incentive scheme rewards (reported) output, rather than (reported) effort. Given that effort reports are often harder to verify than output reports, this is a common feature in the incentive schemes used by private, public and non-profit organizations. In the financial sector, for example, a large fraction of the pay of financial analysts is variable and proportional to the amount of money they raise, while the head of the unit is typically paid a bonus proportional to the amount of money raised in the entire unit. In the retail sector, the commissions earned by both managers and frontline salesmen are a function of total revenues. In most micro-finance or agriculture extension programs, frontline workers are rewarded for the number of clients who take up the financial/agriculture product in their village, while their supervisors are rewarded for the total number of clients in the district. We later show that targeting output has the additional advantage of incentivizing both the worker and the supervisor to internalize some of the positive spillovers of their effort on the productivity of other subject.

**Transparency of the incentive scheme** – To mirror most workplace environments where supervisors have information about the pay structure of the subordinates but subordinates are not informed about their superior’s compensation ([Cullen and Perez-Truglia 2019, 2021](#); [Deserranno, Kastrau, and León-Ciliotta 2021](#)), we informed all supervisors in the study about the worker incentives but did not inform the workers about the supervisor incentives. As we discuss in [Section 5.3](#), this limits the presence of negative morale concerns resulting from pay inequality. Workers could only learn about the presence of supervisor incentives from the supervisors themselves, and few supervisors seem to have shared this information with their workers.

A second important point is that supervisors were not given information about the number of visits reported by each worker, nor about worker earnings from the incentive scheme. Since worker reporting is not constant across experimental groups, disclosing this information would have introduced differential observability of worker effort across treatments, and hence would have confounded the interpretation of our results. Additionally, the fact that supervisors are not aware of worker earnings further minimizes the possibility that the supervisor and the worker collude to report visits that have not actually been carried out.

**Side payments** – Importantly, we made clear to all supervisors that they could share all or part of their incentive with workers at their discretion. These transfers could potentially be used to incentivize worker effort. However, whether supervisors will choose to provide such

payments is an open question. While recent studies have highlighted the use and sharing of bribes in organizations to access jobs or rents (Weaver 2021; Lameke et al. 2020), there is still very little evidence on whether individuals are able to use transfers to incentivize each other to exert more effort. A number of features, which are common across organizations, may make such informal incentives hard to implement. First, supervisors have a limited ability to precisely observe the worker’s level of effort and reporting behavior, since production is decentralized (also, as explained above, we did not inform supervisors of the number of reports filed by each worker). This makes it hard for the supervisor to assess whether workers exert the level of effort that was requested from them in exchange for a side payment. Second, making binding commitments may be difficult because side contracting is inherently informal and the worker would have limited means to punish the supervisor for defaulting on a side payment (e.g., the worker’s threat to reduce future effort would not be credible, since the organization may punish the worker for such low effort). Given this difficulty, the supervisor may need to compensate the worker for the perceived risk of default (Bubb, Kaur, and Mullainathan 2018). Finally, there may be social norms or psychological factors that limits redistributions within the boundaries of the same organization (Hines and Thaler 1995). The second and third factor are also likely to inhibit transfers from workers to supervisors.

## 2.3 Data and Balance Checks

### 2.3.1 Data Sources

Our study leverages three main sources of data:

*Staff surveys.* All 372 supervisors and 2,970 health workers in the 372 PHUs were surveyed at baseline (in April-May 2018) and at endline (fifteen to sixteen months after the implementation of the treatments, in June-September 2019). They were surveyed on their demographic background, their health knowledge, and their job (number of years of experience, number of hours dedicated to the job). We also have access to village-level information (e.g., distance to the health facility, mobile network coverage) collected from a leaflet that is given to each health worker by the PHU.

*Household surveys.* A random sample of three eligible households ( $\sim 7\%$ ) per village were surveyed at endline (in June-September 2019). The respondent of the survey is the female household head, who is the most knowledgeable about health topics. Each respondent was asked questions on the number of visits received by the health worker and the quality of these visits, trust in the health worker, disease incidence among young children, access to pre- and post-natal care. We will later use these data as our main measures of health worker performance.<sup>8</sup>

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<sup>8</sup>To avoid collusion between the worker and the household on misreporting visits, health workers were not informed about how many households we would interview, which ones and when. In line with the absence

*Administrative data.* Throughout the duration of our experiment, we have access to two sources of administrative data. First, we observe the number of SMS reports sent by each health worker, along with the incentive payments. Second, the MoHS provided us with information on the number of health services/patients treated by each local health facility at the monthly level (e.g., number of institutional births at the facility, number of children fully immunized at the facility, number of fever/malaria/diarrhea cases treated at the facility). Each PHU is composed of one health facility.

### 2.3.2 Summary Statistics and Balance Checks

Table 1 reports summary statistics and balance checks for the characteristics of the supervisors (Panel A), health workers (Panel B), households (Panel C), and villages (Panel D).<sup>9</sup> Panel E reports statistics on the number of health services provided by the local health facility (one per PHU) in the month before the start of the experiment.

Panel B shows that 71% of the health workers are male, 70% have completed primary education and 8% have completed secondary school. On average, health workers are 37 years old, are responsible for 55 households each, and live 3.4 km away from the supervisor. Panel A shows that supervisors are more likely to be men than the health workers (92%) and are more likely to have completed secondary school (25%). They are responsible for an average of 8 health workers each. Panel C shows that household respondents are less educated than health workers and supervisors, with only 25% having completed primary school. Household members are also less wealthy, as measured by a wealth score from 0 to 8 that counts the number of items owned on a list of household items (e.g., clothes, pair of shoes, cooking pots). On average, a household owns one out of the 8 items while workers and supervisors own 2.5 and 3 items respectively. Households live on average 1.4 km away from the health worker.

Panel D shows that 77% of the villages have an accessible road to the health facility. Phone network is available in 84% of the villages but is reliable only in 41% of the villages. As we will document later, the lack of reliable phone availability will substantially increase the cost of SMS reporting. Finally, Panel E shows health facilities record 47 pregnant women visits per month, 13 institutional births, 11 infants immunized, 66 cases of malaria and diarrhea among children under five.

To perform the balance checks, we regress each baseline characteristic on a dummy variable for each of the 3 treatments, controlling for stratification variables and clustering standard errors at the PHU level in worker/village level regressions. Column (11) reports the

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of collusion, we show in Section 4.1 that households who are close friends or family members of the health worker are equally likely to report visits than households who are socially distant.

<sup>9</sup>Given the absence of a baseline household survey, we asked households in our endline survey a set of retrospective questions that are unlikely to vary over time (i.e., age, education, location) and report those in Panel C.

p-value from a joint F-test of the equality of all treatment groups. The baseline characteristics are balanced across treatments except for the age of the health worker (p-value of 0.062). In Table A.1, we report the p-value for each pairwise treatment comparison. Out of 156 pairwise comparisons, 16 are statistically significant with a p-value below 0.1.

### 3 Model

We propose a simple model of service provision that features both contractual frictions and a positive complementarity between worker and supervisor effort. The model illustrates how the combination of effort complementarities and contractual frictions makes one-sided incentive schemes sub-optimal.

For simplicity, we consider the case of a single frontline worker (player 1) and a single supervisor (player 2).<sup>10</sup> The worker’s task is to visit households and offer them health services. The supervisor’s task is to make it easier for the worker to deliver this service, as explained in Section 2 (e.g., by training and advising the worker). The players interact over two periods. In the first period, the supervisor chooses a level of effort  $e_2$ , and offers to pay the worker a side payment of  $s \in [0, \infty)$  for every visit that the worker completes. In the second period, the worker observes the effort choice of the supervisor and the side payment they offer, and then chooses effort  $e_1$ . This sequential structure reflects the hierarchical nature of the relationship as well as the fact that much of the support offered to the worker (e.g., training) is given in advance of the worker’s choice of effort.

Offering side payments is costly. We model this by assuming that a side payment of  $s$  costs to the supervisor  $zs$ , with  $z \geq 1$ .  $z$  is a reduced form parameter that captures any barrier to the offer of a side payment (e.g., the poor observability of worker effort, social norms, stickiness of payments), or the difficulty of making binding commitments (e.g., the supervisor may need to compensate the worker for the perceived risk of default). These contractual frictions limit the scope for Coasian bargaining.

Household visits  $y$  are produced as a result of both worker and supervisor effort. We capture this with the following output function:

$$y = \alpha e_1 + \gamma e_1 e_2 \tag{1}$$

with  $\alpha$  is weakly positive. Importantly, when  $\gamma > 0$ , efforts are strategic complements: the higher the effort of one player, the larger the return to the effort of the other player. Also, this functional form captures the intuition that, when  $e_1 = 0$ , the supervisor cannot generate any visit no matter how much effort she spends training and advising the worker.

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<sup>10</sup>This departs from our empirical setting, in which supervisors are responsible for multiple workers. As explained at the end of the section, this simplification does not affect the main results of the model.

Both players maximize a private payoff that is given by the benefit that the player gets from the visits completed by the worker minus the cost of effort. We assume that each player  $i$  gets a benefit of  $b_i$  for every completed visit. This captures the combination of intrinsic and extrinsic motives that players may have to exert effort in the absence of performance-based incentives (e.g., there may be a threat of losing the job or social status that decreases in  $y$ ).<sup>11</sup> Additionally, the worker gets a monetary payment of  $pm$  per visit in the three treatments, where  $p \in [0, 1]$  is the share of the output incentive assigned to the worker, i.e., in the *worker incentives treatment*,  $p = 1$ ; in the *shared incentives treatment*,  $p = 0.5$ ; and in the *supervisor incentives treatment*,  $p = 0$ .<sup>12</sup> The supervisor, on the other hand, is paid an incentive of  $(1 - p)m$  per visit completed by the worker. Further, the worker also receives a transfer from the supervisor of  $s$  per visit, and the supervisor pays an amount  $zs$  per visit in order to make this transfer.<sup>13</sup> Finally, both agents bear a convex cost of effort:  $c(e_i) = c_i e_i^2$ . In sum, the payoffs of the worker and of the supervisor are given by:

$$\pi_1 = (b_1 + pm + s) * y(e_1, e_2) - c(e_1) \quad (2)$$

$$\pi_2 = (b_2 + (1 - p)m - zs) * y(e_1, e_2) - c(e_2). \quad (3)$$

To solve the model, we first find the optimal level of worker effort in the second period, conditional on supervisor effort and side payments. We then derive the optimal effort and side payment chosen by the supervisor in the first period, taking into account the worker's optimal response in the second period. To obtain our main analytical results, we simplify the problem and assume that  $b_1 = b_2 = 0$ ,  $c_1 = c_2 = c$ ,  $m = 1$  and  $\alpha = 1$ . This enables us to illustrate the core features of the model, which are determined by the production function, the possibility of side payments, and the sequential interaction, while setting aside additional considerations that emerge when costs or benefits are asymmetric. We will relax these assumptions when we take the model to the data in Section 6.

In this simplified setting, the optimal side payment is given by:

$$s^* = \begin{cases} \frac{1-p(1+z)}{2z} & p \leq \frac{1}{1+z} \\ 0 & p > \frac{1}{1+z} \end{cases} \quad (4)$$

This formula shows that the optimal side payment decreases with the contractual frictions ( $z$ ) and the incentive offered to the worker ( $p$ ). If contractual frictions are large and the

<sup>11</sup>In the empirical setting, agents also receive a fixed wage on top of the incentives. Given the linear utility specification, the introduction of this additional term will not affect our conclusions.

<sup>12</sup>In the empirical setting, agents are paid uniquely for the visits they performed *and* subsequently reported. We abstract from modeling worker reporting behavior because it complicates the model without affecting its main results. See the discussion at the end of the section.

<sup>13</sup>In practice, transfers from supervisors to workers could be fixed (not proportional to visits) or based on the number of visits reported by the worker. Again, such extensions do not affect the main intuition of the results.

worker receives a large share of the incentive ( $p > \frac{1}{1+z}$ ), the supervisor will not make any side payment. We derive optimal efforts for these two cases – positive side payments ( $p \leq \frac{1}{1+z}$ ) and zero side payments ( $p > \frac{1}{1+z}$ ) – and present the complete mathematical analysis of the model in Appendix D. As expected, the efforts of both players increase in the strength of the complementarity. Further, due to the complementarity, agents’ effort do not necessarily increase monotonically in the share of the incentive that is offered to them.

We can use the model to illustrate how the optimal incentive scheme depends on contractual frictions and complementarities in effort. In particular, we consider a policy maker that wants to find the level of  $p$  that maximizes visits. In what follows, we will call incentive schemes that only incentivize one player ( $p = 1$  or  $p = 0$ ) “one-sided,” and schemes that incentivize both players ( $0 < p < 1$ ) “two-sided.” Also, we will refer to incentive schemes that weakly maximize visits as “optimal.” Finally, we restrict attention to values of  $\gamma$  and  $c$  such that  $z\gamma^2 < 8c^2$ . This condition limits the relative size of the complementarity, guaranteeing positive optimal efforts (as we show in Appendix D.2). We can prove the following result.

**Result 1.** *When effort complementarity is lower than a threshold level  $t$ , there is a unique optimal incentive scheme, which is one-sided:  $p^* = 1$ . When effort complementarity is equal or larger than  $t$ , there is always a two-sided scheme which is optimal:  $p^* \in (0, 1)$ . If there are contractual frictions, this optimal two-sided scheme is the unique optimal scheme. If there are no contractual frictions,  $p = 0$  may also be optimal.*

This result is established in two steps, which are discussed in detail in Appendix D and summarized here.

When complementarities are low ( $\gamma < t$ ), supervisor effort has only a limited effect on the worker’s ability to carry out household visits. In this case, it is straightforward to show that household visits are maximized by offering the entire incentive to the worker.

When complementarities are large ( $\gamma \geq t$ ), supervisor effort becomes central to the optimal incentive decision. If contracting is costly ( $z > 1$ ), incentive schemes that concentrate most of the rewards on one subject are not effective, since the drop in productivity that comes from the low effort of one subject more than offsets the monetary incentive offered to the other subject. Instead, efforts are maximized by intermediate values of  $p$ . Thus, the optimal incentive scheme is two-sided, as we show in Figure 1.<sup>14</sup>

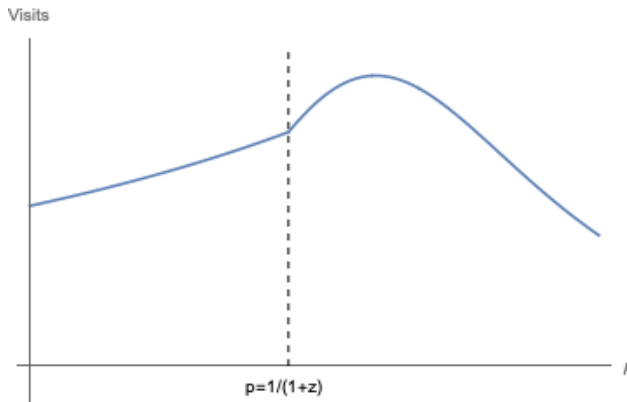
If complementarities are large ( $\gamma \geq t$ ) and there are no contractual frictions ( $z = 1$ ), the supervisor is able to perfectly match any changes in incentive in the interval  $[0, \frac{1}{1+z}]$  with a commensurate change in side payments. All values of  $p$  in that interval result in the same

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<sup>14</sup>More precisely, the optimal incentive is either  $p^* = \frac{1}{1+z}$  (which is the optimal incentive in the interval  $[0, \frac{1}{1+z}]$ ) or  $p^* = \frac{1}{6} + \frac{\sqrt{\gamma^2 + 24c^2}}{6\gamma}$  (which is the optimal incentive in the interval  $(\frac{1}{1+z}, 1]$ ). In Figure A.2, we show how optimal efforts and side payments change as  $p$  changes.



Figure 1: Optimal Incentives ( $\gamma \geq t$  and  $z > 1$ )



number of visits. If this is the highest possible number of visits (as shown, for instance, in the example analyzed in Figure A.1b), then all  $p \in [0, \frac{1}{1+z}]$  are optimal.

In sum, the model clarifies that, when efforts are strong strategic complements, it is optimal to offer a two-sided incentive scheme that rewards both players. Furthermore, in this case, we may observe that subjects' own efforts do not increase monotonically with the incentive that is offered to them. One final implication of the model, which we explore in Appendix D, is that the difference in output between the optimal two-sided incentive scheme and the one-sided scheme  $p = 1$  increases in the complementarity  $\gamma$ . Thus, if in the experiment we find that a two-sided incentive scheme is optimal, we would also expect that the difference in output between this scheme and the worker incentive scheme is larger for supervisor-worker pairs that have a high  $\gamma$ . We will explore these predictions empirically in Section 5.

Furthermore, the model sheds light on the important role played by side payments. In particular, two results will help us interpret our experimental results. First, the model shows that, when there are no contractual frictions, all incentive schemes that motivate positive side payments produce the same number of visits. In contrast, when there are contractual frictions, changes in the allocation of incentives always change output. In other words, if we observe positive side payments and differential impacts of the different treatments, this indicates that the supervisor and the worker cannot contract costlessly. Second, the model shows that there is an additional factor that can limit side payments. In Appendix D.7, we present an extension of the model that allows for heterogeneity in benefits and costs. This extended model shows that the supervisor will not offer any side payment when the benefit  $b_2$  that she receives from household visits absent our intervention is low compared to the benefit  $b_1$  that is received by the worker.<sup>15</sup> In these cases, it would be optimal for the worker

<sup>15</sup>Both  $b_1$  and  $b_2$  may stem from the agents' worry that low output will result in their dismissal from the organization. As supervisors tend to be more experienced and established in the organization, it is likely that they are less concerned by the possibility of being fired, compared to workers. Alternatively, supervisors may have better outside options and would hence suffer a smaller utility loss if they lose their position.

to pay the supervisor to exert effort – an action which we do not allow in the model and do not observe in the data, presumably because the frictions preventing transfers from the bottom to the top of the hierarchy are even larger than the frictions that impede transfer from the top to the bottom. In sum, we can observe limited side payments either because of high contractual frictions preventing the supervisor from offering side payments, or because of an asymmetry in how much workers and supervisors value output. However, in the latter case, these limited side payments are sufficient to equalize output.

Finally, we note that the model departs from our empirical setting in two main ways. First, in the model, the incentive is paid on the basis of the number of actual visits completed, rather than the number of visits reported. We could enrich the model with a function  $r(p)$  (with  $r'(p) > 0$ ) that determines the reporting rate chosen by the worker. Since the reporting rate naturally increases in  $p$ , this would raise the relative attractiveness of the worker incentive scheme compared to the other schemes. However, as long as the elasticity of reporting with respect to  $p$  does not exceed a threshold, all model results would remain qualitatively unchanged. Second, in the model, we abstract from the fact that each supervisor has multiple workers. This prevents us from exploring the optimal targeting of supervisor effort across heterogeneous workers. Empirically, however, we do not find extensive evidence of targeting,<sup>16</sup> likely due to a combination of limited worker heterogeneity, imperfect knowledge about worker types, and organizational constraints that prevent targeting. We thus do not extend the model in this direction.

## 4 Main Results

### 4.1 Output

**Quantity of visits** – We start by assessing the causal effect of our incentives treatments on the number of visits provided by health workers. We estimate the following regression equation:

$$Y_{ij} = \alpha + \beta_1 T_{worker,j} + \beta_2 T_{supv,j} + \beta_3 T_{shared,j} + Z_j + \varepsilon_{ij} \quad (5)$$

where  $Y_{ij}$  represents the number of household visits provided by health worker  $i$  in PHU  $j$ .  $T_{worker,j}$ ,  $T_{supv,j}$ , and  $T_{shared,j}$  are indicators for whether incentives in PHU  $j$  were assigned to health workers only, supervisor only, or were shared between the two. In our model’s notation, these correspond to  $p = 1$ ,  $p = 0$  and  $p = 1/2$ , respectively.  $Z_j$  are the stratification variables.<sup>17</sup>  $\varepsilon_{ij}$  is an error term clustered at the level of the treatment assignment, the PHU.

<sup>16</sup>The only dimension where we find evidence of targeting is worker experience. However, within-PHU variation in experience is limited, constraining the scope for effort targeting. See Section 5.1.

<sup>17</sup>As mentioned, these include district fixed effects, whether the average distance between the residence of the supervisor and their health workers is above or below the median, and whether the number of health

To measure the number of household visits provided by the health worker, we asked each sampled household to report the total number of natal- and disease-related visits received from the health worker in the six months preceding the endline survey.<sup>18</sup> For each worker, we then calculate the mean number of visits received by a household (mean of 7.3). We also study the coverage and range of services provided by the health worker, which we proxy with the share of households who were visited at least once (mean of 71%) and the number of different visit types households received (mean of 1.7).

Our main results are reported in Table 2 column (1) and the corresponding Figure 2. They show that introducing performance-based incentives significantly boosts the number of household visits provided by the health worker, regardless of whether the incentives are one- or two-sided. The mean number of visits per household in the control group is 5.334. This number increases by 2.090 (40%) in the worker incentives treatment, by 2.145 (39%) in the supervisor incentives treatment and by 3.356 (63%) in the shared incentives treatment. Interestingly, offering the entire incentive to the health workers is equally effective than offering the entire incentive to the supervisor. Both interventions, however, are outperformed by the two-sided incentive scheme, which achieves 17% more visits overall. Relative to the control group, the boost in visits generated by the two-sided incentive scheme is 61% larger than the boost that results from either one of the one-sided schemes. When we break down household visits by their type, we find that, compared to the one-sided treatments, shared incentives generate significant gains over both natal-related visits and disease-related visits (Table A.3).<sup>19</sup> In line with column (1), we find that health workers in the shared incentives treatment also achieve higher coverage (column 2) and provide a higher variety of services (column 3).

**Quality of the visits and targeting** – The higher number of visits provided by workers in the shared incentives treatment may potentially come at the expense of visit length (which is not incentivized), so that the aggregate amount of time dedicated to the job remains unchanged. This would be problematic: as discussed earlier, workers are expected to follow a checklist when they visit a household and short visits may be an indication that such checklist is not properly followed, and thus that the service provided may be of lower quality.

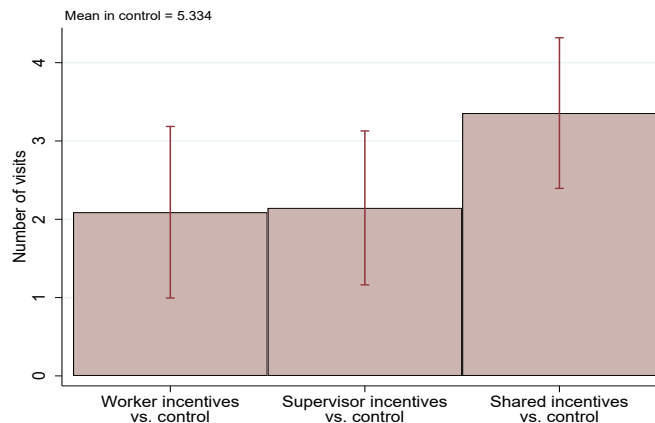
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workers in the PHU is above or below the median.

<sup>18</sup>To minimize recall bias, households were asked about visits received “since the start of the year,” which corresponds roughly to the past 6 months.

<sup>19</sup>These results estimate the treatment effects on the average number of visits provided by the health worker to a single sampled household in the six months preceding the endline survey. For completeness, in Table A.2, we also report the corresponding treatment effects on the *total* number of visits provided to sampled households per month (column 1) and on the *total* number of visits provided in the community per month (column 2). The latter outcome variable is measured as the number of visits per month in our sample divided by the share of households included in our sample. We estimate that health workers provide a total of 41 monthly household visits in the community in the control group. This number goes up to 59 in  $T_{worker}$  and  $T_{supv}$ , and to 67 in  $T_{shared}$ .

Figure 2: Effect of Incentives on the Number of Visits



Notes: The figure plots the difference in the number of visits provided by the health worker between each treatment group and the control group. The coefficients are estimated from a regression of the number of visits on the treatment dummies, controlling for stratification variables with standard errors clustered at the PHU level. Bars are 95% confidence intervals.

Table 2 (column 5) shows that, conditional on having received at least one visit, the average visit length reported by a household (23 minutes) did not decrease in the shared incentives treatment.<sup>20</sup> The average number of health topics the household discussed per visit with the health worker increases by 26% in the shared incentives treatment (column 6), in line with these workers receiving more training from the supervisor. The share of households who report trusting the health worker in the shared incentives treatment also increases: it is 7.1 percentage points (10%) higher in the shared incentives treatment than in the control, and 3.5 percentage points (5%) higher than in both one-sided incentives treatments (column 7). This is an important result because trust in health service providers is known to be one of the main determinants of the demand for health services (Alsan 2015; Lowes and Montero 2021; Martinez-Bravo and Stegmann 2022; León-Ciliotta, Zejcirovic, and Fernandez 2022).

We also explore whether the higher number of visits in the shared incentives treatment comes at the expense of worse targeting of households: health workers may switch from visiting the most deserving households (i.e., poor households) to households who can be visited at a lower cost (i.e., households who are located close by or who are friends or family members). An increase in mis-targeting would be concerning as it would offset some of the gains coming from a larger number of visits. To analyze targeting, we run a household-level regression of the number of visits received by the household on the treatments dummies interacted with whether the household is poor (wealth score below median), lives within 30 minutes of the health worker’s home and is a family member or a friend of the health

<sup>20</sup>Obviously, this result has the caveat that we are conditioning the sample on a potentially endogenous variable. When we assign an average visit length of zero to the 29% of households who were never visited by the worker, we obtain that the shared incentives increase visit length (see column 4). This captures both the intensive and the extensive margin of effort.

worker.<sup>21</sup> Table A.4 shows that households who are socially or geographically close to the health worker are less likely to be targeted in the control group (columns 2 and 3), while the household’s wealth score does not predict visits (column 1). Such targeting remains nearly unchanged when workers are paid a higher incentive. Overall, these results alleviate concerns related to quantity-quality trade-offs.

**Access to natal-care services and disease incidence** – We now test whether the increase in the number of natal- and disease-related services provided by the health worker in the shared incentives treatment translates into better access to health services and better health outcomes.

We start by analyzing households’ access to pre- and post-natal care, which we estimate with an equally-weighted average of z-scores of six variables: one related to pre-natal care and five related to post-natal care. Pre-natal care is measured by asking all women who were pregnant at endline and those who gave birth in the year preceding the endline survey whether they received at least four pre-natal visits from any provider. Post-natal care is measured by asking all women who gave birth in the year preceding the endline survey whether they gave birth in a health facility (vs. at home), whether they received at least one post-natal visit within two days of birth, whether they breastfed their infant for at least six months, and whether their infants are up-to-date on the vaccination schedule. Table 3 (column 1) shows that the increase in the number of natal-related services provided by the health worker in the shared incentives treatment translates into better access to pre- and post-natal care. More precisely, the ante- and post-natal care index is 0.2 standard deviations (0.092/0.44) higher in the shared treatment relative to the control (significant at the 1% level). Columns (2) to (6) present the results for each each single component of the index.

Next, we analyze diseases incidence among children under the age of five, which we proxy with an equally-weighted average of z-scores of three variables: the share of households who report that at least one child under five years of age had fever, diarrhea or cough in the past month.<sup>22</sup> Table 3 (column 7) shows that disease incidence index is 0.11 standard deviations (-0.053/0.47) lower in the shared incentives treatment than in the control group (significant at the 5% level). This is driven by households in the shared incentives treatment reporting fewer fever instances, while we see no effect for diarrhea and cough (columns 8-10). We also find that the household respondent in the shared incentive treatment is more likely to

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<sup>21</sup>More precisely, we run the following household-level regression:  $Y_{hij} = \alpha + \beta_1 T_{worker,j} + \beta_2 T_{supv,j} + \beta_3 T_{shared,j} + \beta_4 X_h + \beta_5 T_{worker,j} * X_h + \beta_6 T_{supv,j} * X_h + \beta_7 T_{shared,j} * X_h + Z_j + \varepsilon_{hij}$ , where  $Y_{hij}$  represents the number of visits that the household  $h$  received from health worker  $i$  in PHU  $j$  and  $X_h$  is a household characteristic (e.g., poor, social/geographical distance to health worker). All the other variables are defined as in equation (5).  $\varepsilon_{hij}$  is an error term clustered at the PHU level.

<sup>22</sup>The three most serious and common diseases in Sierra Leone are malaria, pneumonia and diarrhea. Because households may not be aware of which disease a child suffered from, we asked them to report whether any child had common symptoms associated with each disease (fever, cough and diarrhea).

know the appropriate actions to prevent malaria (i.e., sleep under a treated bednet) and diarrhea (i.e., wash hands with soaps, drink clean water). Despite an effect on the access to natal services and disease incidence/knowledge, we find no treatment effects on under-five mortality rates. This is maybe not that surprising given the relatively short timeframe of the experiment.

We corroborate these results using administrative records from the local health facility (PHU-level data), which do not suffer from any recall or response bias. The results are presented in Table A.5. In line with the household survey data, we find that the number of recorded pregnant women services, institutional births and fully immunized infants at the health facility is higher in the shared incentives treatment than in the other groups, albeit the results are less precisely estimated. All three incentives treatments appear to increase the number of malaria and diarrhea cases treated at the health facility relative to the control group. Given the lower disease incidence rate reported by our sampled households, these positive coefficients are consistent with health workers referring sick children to the health facility more frequently in the treatment groups than in the control.

## 4.2 Reporting and the Cost-Effectiveness of the Intervention

This section assesses the relative cost-effectiveness of the three incentive schemes. All schemes pay 2,000 SLL per visit *reported* by the health worker. Cost-effectiveness is thus a function of both the actual number of visits carried out and the number of visits reported. We start by evaluating, in Table 4, whether the number of visits reported is impacted by our treatments. Column (1) shows that that reported visits are highest in the worker incentives treatment, even though actual visits are maximized by shared incentives. More precisely, we find that, in the six months preceding the endline survey, workers send an average of 8.7 SMS reports per month in  $T_{worker}$ , 6.3 SMS reports per month in  $T_{shared}$ , and 3.7 SMS reports per month in  $T_{supv}$ . These reporting differences across treatments are relatively stable over time (see Figure A.3). These results imply that that the most expensive incentive scheme for the organization is  $T_{worker}$ . More precisely, Table 4 (column 8) shows that the average monthly cost per PHU is 132 thousand SLL in  $T_{worker}$ , 94 thousand SLL in  $T_{shared}$ , and 54 thousand SLL in  $T_{supv}$ .

In Table 4 (column 2), we present results on the reporting rate, i.e., the ratio between the number of SMS reports per month (column 1) and the *actual* number of visits per month.<sup>23</sup>

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<sup>23</sup>The latter is calculated as the number of actual visits among the random sample of households we interviewed scaled up for the number of households in the community. See Table A.2, column (2). While the reporting rate we obtain from this calculation may be over- or under-estimated for a single health worker, average differences across treatments are meaningful and accurate. Note that households have no strategic incentive to misreport the number of visits received by the health worker and that the survey was not announced beforehand so that the health worker could not have influenced households to give favorable answers during the survey.

We also present results on dummies capturing whether a worker under-reports or over-reports actual visits. This analysis shows that health workers generally under-report the number of visits provided, especially when they are not incentivized to do so: they report 30.3% of the actual visits in  $T_{worker}$ , 17.1% in  $T_{shared}$ , 13.8% in  $T_{supv}$ . Moreover, the share of workers who under-report is 12 times larger than the share of workers who over-report (Table 4, columns 3-4).

These results confirm that reporting is costly, so that workers under-report even in  $T_{shared}$  and  $T_{worker}$  when they receive monetary incentive for reporting. As explained in Section 2, we hypothesize that a key driver of reporting costs is the poor quality of the mobile phone network, which makes it very hard to send SMS messages from some villages. Consistently with this hypothesis, we find that the reporting rate increases with the level of the incentives only in the 85% of villages that have network connectivity, while it does not vary with incentives in the remaining villages where network connectivity is virtually absent (Table A.6). In villages with network connectivity, we estimate an elasticity of reporting to incentives of 0.75, and hence estimate that an incentive of 3,800 SLL would lead health workers to report 100% of their visits.<sup>24</sup>

**Policy choice** – What policy should the organization adopt on the basis of these results? Suppose that the organization wants to maximize household visits, conditional on the payment per *actual* visit not exceeding 2,000 SLL. In this case, the shared incentive intervention is unambiguously optimal for the organization. On the one hand, over-reporting is minimal in all treatments, so the cost per actual visit never exceeds 2,000 SLL. On the other hand, shared incentives maximize actual visits, and so satisfy the organization’s objective.<sup>25</sup>

The shared incentive intervention is also optimal if the organization’s objective is to maximize cost-effectiveness, i.e., to maximize the amount of actual visits generated per dollar spent. In Table 4 (column 9), we show that in the worker incentives treatment, the organization obtains an additional 6.5 visits per worker for each 2,000 SLL spent on incentives. This figure goes up to 9.6 visits for each 2,000 SLL spent in the supervisor incentives treatment, and to 16.1 visits for each 2,000 SLL spent in the shared incentives treatment (a significant difference of 9.6 visits compared to worker incentives).<sup>26</sup>

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<sup>24</sup>In villages with network connectivity, the reporting rate is 13.7 percentage points (75%) higher in  $T_{worker}$  relative to  $T_{shared}$ . Because the incentives paid to the worker for reporting is twice as high in  $T_{worker}$  than in  $T_{shared}$ , the estimated elasticity of reporting to incentives is 0.75 (75%/100%).

<sup>25</sup>Note that over-reporting is minimal in our setting thanks, in part, to the presence of a fairly sophisticated and independent monitoring system. In the absence of such monitoring system, over-reporting may occur more frequently, especially in the worker incentives, and this would presumably make the worker incentives even less attractive relative to the other treatments.

<sup>26</sup>A key caveat is that these results are driven by the differential rate of under-reporting. Due to under-reporting, the organization saves on incentive payouts that should instead accrue to workers and supervisors. If reporting costs decrease over time, the number of additional visits produced for each 2,000 SLL spent will tend to progressively converge to the same figure across treatments. Further, the organization may want to

Shared incentives, however, impose a larger total cost compared to supervisor incentives. If this cost breaks the organization’s budget constraint, the organization could either opt for supervisor incentives, which offer a similar increase in visits as worker incentives, for a lower cost; or it may decrease the amount of the incentive paid in the shared incentive scheme.

## 5 Mechanisms

The previous section showed that health workers provide significantly more household visits under shared incentives than under the one-sided incentives schemes. In this section, we explore the mechanisms underlying this result. Guided by the theoretical framework developed in Section 3, we provide evidence consistent with the presence of *both* complementarities in the effort exerted by the supervisor and the health worker and limited side payments. We then present evidence against two alternative mechanisms: a sharp discontinuity in either the utility or the cost function, and inequality aversion.

### 5.1 Effort Complementarities

Three pieces of evidence point to the presence of strong effort complementarities in our setting.

**Supervisor effort** – First, we estimate the effects of our three incentive schemes on the levels of effort exerted by the supervisor. If effort complementarities were absent or weak ( $\gamma < t$ ), the effort of the supervisor should monotonically increase with the level of the supervisor’s incentives, i.e., be higher in the supervisor incentives treatment relative to the other groups. We show next that this is not the case.

Recall from Section 2.1 that supervisors have three main tasks: (i) they provide in-the-field training and advising by accompanying health workers on household visits (henceforth, an “accompanied visit”), (ii) organize one-to-one meetings with each health worker and (iii) organize monthly one-day general trainings. We measure (i) with the fraction of households who report having received *at least one* accompanied visit in the six months preceding the endline survey.<sup>27</sup> While the vast majority of household was visited by the health worker, only 16.4% report having received *at least one* an accompanied visit. This implies that the increase in visits we documented in the previous section are mostly “unaccompanied” visits. No household reports having received a visit from the supervisor without the presence of the

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design a scheme to reimburse agents for the incentives that have not been claimed, for equity reasons or to comply with labor laws. Finally, these cost-effectiveness differences would not arise in settings where output is observable and hence incentives can be tied to actual output.

<sup>27</sup>To minimize the extent to which our measure of supervisor effort captures output (number of visits), we neither use the *total* number of accompanied visits nor do we use the *share* of visits in which the supervisor accompanied workers.



health worker. We measure (ii) and (iii) by asking health workers the number of times the supervisor provided them one-to-one meetings in the six months preceding the endline survey (mean of 1.375) and whether the supervisor organized a general training in the last month (mean of 99.4%).

Table 5 column (1) shows that the share of households who report having received an accompanied visit is 5.7 percentage points (35%) and 6.2 percentage points (38%) higher in  $T_{supv}$  and  $T_{shared}$  respectively, relative to the control group, while there is no difference between  $T_{worker}$  and the control group. Importantly, the coefficients for  $T_{supv}$  and  $T_{shared}$  are nearly identical, and this is despite the fact that the supervisor is paid an incentive which is twice as high in the former than in the latter. This suggests that the overall returns to supervisor effort are similar in the supervisor and shared incentive schemes, which is consistent with the existence of effort complementarities that indirectly compensate the supervisor in the shared incentive scheme for the lower monetary payment.

Columns (2) and (3) of Table 5 show that our treatments do not affect the number of times the supervisor provided one-to-one meetings to the health worker, and the likelihood that the supervisor organized a training in the past month are unchanged. The latter is not surprising as almost all supervisors organize such trainings.

Two pieces of evidence provide direct support of the supervisors playing an “enabling” role rather than only a “monitoring” one. First, Table A.7 column (1) shows that health workers improve their health knowledge the most in the shared incentives treatment. Health knowledge is measured with a 7-questions quiz on health questions which was administered to health workers at baseline and endline. This result is consistent with health workers being trained more effectively in the shared incentives treatments,

Second, Table A.4 (column 5) shows that the boost in visits in the shared incentives treatment is similar for households that received an accompanied visit and those that did not, with the obvious caveat that this variable is endogeneous. If the role of the supervisor was limited to monitoring, we would expect health workers to target their visits towards households that were in direct contact with the supervisor in the past, since presumably the supervisor would find it easier to contact these households again and to monitor whether the worker has visited them. That shared incentives boost visits for households who were never in direct contact with the supervisor is also consistent with health workers in this treatment having received better training and being able to raise demand for their visits even when unaccompanied.

Finally, note that only 16% of the health workers report that their supervisors ever helped them with the SMS reporting (Table A.7, column 2). This is not surprising as all health workers received extensive training on how to report at the start of the experiment (see Section 2). Interestingly, the share of supervisors who helped health workers with reporting is comparable in the two one-sided treatments relative to the control group and is slightly

lower in the shared incentives treatment. This indicates that the introduction of supervisor incentives did not divert supervisor’s time away from productive tasks (e.g., training workers on health issues) and towards unproductive ones (e.g., help with reporting).

**Heterogeneity by health worker’s experience** – As a second piece of evidence, we present heterogeneous treatment effects by an empirical proxy of effort complementarity: limited health worker’s experience. Health workers with little experience are less knowledgeable about health issues and less-known in the community, and they thus plausibly benefit more from the training and advice of the supervisor. We thus expect the shared incentives treatment to be more effective in boosting output and supervisor effort for these health workers, compared to their more experienced counterparts.

Table A.9 estimates a fully interacted model and presents the treatment effects for workers with experience below the median (i.e., below 4 years) in Panel A and for workers with experience above the median in Panel B. For inexperienced workers, the shared incentives treatment increases the number of household visits provided by the health worker by 4 (85%) relative to the control group (column 1), and increases supervisor effort (measured with the share of households in which the health worker was accompanied by the supervisor) by 9.2 percentage points (70%; column 3). For experienced workers, these effects are significantly lower: they are about half the magnitude for visits and one third of the magnitude for supervisor effort. The results are robust to controlling for all worker characteristics correlated with health worker experience (listed in Table A.8 column 1), and their interaction with the three treatment dummies (columns 2 and 4). Overall, the results confirm that the shared incentives treatment is particularly effective in boosting output and supervisor effort when effort complementarity between the layers of the organization is likely high.<sup>28</sup>

**Mediation analysis** – As a final evidence in favor of effort complementarities, we perform a mediation analysis to test whether the boost in visits attributable to worker effort increases when supervisors exert more effort. Following Acharya, Blackwell, and Sen (2016), we estimate the Controlled Direct Effect (CDE) of the worker incentives treatment on visits *net of a mediator* — here, supervisor’s effort. This quantity captures the treatment effect that would be observed if supervisor effort was fixed at an exogenous level, while worker’s effort (which is not directly observable in our setting) was allowed to respond to the incentives.<sup>29</sup> We then

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<sup>28</sup>In contrast with Bandiera, Barankay, and Rasul (2007), Table A.12 shows that supervisors are not more likely to target their effort towards health workers who they perceived as highly ranked in terms of performance at baseline, and are also equally likely to target their friends/family members. We also find no heterogeneity in supervisor effort and household visits with respect to the supervisor’s span of control (the number of workers per supervisor). This might be explained by limited variation in span of control in our setting.

<sup>29</sup>We focus on the comparison between the worker incentives treatment and the control group since a mediation analysis performed on the other treatments would be complicated by the fact that in those treatments

present this “de-mediated” effect for different levels of supervisor’s effort. In the presence of effort complementarities we would expect the increase in visits generated by the worker to grow in supervisor effort (when supervisor effort increases, the worker exerts more effort and the return to worker effort increases).

In line with this, Figure A.4 (top panel) shows that the effect of worker effort on output increases substantially with supervisor effort (as measured with the fraction of household visits in which the health worker was accompanied by the supervisor). Indeed, the CDE of the worker incentives treatment on visits is close to zero when 0% of the household visits were accompanied by the supervisor and goes up to more than 2 at the opposite extreme when 100% of the household visits were accompanied.<sup>30</sup> This is consistent with a strategic complementary between worker effort and the in-the-field-training offered by the supervisor. We also find evidence of a strong complementarity between worker effort and the general training provided by the supervisor, while we see no complementarity with respect to the one-to-one meetings.

## 5.2 Limited Side Payments

In this section, we document that side payments are limited in our context, and present suggestive evidence that this is because of the presence of contractual frictions.

To measure side payments, we collected detailed data on monetary and in-kind transfers from both the supervisors and the health workers. At endline, all supervisors were asked whether they transferred part or all of their incentive (if any) to health workers since baseline. If they did, we then asked each health worker to assess the value (in-cash or in-kind) of this side payment.<sup>31</sup>

Side payments are generally small and infrequent. First, in column (1) of Table 6 we show that, while the share of supervisors who make positive side payments increases with the level of the supervisor incentive (1.1% in the control group, 1.6% in  $T_{worker}$ , 11.3% in  $T_{shared}$ , and 19.4% in  $T_{supv}$ ), in all treatments the large majority of supervisors do not make any transfers. Second, in column (3) of Table 6, we document that the average amount that a supervisor transfers to a worker *over an entire month* is 702 SLL (resp., 431 SLL) in  $T_{supv}$  (resp.,  $T_{shared}$ ). These amounts are very small if one considers that the supervisor earns an

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the supervisor is directly incentivized to exert effort.

<sup>30</sup>We produce Figure A.4 by following the steps outlined in Acharya, Blackwell, and Sen (2016). First, we regress the number of visits provided by a health worker on the worker incentives treatment, the mediator (supervisor’s effort), and their interaction. From this, we obtain a de-mediated outcome, defined as the difference between actual visits and predicted visits based on the coefficients of all covariates (except the treatment) estimated at different levels of the mediator. Finally, we run a regression of the de-mediated outcome on the treatment and report the coefficients for different levels of the mediator.

<sup>31</sup>This was asked to health workers rather than supervisors to limit recall bias. To make sure workers and supervisors did not under-report transfers, everyone was made aware from the very start of the experiment that supervisors are entirely free to share incentives with their workers. See Section 2.2 for details.

incentive of 2,000 SLL (resp., 1,000 SLL) per visit reported in  $T_{supv}$  (resp.,  $T_{shared}$ ), and that the average supervisor in  $T_{supv}$  (resp.,  $T_{shared}$ ) earns 55,280 SLL (resp., 47,097 SLL) per month from the incentive payment, as shown in Table 4 (column 7). Workers also occasionally make side payments to their supervisor when they are paid an incentive, but the amount of such transfers is negligible (average of 151 SLL in  $T_{worker}$ ). Overall, this evidence shows that side payments do happen in our context, but their frequency and magnitude is minimal.

Why are side payments limited? In Section 3, we discussed two possible explanations, both centered on contractual frictions. First, the supervisor may find it optimal to offer a sizable side payment to the worker, but top-to-bottom contractual frictions partially limit her ability to offer these payments. Second, the optimal side payment may be small or even zero, since  $\beta$ , the value that the supervisor attaches to household visits is small compared to that attached by the health worker. If the asymmetry is large enough, the worker may actually find it desirable to offer a payment to their supervisor, but bottom-to-top contractual frictions may prevent them from doing so. We also pointed out that, as long as we observe positive net payments from the supervisor to the worker, we can disentangle these two potential explanations by looking at the impacts on visits of the different treatments. If the level of side payments is low due to top-to-bottom contractual frictions, we expect that changes in the share of the incentives allocated to the worker can generate large differences in visits. In contrast, if there are no top-to-bottom frictions and we observe a low level of side payments to the worker due to the relative low value that the supervisor attaches to output compared to the worker, we should observe the same number of visits for all incentive schemes that generate positive side payments. Our results in the previous section, which show that visits are far from being equalized across treatments (see Figure 2) despite side payments being positive, point to the likely presence of top-to-bottom contractual frictions in our setting. In what follows, we present two additional pieces of evidence pointing to the presence of these top-to-bottom contractual frictions.

**Heterogeneity by supervisor’s observability of worker output** – Our first piece of evidence comes from the analysis of the sensitivity of side payments to proxies for top-to-bottom contractual frictions. These frictions are more likely to be present when worker effort or output is not observable to the supervisor, since this makes contracts hard to enforce. To measure the observability of output, we leverage the fact that, at endline, we asked each supervisor to rank the workers she supervises from the best to the worse in terms of their “overall work as a health worker.” We correlate this *perceived* rank with the *actual* rank of health workers obtained on the basis of the number of households visits completed at endline. The correlation is positive and significant for over 60% of the supervisors. However, a group of supervisors has very limited information: for 10% of the supervisors in our sample, the

correlation is negative.<sup>32</sup>

Table A.10 (column 1, Panel A) shows that side payments in both  $T_{supv}$  and  $T_{shared}$  are inexistent for the supervisors who observe worker output poorly. In contrast, side payment are positive (even though limited) for the remaining supervisors, who can better observe worker output (column 1, Panel B). These heterogeneous effects are robust to controlling for correlates of the observability of output (column 2). Overall, these results are consistent with side payments being larger when worker output is more observable and hence when contractual frictions are likely weaker. This result provides evidence on the likely importance of top-to-bottom contractual frictions in preventing transfers from supervisors to workers. Importantly, output observability seems to be limited for most supervisors, which could make contracting difficult even for supervisors who are in the upper part of our proxy measure of observability.<sup>33</sup>

**Heterogeneity by the value of worker and supervisor outside options** – Our next piece of evidence comes from the analysis of worker-supervisor pairs where the worker has better outside options than their supervisor. In these pairs, the worker is likely to exert less effort than the supervisor would find optimal, and we thus expect the supervisor to have strong reasons to offer a sizable side payment to the worker.<sup>34</sup> The second explanation for low transfers — that these are optimal from the point of view of the supervisor — is unlikely to apply here. Thus, if side payments in these pairs were also limited, this would provide indirect evidence in favor of the first explanation — that contracting frictions limit the supervisor’s ability to incentivize the worker through transfers.

In Table A.11, we estimate treatment effects for the subsample of worker-supervisor pairs where the worker has a better outside option than the supervisor. We capture outside options using the hourly wages that individuals earn in their second job. We show that, even within that sample, side payments are limited and visits are not equalized across treatments. This points to the presence of additional constraints to side payments, such as top-to-bottom contractual frictions.

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<sup>32</sup>Table A.8 shows that these poorly-informed supervisors tend to live further away from the health workers, while they have the same education, age, and wealth score.

<sup>33</sup>Interestingly, we do not observe any heterogeneity in side payments with respect to whether the worker is a friend or family member of the supervisor (Table A.12). This suggests that social distance/relational contracts have limited ability to attenuate contractual frictions within our organization. This is in contrast with a number of papers showing that relational contracts attenuate frictions *across* organizations (McMillan and Woodruff 1999; Macchiavello and Morjaria 2015; Adhvaryu et al. 2020; Macchiavello and Morjaria 2021).

<sup>34</sup>In our framework, it is natural to think of outside options as a key driver of parameters  $b_1$  and  $b_2$ , since they determine the extent to which agents are concerned about losing their job due to underperformance. Agents with better outside options are thus likely to exert less effort.

### 5.3 Alternative Mechanisms

The previous section provides empirical support for our theoretical framework, in which two-sided incentives outperform one-sided incentives due to the presence of *both* effort complementarities and limited side payments. This section examines two alternative mechanisms that are not considered in our model, but could explain why two-sided incentives outperform one-sided incentives: a sharp discontinuity in agents' utility or cost function, and inequality aversion. We discuss each one of these in turn and provide evidence against both of them.

**A discontinuity in agents' utility or cost functions** – In the absence of effort complementarities, shared incentives could outperform the one-sided incentives if there was of a sharp discontinuity in agents' utility function for incentive payments above 1,000 SLL. In this case, one-sided incentives would fail to motivate either of the two agents substantially more than the shared incentive treatment. Thus, in principle, this mechanism could explain why the supervisors provide the same amount of effort in  $T_{supv}$  and  $T_{shared}$  (Table 5). Furthermore, this could also explain why the shared incentives treatment leads to more visits relative to the other treatments.

However, the discontinuity in the utility function necessary to rationalize our findings seems implausible. To explain the same level of supervisor's effort in  $T_{supv}$  and  $T_{shared}$ , this mechanism requires agents' marginal utility to be close to zero for incentives beyond 1,000 SLL. While having a very low marginal utility from additional income could be reasonable at high levels of income (e.g., corporate managers refusing to work additional hours even for a large pay raise), this is unlikely in the context of doubling a relatively large piece-rate incentive for workers in rural villages in one of the world's poorest countries.<sup>35</sup> To corroborate this, Figure A.5 (Panel A) displays non-parametric plots of the treatment effects on the number of visits and on supervisor effort, by worker and supervisor wealth score. If the utility function was non-linear and flat past a certain level of income (as this hypothesis implies), we should observe wealthier workers respond less to incentives than poorer workers. The figure shows instead that the treatment effects are constant and smooth over the worker and supervisor wealth score distribution. If anything supervisor effort appears to slightly increase with supervisor wealth.

Alternatively, there may be a similar discontinuity in the cost function. Here, the marginal cost of effort would need to rise sharply at the level of efforts agents provide for a 1,000 SLL incentive. This would be the case if, for example, the distance of households from the health worker had a bimodal distribution, with a group of near-by households that can be reached at low cost, and a group of far-away households that can only be reached at a cost above

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<sup>35</sup>Workers in our sample earn an average of 1,443 SLL per hour in their alternative occupation. This is low relative to the amount they can earn for providing one household visit (1,000 or 2,000 SLL for a 15 minutes visit).

2,000 SLL per visit. Again, this is a very unlikely scenario as it requires a sharp convexity in the workers’ and supervisor’s cost of effort around the 1,000 SLL cutoff. Panel B of Figure A.5 presents non-parametric plots of the treatment effects on the number of visits and the supervisor effort over the distribution of household-worker distance (a proxy for the worker’s cost of visiting a specific household) and worker-supervisor distance (a proxy for the supervisor’s cost of training/monitoring a health worker). We see no sharp discontinuity in any of the treatment effects by cost of effort.

A last possibility is that the results are explained by a discontinuity in the production function, such that the return to the worker effort increases with the effort of the supervisor only up to a threshold which coincides with the effort level exerted by the supervisor in the shared incentives treatment. In contrast with this, Figure A.6 shows that the non-parametric relationship between realized visits and supervisor effort is steadily positive.

**Inequality aversion** – Another mechanism that could explain our core findings is based on aversion to pay inequality. For example, in the supervisor incentives treatment, the health workers may think that it is unfair that the supervisor earns money for services provided by the worker, while the worker themselves does not earn anything. Similarly, the supervisor may think that it is unfair that she is not paid any incentive in the worker incentives treatment. If this was the case, then one-sided incentives may *reduce* the effort of the non-incentivized worker, while raising the effort of the incentivized one. This could, in turn, explain why one-sided incentives are outperformed by two-sided incentives.

We provide three pieces of evidence against this mechanism. First, recall from Section 2.2 that health workers were not told about the introduction of supervisor incentives and few seem to have learned it from the supervisor: in  $T_{supv}$  (resp.,  $T_{shared}$ ), only 15% (resp., 20%) of workers reported that their supervisor receives an incentive. Of these, only 2% (resp., 10%) were aware of the exact amount earned by the supervisor while the rest under-estimated this amount. Second, Table A.13 shows that there is no evidence for workers in  $T_{supv}$  and supervisors in  $T_{worker}$  to be less satisfied with their payment, the organization making the payments, or their job in general compared to the control group. If inequality aversion or fairness concerns were the main mechanism driving our results we would instead expect the non-incentivized workers in  $T_{supv}$  and the non-incentivized supervisors in  $T_{worker}$  to be less satisfied than workers and supervisors in the control group.<sup>36</sup> Third, we observe that the supervisor’s effort is higher (and not lower) in  $T_{worker}$  relative to the control group, which cannot be reconciled with supervisors being demotivated by workers receiving incentives. All in all, these three pieces of evidence make it unlikely that inequality aversion alone drives

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<sup>36</sup>Workers in all treatments are equally likely to find the work environment competitive or to self-identify with their job: columns (7) and (8) in Table A.13. We also find no differential treatment effects on visits depending on the workers’ level of inequality aversion, estimated with a set hypothetical questions (columns 9 to 11).

our results.

Finally, we note that the absence of changes in satisfaction with the job and the organization is also inconsistent with the hypothesis that agents increase effort in the shared incentives treatment due to positive reciprocity. Under this story, any incentive payment would elicit a positive effort response that does not depend on the amount of the incentive paid. However, it is unlikely that reciprocal agents would also increase effort, but not report higher satisfaction with the organization.

## 6 Structural Model

In this section, we use the exogenous variation generated by the interventions to structurally estimate the model presented in Section 3. First, we present our identification and estimation strategy. We then discuss the fit of the empirical and simulated moments. Finally, we present parameter estimates, and conclude with a set of counterfactual policy exercises.

### 6.1 Identification and Estimation

Our main objective is to estimate the following parameters of the model: the complementarity of effort  $\gamma$ , the cost of effort  $c_1$  and  $c_2$ , the baseline incentives  $b_1$  and  $b_2$ , and  $\alpha$ , the marginal product of worker effort in the absence of complementarities. We identify these six parameters using a core set of eight empirical moments. The mean of output (household visits) in the four experimental conditions gives us an initial set of four moments, and the mean of supervisor effort in the four conditions gives us an additional four moments.<sup>37</sup> The parameters are jointly identified by these empirical moments. Intuitively, the moments capturing supervisor effort are highly informative about the cost and benefit parameters of the supervisor. Conditional on those parameters, the moments capturing output are informative about the cost and benefit of the worker, the complementarity of effort, and parameter  $\alpha$ .

The model makes additional predictions about side payments and worker effort. A key point is that, when the model predicts positive side payments for the case of no contractual frictions ( $z = 1$ ), we are also able to estimate  $z$  — either leveraging direct data on side payments or indirectly since supervisor effort is informative about contractual frictions when side payments are positive. The side payment data can also be useful to discipline some of the other estimates of the model. Thus, in a robustness exercise we present later, we estimate

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<sup>37</sup>The measure of visits we use for the structural analysis is total visits per month. We obtain this by multiplying the number of visits per month per surveyed household by the number of households served by the health worker (as reported in Table A.2, column 2). To reflect the fact that some visits are not reported, we adjust this number down by multiplying it by the average reporting rate (17%). The measure of supervisor effort we use is the fraction of household visits in which the health worker was accompanied by the supervisor (as reported in Table 5, column 1).



a model that uses the eight original moments plus three moments capturing the average side payment in each treatment group. On the other hand, we do not have good data on worker effort, since it is hard to obtain a clean measure of worker effort that is empirically distinct from output (household visits). We thus do not use any moment describing worker effort.

To estimate the model we use a classical minimum distance estimator (Wooldridge 2010). We save the empirical moments in a vector  $\mathbf{m}$ . For a parameter vector  $\boldsymbol{\theta}$ , we solve the model and calculate the simulated moments  $\mathbf{m}_S(\boldsymbol{\theta})$ . We update  $\boldsymbol{\theta}$  in order to solve:

$$\hat{\boldsymbol{\theta}} = \min_{\boldsymbol{\theta}} [\mathbf{m}_S(\boldsymbol{\theta}) - \mathbf{m}]' \cdot J(\mathbf{m})^{-1} \cdot [\mathbf{m}_S(\boldsymbol{\theta}) - \mathbf{m}]. \quad (6)$$

$J(\mathbf{m})$  is a diagonal matrix that contains the variance of each moment, ensuring that more precisely estimated moments get a greater weight in estimation.<sup>38</sup> We calculate  $J(\mathbf{m})$  using a bootstrap with 1,000 replications. Table 7 presents our main structural results and Table 8 describes the empirical fit of the simulated moments.

The estimated model fits the empirical moments tightly. In particular, the estimated model matches both the moments related to supervisor effort and those related to household visits. Crucially, the estimated model is able to reproduce the key result that visits are maximized by the shared incentives treatment. Finally, the estimated model predicts that the supervisor does not offer any side payment to the worker. Indeed, our descriptive evidence shows that side payments are a very small fraction of the incentive received by the supervisor and thus cannot constitute a major motivating factor for the worker. The estimated model is able to reproduce this qualitative fact without using any information on side payments. Importantly, when we estimate the model again using side payments, we obtain a set of parameter estimates that is remarkably similar to the original set of estimates (see Tables A.14 and A.15).

## 6.2 Parameter Estimates

Our structural estimates show that worker and supervisor effort are strongly complementary, and that contracting through side payments is very costly (Table 7).

The estimated complementarity parameter  $\gamma$  determines a substantial increase in the marginal product of worker effort. Compared to a setting where  $\gamma = 0$ , the number of household visits generated by a unit of worker effort is 17% larger when the supervisor exerts the control level of effort, and 36% larger when the supervisor exerts the shared incentives level of effort. Supervisor effort thus plays a key role in enabling the worker to carry out

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<sup>38</sup>To reflect the fact that visits are more precisely measured than supervisor effort (which we can only proxy), we apply a simple multiplicative penalty to the weight that supervisor effort gets in the loss function. This ensures the estimator prioritizes fitting the moments related to visits, compared to the moments related to supervisor effort. While this helps us refine our estimates, it should be noted that the quantitative difference between the estimates we obtain with and without the penalty is small.

household visits, and this results in a strong strategic complementarity between the efforts of the two agents.

Second, we find that the baseline incentive of the supervisor to exert effort in the control group ( $b_2$ ) is lower than that of the worker ( $b_1$ ). This is not surprising, since their role is probably harder to monitor and incentivize, especially if the organization under-appreciates the strategic complementarity of effort and thus the possibility to incentivize the supervisor through piece rates based on final output. The supervisor also has a high unit cost of effort ( $c_2$ ). As a result, interventions that fail to incentivize the supervisor may be ineffective: the contribution of the supervisor is key to ensure the worker can be productive, but, absent additional incentive, the supervisor will under-provide her key support to the worker.

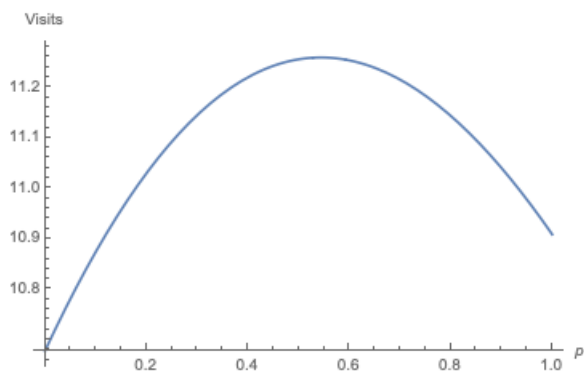
Finally, as discussed above, since these estimated benefits imply that the optimal side payment is zero, we are unable to provide an estimate for  $z$ .

### 6.3 Counterfactual Policies

We conduct three counterfactual policy experiments that explore, in turn, how to optimally share the incentive between the two agents, how the optimal incentive changes as key structural parameters vary, and the impact of an alternative policy that directly incentivizes effort.

We find that offering an equal share of the incentive to the worker and the supervisor is almost optimal. In Figure 3, we show that, in order to maximize household visits, the worker should be offered 54% of the overall incentive, which is very close to the equal share that we offered in the shared incentives treatment. In other words, given the strong complementarity and large contractual frictions we have estimated, the optimal incentive scheme is one that rewards both agents with a similar payment.<sup>39</sup>

Figure 3: Optimal Incentive  $p^*$

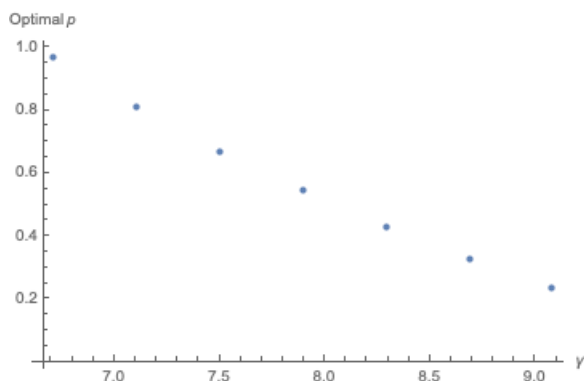


This result, however, depends strongly on the strength of the complementarity between

<sup>39</sup>This is a similar exercise than the one done in the simulations shown in Figure 1, but here we are using the estimated parameters from the model to simulate the optimal incentive split between the layers.

worker and supervisor effort. We illustrate this point with our second counterfactual experiment in Figure 4. Here, we plot the optimal share of the incentive offered to the worker ( $p^*$ ) for different levels of complementarity. A key result that emerges from this analysis is that, as the complementarity parameter shrinks, the optimal incentive offered to the worker increases substantially. Quantitatively, if the complementarity parameter was 10 percent *lower* than what we estimate, the optimal incentive would give 80 percent of the piece rate to the worker. If the complementarity parameter was instead 10 percent *higher* than what we estimate, the optimal incentive would give 60 percent of the piece rate to the supervisor. Thus, these results suggest that in organizations in which effort complementarity is weaker than in our settings – e.g., settings in which the role of the supervisor is limited to monitoring, distributing tasks or to making personnel decisions, but not to train and advise workers — the optimal split is one that allocates significantly more to the worker. And in organizations in which effort complementarity is stronger – e.g. organizations where supervisors are closely involved in production — the optimal incentive scheme allocates the largest share of the piece rate to the supervisor.

Figure 4: Optimal Incentive  $p^*$  by Complementarity  $\gamma$

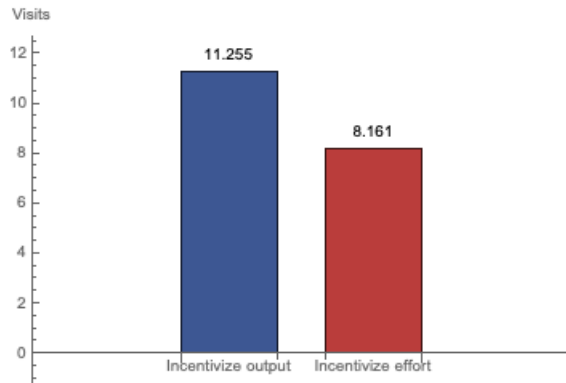


Our final key result highlights that tying incentives to joint output is more effective than directly incentivizing effort (e.g., incentivizing supervisors on the amount of supervision and training, and incentivizing health workers on the number of times they attempt to approach a household, regardless of whether this results in a visit or not). In Figure 5, we compare the maximum number of visits that are generated through (i) a scheme that equally shares a payment of 2,000 SLL per visit between the worker and the supervisor, and (ii) a scheme of the same cost that optimally offers incentives directly tied to individual effort.<sup>40</sup>

What emerges is that, at the current level of complementarity, incentivizing output

<sup>40</sup>In this comparison, we assume that effort can be observed and is perfectly predictive of output. Hence, we abstract from issues related to asymmetric information, which may decrease the effectiveness of both incentive schemes. In the effort incentive case, since effort can be observed, the payoff to the worker becomes  $\pi_1 = e_1 * (b_1 + mp)$  and the payoff to the supervisor  $\pi_2 = e_2 * (b_2 + (1 - m) * p)$ . In this model, the supervisor always offers zero side transfer since her reward only depends on her own effort.

Figure 5: An Alternative Policy that Targets Effort



through an equally-shared piece rate generates 38% more visits that optimally incentivizing effort, for the same cost. This is because, when efforts are highly complementary, output incentives implicitly help agents internalize the positive external effect that their effort has on the other player. This makes output incentives particularly effective.

## 7 Conclusion

In this paper, we provide novel evidence on the optimal structure of performance incentives in a hierarchical organization. We do so by designing a field experiment in collaboration with the national Community Health Program in Sierra Leone, which is structured in two layers: frontline health workers and supervisors. The experiment creates random variation in the recipient of a new incentive scheme that rewards household health visits, while holding the total payout per visit constant. The visit piece-rate is offered either entirely to the worker, entirely to the supervisor, or is split equally between the two agents. We find that all treatments increase household visits relative to the control condition, and that the shared incentives treatment generates the largest increase in visits.

Before releasing the results of the field experiment, we invited social scientists to forecast them on the online Social Science Prediction Platform.<sup>41</sup> The majority (52%) of survey participants forecasted that one-sided worker incentives would maximize health visits.<sup>42</sup> This is not surprising, since worker incentives have received much attention in the existing empirical literature, as we discuss in the introduction. In line with most of this literature, the results from this paper show that incentivizing frontline health workers increases output relative to a control group without incentives. However, our results also show that sharing the same

<sup>41</sup>See Appendix E for more details about the prediction survey.

<sup>42</sup> 28% forecasted shared incentives to maximize visits, 4% forecasted supervisor incentives to be the most effective, and 18% forecasted that all three treatments would have the same effect.

piece rate equally between the worker and her superior generates a treatment effect that is almost two thirds larger.

The key finding that output is highly responsive to the allocation of the incentive has a number of important implications. First, when incentives are not redistributed through side transfers, organizations need to fine-tune the allocation of payments to maximize output. Our empirical results document a context where the complementarity between worker and supervisor effort is strong, and hence where sharing a piece-rate across the layers of the organization has a large impact on output. We would expect weaker complementarities, and hence a less pronounced impact of shared incentives, in contexts in which the role of the supervisor is more focused on monitoring.

Second, organizations may consider introducing reforms that facilitate side-transfers across layers. These policies could be attractive in contexts where the organization has an imperfect understanding of the production function, and may want to rely on supervisors – who have more local knowledge – to redistribute incentives to bottom-tier workers at their discretion. Such delegation can however be optimal only if the interests of the supervisors are aligned with those of the organization. If supervisors are poorly motivated to generate output — as our structural estimation suggests —expanding the scope for transfers from supervisors to workers may instead be detrimental to the performance of the organization. Understanding how to increase side payments across layers of an organization and their effect on organization performance is a great avenue for future research.

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Table 1: Summary Statistics and Balance Checks

Sample of villages:	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)		(10)		(11)
	All				Control				Worker Incentives Treatment				Supervisor Incentives Treatment				Shared Incentives Treatment				F-test of joint significance (p-value)
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	
<b>A. Characteristics of the supervisors (N=372)</b>																					
Male = {0, 1}	0.919	0.273	0.925	0.265	0.925	0.265	0.925	0.265	0.925	0.265	0.914	0.265	0.914	0.265	0.914	0.282	0.914	0.282	0.914	0.282	0.988
Age (in years)	37.84	8.856	37.91	9.329	37.91	9.329	37.91	9.329	37.46	7.869	36.85	8.690	36.85	8.690	37.17	11.21	37.17	11.21	37.17	11.21	0.062
Completed primary education = {0, 1}	0.739	0.440	0.763	0.427	0.731	0.446	0.731	0.446	0.731	0.446	0.785	0.413	0.785	0.413	0.677	0.470	0.677	0.470	0.677	0.470	0.301
Completed secondary education = {0, 1}	0.253	0.435	0.226	0.420	0.226	0.446	0.226	0.446	0.269	0.446	0.215	0.413	0.215	0.413	0.301	0.461	0.301	0.461	0.301	0.461	0.533
Wealth score (0 to 8)	3.013	1.227	3.097	1.269	3.097	1.269	3.097	1.269	2.914	1.222	2.914	1.239	2.914	1.239	3.129	1.182	3.129	1.182	3.129	1.182	0.507
Number of health workers responsible for	7.984	2.861	7.559	2.799	7.559	2.799	7.559	2.799	8.355	2.831	8.011	2.902	8.011	2.902	8.011	2.899	8.011	2.899	8.011	2.899	0.289
<b>B. Characteristics of the health workers (N=2,970)</b>																					
Male = {0, 1}	0.708	0.455	0.727	0.446	0.727	0.446	0.727	0.446	0.721	0.449	0.710	0.454	0.710	0.454	0.675	0.469	0.675	0.469	0.675	0.469	0.407
Age (in years)	37.12	11.47	35.95	11.14	35.95	11.14	35.95	11.14	37.79	11.72	37.48	11.72	37.48	11.72	37.17	11.21	37.17	11.21	37.17	11.21	0.062
Completed primary education = {0, 1}	0.697	0.460	0.727	0.446	0.727	0.446	0.727	0.446	0.694	0.461	0.703	0.457	0.703	0.457	0.666	0.472	0.666	0.472	0.666	0.472	0.301
Completed secondary education = {0, 1}	0.077	0.267	0.070	0.255	0.070	0.267	0.070	0.267	0.076	0.265	0.078	0.268	0.078	0.268	0.085	0.278	0.085	0.278	0.085	0.278	0.867
Wealth score (0 to 8)	2.454	1.167	2.430	1.231	2.430	1.231	2.430	1.231	2.400	1.116	2.438	1.120	2.438	1.120	2.550	1.199	2.550	1.199	2.550	1.199	0.273
Number of households responsible for	55.19	78.59	62.72	120.2	62.72	120.2	62.72	120.2	54.08	62.92	53.16	56.37	53.16	56.37	51.26	60.24	51.26	60.24	51.26	60.24	0.375
Distance to supervisor (in km)	3.415	2.945	3.267	2.887	3.267	2.887	3.267	2.887	3.815	3.610	3.107	2.141	3.107	2.141	3.447	2.895	3.447	2.895	3.447	2.895	0.190
<b>C. Characteristics of the female household respondent, aggregated to village level (N=2,970)</b>																					
Age (in years)	27.79	4.576	28.13	4.741	28.13	4.741	28.13	4.741	27.69	4.410	27.56	4.572	27.56	4.572	27.84	4.586	27.84	4.586	27.84	4.586	0.266
Completed primary education = {0, 1}	0.248	0.269	0.259	0.268	0.259	0.268	0.259	0.268	0.225	0.261	0.261	0.272	0.261	0.272	0.247	0.273	0.247	0.273	0.247	0.273	0.203
Completed secondary education = {0, 1}	0.035	0.119	0.039	0.126	0.039	0.126	0.039	0.126	0.033	0.118	0.036	0.118	0.036	0.118	0.033	0.116	0.033	0.116	0.033	0.116	0.912
Wealth score (0 to 8)	1.103	0.872	1.199	1.021	1.199	1.021	1.199	1.021	1.044	0.822	1.117	0.843	1.117	0.843	1.062	0.790	1.062	0.790	1.062	0.790	0.111
Distance to health worker (in km)	1.433	2.630	1.189	2.124	1.189	2.124	1.189	2.124	1.591	2.575	1.438	2.894	1.438	2.894	1.483	2.785	1.483	2.785	1.483	2.785	0.506
<b>D. Characteristics of the village (N=372)</b>																					
Accessible road to health facility = {0, 1}	0.766	0.424	0.778	0.416	0.778	0.416	0.778	0.416	0.762	0.426	0.775	0.418	0.775	0.418	0.747	0.435	0.747	0.435	0.747	0.435	0.797
Phone network available	0.838	0.368	0.824	0.381	0.824	0.381	0.824	0.381	0.845	0.362	0.862	0.345	0.862	0.345	0.821	0.384	0.821	0.384	0.821	0.384	0.490
Phone network is reliable	0.407	0.491	0.464	0.499	0.464	0.499	0.464	0.499	0.362	0.481	0.393	0.489	0.393	0.489	0.413	0.493	0.413	0.493	0.413	0.493	0.247
<b>E. Services provided by the health facility per month (N=372)</b>																					
Number of pregnant women services	47.71	45.80	43.76	42.98	43.76	42.98	43.76	42.98	51.22	57.17	48.43	37.10	48.43	37.10	47.34	44.10	47.34	44.10	47.34	44.10	0.769
Number of institutional births	13.44	8.266	12.58	6.087	12.58	6.087	12.58	6.087	13.67	7.814	13.38	6.845	13.38	6.845	14.13	11.33	14.13	11.33	14.13	11.33	0.509
Number of fully immunized infants	11.41	10.75	10.88	10.10	10.88	10.10	10.88	10.10	11.92	12.58	10.67	7.060	10.67	7.060	12.14	12.39	12.14	12.39	12.14	12.39	0.684
Number of malaria cases treated	45.89	32.03	42.29	26.88	42.29	26.88	42.29	26.88	51.44	38.88	46.63	31.52	46.63	31.52	43.23	29.38	43.23	29.38	43.23	29.38	0.286
Number of diarrhea cases treated	20.45	17.03	19.62	13.25	19.62	13.25	19.62	13.25	21.81	19.47	20.58	21.58	20.58	21.58	19.76	12.02	19.76	12.02	19.76	12.02	0.809

Notes: Each row states the sample mean and standard deviation of a variable, and by treatment group. The last column reports the p-value from the F-test of joint significance of the treatment dummies. This is calculated from a regression of each variable on the 3 treatment dummies, controlling for the stratification variables and using standard errors clustered at the PHU level in worker/village level regressions or robust standard errors in PHU/supervisor level regressions.

Table 2: Visits

Dep. Var.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Household visits provided by the health worker in the past 6 months						
	Number of visits	% households visited	Number of visit types	Average visit length	Average visit length (conditional on at least one visit)	Number of health topics discussed per visit	% households who trust the health worker as a health provider
Worker incentives	2.090*** (0.558)	0.072*** (0.025)	0.250*** (0.094)	2.024** (0.941)	0.603 (1.423)	0.164 (0.127)	0.037 (0.023)
Supervisor incentives	2.145*** (0.501)	0.082*** (0.025)	0.325*** (0.100)	1.933** (0.926)	-0.070 (1.409)	0.173 (0.130)	0.031 (0.024)
Shared incentives	3.356*** (0.492)	0.127*** (0.023)	0.565*** (0.092)	4.134*** (0.927)	1.590 (1.290)	0.528*** (0.134)	0.071*** (0.024)
Unit	Worker	Worker	Worker	Worker	Worker	Worker	Worker
Observations	2,926	2,926	2,926	2,926	1,803	2,926	2,926
Mean dep. var.	7.296	0.709	1.745	14.388	23.404	2.248	0.745
Mean dep. var. in Control	5.334	0.637	1.448	12.324	22.736	2.015	0.707
p-value Worker = Supervisor	0.932	0.710	0.492	0.927	0.635	0.946	0.808
p-value Supervisor = Shared	0.038	0.060	0.026	0.024	0.196	0.017	0.102
p-value Worker = Shared	0.046	0.026	0.002	0.033	0.451	0.013	0.147

Notes: All regressions include stratification variables. Standard errors are clustered at the PHU level. In col. (4), we assign an average visit length of zero to the households who were never visited by the worker. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 3: Health Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	
	Pre- and post-natal care in the past 2 years											
	% women who received at least 4 ante-natal visits before birth		% women with institutional birth		% women who received post-natal visit within 2 days of birth		% women with at least 6 months of breastfeeding		% households with up-to-date infant vaccination		Index (cols. 8-10)	
									Diseases: incidence		Knowledge	
Dep. Var.	Index (cols. 2-6)	% women who received at least 4 ante-natal visits before birth	% women with institutional birth	% women who received post-natal visit within 2 days of birth	% women with at least 6 months of breastfeeding	% households with up-to-date infant vaccination	Index (cols. 8-10)	% children under-5 who had fever	% children under-5 who had cough	% children under-5 who had diarrhea	% household respondents who know how to prevent malaria and diarrhea	
Worker incentives	0.029 (0.028)	0.017 (0.024)	0.022 (0.021)	0.007 (0.026)	-0.002 (0.025)	-0.008 (0.018)	0.010 (0.032)	-0.028 (0.022)	0.016 (0.012)	0.005 (0.007)	0.062* (0.032)	
Supervisor incentives	0.042 (0.029)	0.032 (0.026)	0.035* (0.019)	-0.022 (0.024)	0.016 (0.025)	0.015 (0.019)	-0.028 (0.032)	-0.014 (0.028)	-0.005 (0.012)	-0.005 (0.005)	0.053* (0.032)	
Shared incentives	0.092*** (0.028)	0.058** (0.025)	0.036* (0.019)	0.017 (0.027)	0.040 (0.025)	0.025 (0.019)	-0.053** (0.026)	-0.058*** (0.022)	-0.007 (0.011)	-0.001 (0.005)	0.086*** (0.030)	
Unit	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	
Observations	2,499	2,499	2,499	2,499	2,499	2,499	2,826	2,823	2,825	2,826	2,970	
Mean dep. var.	-0.006	0.778	0.868	0.305	0.666	0.230	-0.009	0.183	0.072	0.016	0.563	
Mean dep. var. in Control	-0.048	0.750	0.845	0.303	0.652	0.222	0.009	0.208	0.071	0.017	0.511	
p-value Worker = Supervisor	0.656	0.509	0.491	0.258	0.439	0.223	0.273	0.580	0.088	0.129	0.796	
p-value Supervisor = Shared	0.077	0.243	0.963	0.138	0.330	0.630	0.397	0.086	0.868	0.343	0.312	
p-value Worker = Shared	0.024	0.052	0.469	0.703	0.077	0.091	0.025	0.105	0.056	0.360	0.460	

Notes: The index in col. (1) [resp., col. (7)] estimates an equally weighted average of the z-scores of variables in cols. (1)-(5) [resp., cols. (7)-(9)]. The sample in cols. (1)-(6) is restricted to households with at least one pregnant woman or with a child below age of 5, the sample in columns (7)-(10) is restricted to households with at least one child below age of 5. A household respondent knows how to prevent malaria and diarrhea if she reports that children should "sleep under mosquito nets that is sprayed with mosquito repellent/insecticide" and use soap, use toilet facility to defecate, drink clean water. All regressions include stratification variables. Standard errors are clustered at the PHU level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

Table 4: Reporting and Incentives Payouts

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Reporting			Cost of the intervention (in 1,000 SLL)					
Dep. Var.	Number of reports per month	Reporting rate = number of reports/ number of visits	Over-reporting = {0, 1} [number of reports > number of visits]	Under-reporting = {0, 1} [number of reports < number of visits]	Incentives payment per health worker	Total incentives payment across all health workers	Incentives payment per supervisor	Total incentives payments in the PHU = cols. 6+7	Number of visits per worker for each 2,000 SLL spent
Worker incentives	7.182*** (0.759)	0.222*** (0.043)	0.046** (0.018)	-0.002 (0.024)	16.054*** (1.352)	132.903*** (12.000)	-1.310 (1.832)	131.593*** (11.962)	-
Supervisor incentives	2.181*** (0.586)	0.058* (0.034)	-0.006 (0.015)	0.041* (0.021)	-0.047 (0.185)	-1.172 (2.631)	55.280*** (8.095)	54.108*** (8.377)	3.126 (4.151)
Shared incentives	4.757*** (0.829)	0.091** (0.036)	0.009 (0.015)	0.046** (0.021)	5.584*** (0.691)	46.857*** (6.680)	47.097*** (6.534)	93.953*** (13.164)	9.574** (4.826)
Unit	Worker	Worker	Worker	Worker	PHU	PHU	PHU	PHU	PHU
Observations	2,970	2,624	2,926	2,926	372	372	372	372	279
Mean dep. var.	5.213	0.177	0.069	0.862	5.431	45.535	25.858	71.392	27.876
Mean dep. var. in Control	1.525	0.078	0.055	0.840	0.000	0.000	0.000	0.000	6.508
Mean dep. var. in Worker T.	<0.001	<0.001	0.004	0.059	<0.001	<0.001	<0.001	<0.001	-
p-value Worker = Supervisor	0.008	0.398	0.333	0.802	<0.001	<0.001	0.428	0.009	0.223
p-value Supervisor = Shared	0.026	0.005	0.050	0.035	<0.001	<0.001	<0.001	0.032	-

Notes: In col. (2), the reporting rate is measured as the number of reports (col. 1) divided by the number of household visits. In cols. (3)-(4), under (over) reporting is an indicator for whether the number of reports is lower (higher) than the number of household visits. Col. (9) excludes the control group. The outcome variable in col. (9) calculates the number of visits performed by the average worker in the PHU minus the mean number of visits in the control, divided by the total incentive payout in the PHU (col. 8). We winsorize the top and bottom 1% of the outcome variable due to the presence of outliers and input the maximum value of the outcome variable for the few PHUs in which the total incentives payout is zero. All regressions include stratification variables. Standard errors are clustered at the PHU level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 5: Supervisor Effort

	(1)	(2)	(3)
	<i>In-the-field supervision</i>	<i>One-to-one trainings</i>	<i>General training</i>
Dep. Var.	% Accompanied household visits	Number of times supervisor visited health worker in the past 6 months	Supervisor organized training in the past month = {0, 1}
Worker incentives	0.030 (0.022)	-0.050 (0.137)	0.004 (0.005)
Supervisor incentives	0.057** (0.023)	-0.041 (0.137)	0.006 (0.005)
Shared incentives	0.062*** (0.021)	-0.043 (0.139)	0.003 (0.005)
Unit	Worker	Worker	Worker
Observations	2,919	2,833	2,864
Mean dep. var.	0.204	1.375	0.994
Mean dep. var. in Control	0.164	1.417	0.991
p-value Worker = Supervisor	0.293	0.950	0.443
p-value Supervisor = Shared	0.846	0.987	0.463
p-value Worker = Shared	0.181	0.963	0.916

Notes: Variable in col. (1) is reported by the household and aggregated at worker level. Variables in cols. (2)-(3) are reported by the health worker. All regressions include stratification variables. Standard errors are clustered at the PHU level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

Table 6: Side Payments

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	Supervisor shared incentive with health worker = {0, 1}	Health worker shared incentive with supervisor = {0, 1}	... from supervisor to health worker	... from health worker to supervisor	Net transfer (col. 3-4)
Worker incentives	0.005 (0.016)	0.073*** (0.014)	0.110 (0.090)	0.151*** (0.056)	-0.042 (0.077)
Supervisor incentives	0.183*** (0.047)	-0.001 (0.008)	0.702*** (0.190)	0.104** (0.043)	0.598*** (0.190)
Shared incentives	0.102*** (0.039)	0.041*** (0.015)	0.432*** (0.158)	0.084* (0.043)	0.348** (0.164)
Unit	Worker	Worker	Worker	Worker	Worker
Observations	2,915	2,909	2,488	2,488	2,488
Mean dep. var.	0.084	0.049	0.308	0.101	0.207
Mean dep. var. in Control	0.011	0.019	0.000	0.016	-0.016
p-value Worker = Supervisor	<0.001	<0.001	0.004	0.484	0.001
p-value Supervisor = Shared	0.171	0.005	0.273	0.725	0.318
p-value Worker = Shared	0.013	0.100	0.068	0.325	0.026

Notes: The sample size drops in col. (3)-(5) because a number of health workers answered "don't know" to the question. All regressions include stratification variables. Standard errors clustered at the PHU level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 7: Parameter Estimates

	(1)
Complementarity $\gamma$	7.9 (1.1)
Contractual friction $z$	3.0 (0.1)
Worker unit cost of effort $c_1$	145.3 (26.3)
Supervisor unit cost of effort $c_2$	1611.1 (1150.9)
Worker baseline incentive $b_1$	57.8 (14.6)
Supervisor baseline incentive $b_2$	19.0 (10.0)
$\alpha$	5.1 (1.0)
$\Delta$ in marginal product of worker effort (shared incentive)	36%
$\Delta$ in marginal product of worker effort (control)	17%
Total worker cost of effort (control)	173.6
Total supervisor cost of effort (control)	178.9

Notes: The first panel of the table shows parameter estimates obtained using minimum distance estimation. We use eight empirical moments: supervisor effort in each one of the four treatments, and the number of visits per month in each one of the four treatments. Supervisor effort is proxied by the proportion of households that receive a visit where the worker is accompanied by the supervisor. Costs are expressed in thousands of SLL. Bootstrapped standard errors are reported in parenthesis (we bootstrap the estimation 500 times and truncate the estimated coefficients at the 99th percentile of the distribution). The second panel shows some quantities implied by the parameter estimates. To calculate the change in the marginal product of worker effort we take the derivative of the production function with respect to worker effort (i) with  $\gamma = 7.9$  and supervisor effort fixed at the level indicated in parenthesis, and (ii) with  $\gamma = 0$ . To calculate the total cost of an agent's effort we multiply the unit cost of effort with the average effort exerted by the agent in the control group.

Table 8: Moment Fit

Moments	Targeted real	Simulated
Supervisor effort in worker incentives treatment	0.198	0.159
Supervisor effort in supervisor incentives treatment	0.225	0.278
Supervisor effort in shared incentives treatment	0.228	0.230
Supervisor effort in control group	0.164	0.111
Output (visits) in worker incentives treatment	10.551	10.908
Output (visits) in supervisor incentives treatment	10.413	10.678
Output (visits) in shared incentives treatment	11.827	11.255
Output (visits) in control group	7.256	7.174
	Non-targeted real	Simulated
Side payment in worker incentives treatment (1,000 SSL)	0.088	0.000
Side payment in supervisor incentives treatment (1,000 SSL)	0.715	0.000
Side payment in shared incentives treatment (1,000 SSL)	0.428	0.000
Value loss function		3.7

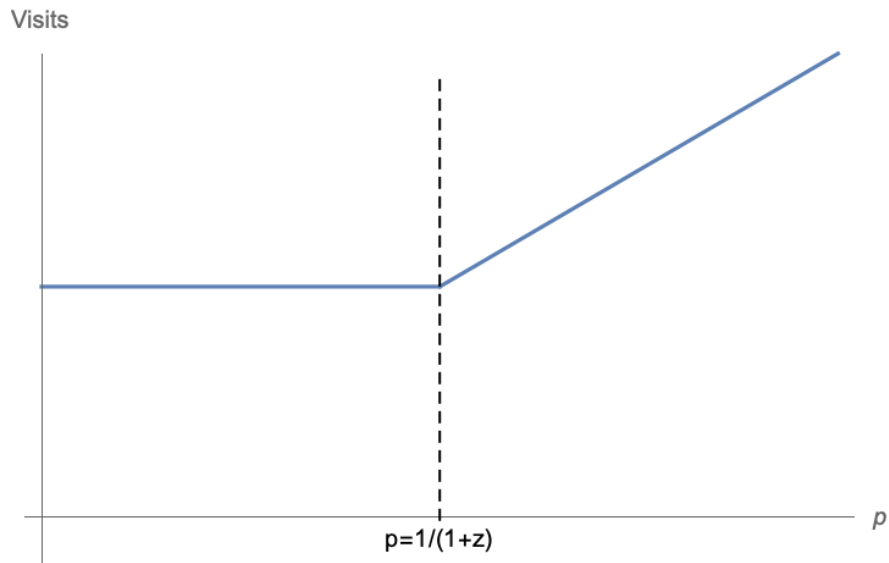
Notes: The first panel of the table shows the empirical moments used for estimation of the structural model and the moments that we simulated with our model using the estimated parameter values. The second panel of the table shows three non-targeted moments, capturing side payments in the three treatment groups.

# Online Appendix (For Online Publication Only)

## A Appendix Figures and Tables

Figure A.1: Optimal Incentives (Continued)

(a) Weak Effort Complementarities and No Contractual Frictions ( $\gamma < t, z = 1$ )



(b) Strong Effort Complementarities and No Contractual Frictions ( $\gamma \geq t, z = 1$ )

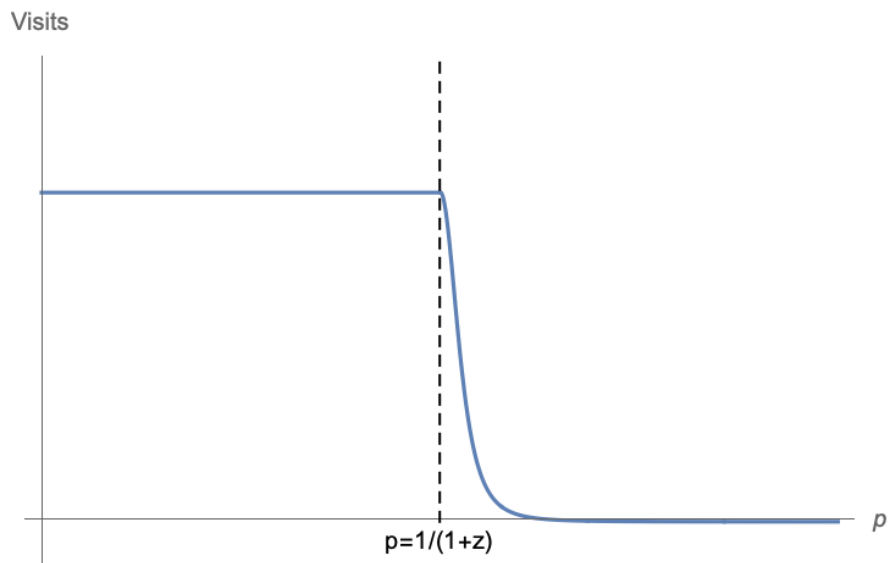
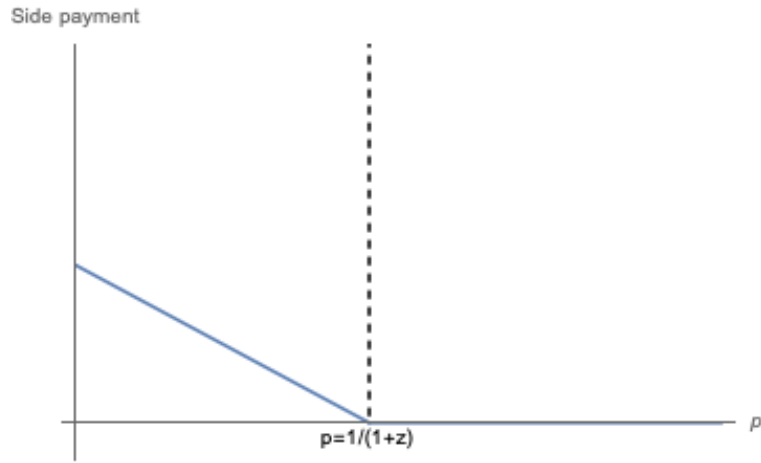


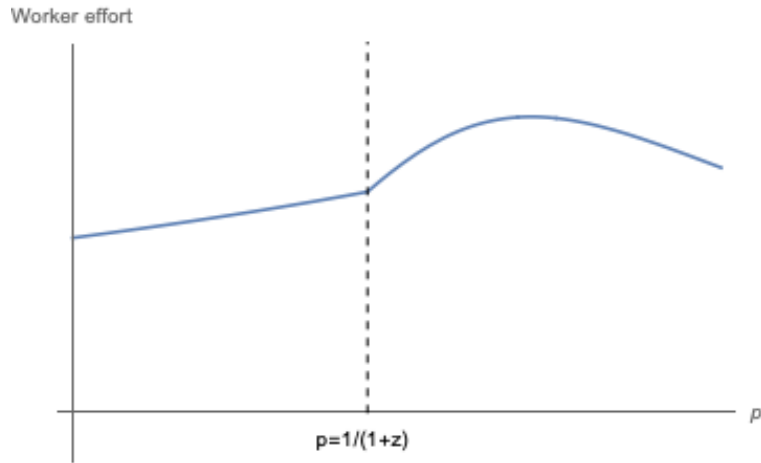


Figure A.2: Side Payment and Efforts as a Function of the Share of the Incentive Offered to the Worker ( $z > 1, \gamma > 0$ )

(a) Side Payment



(b) Worker Effort



(c) Supervisor Effort

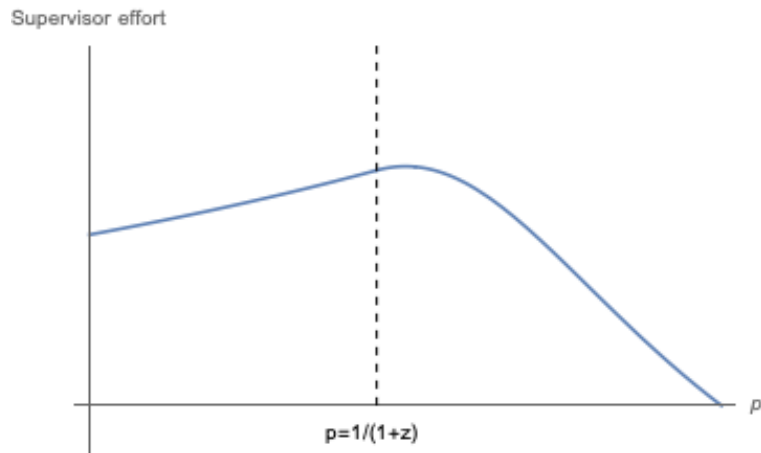
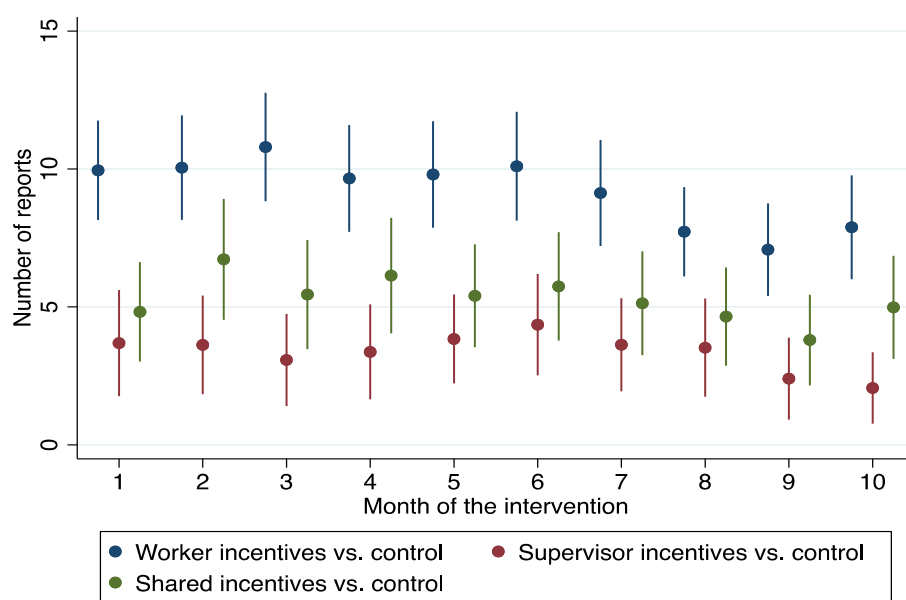
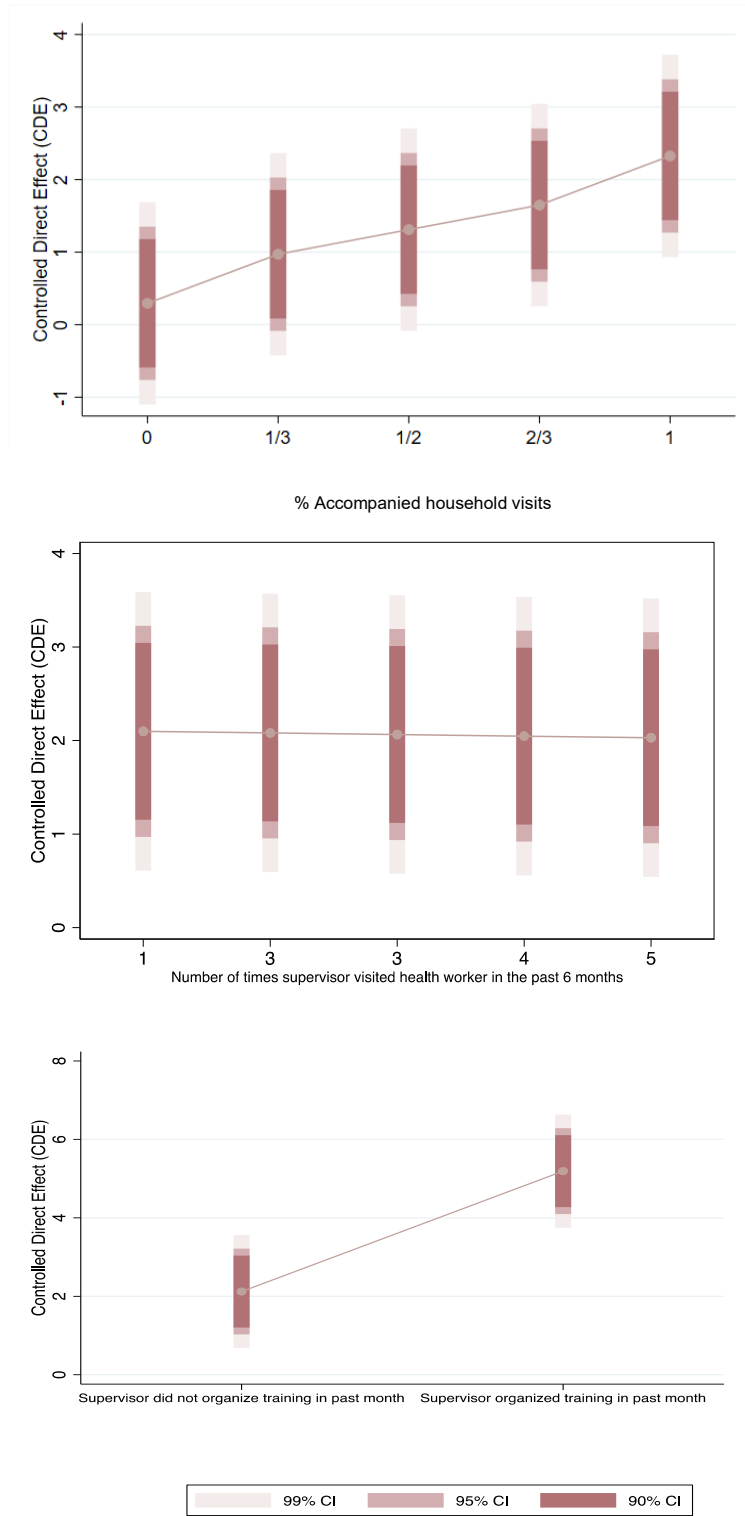


Figure A.3: Monthly Evolution of SMS Reporting



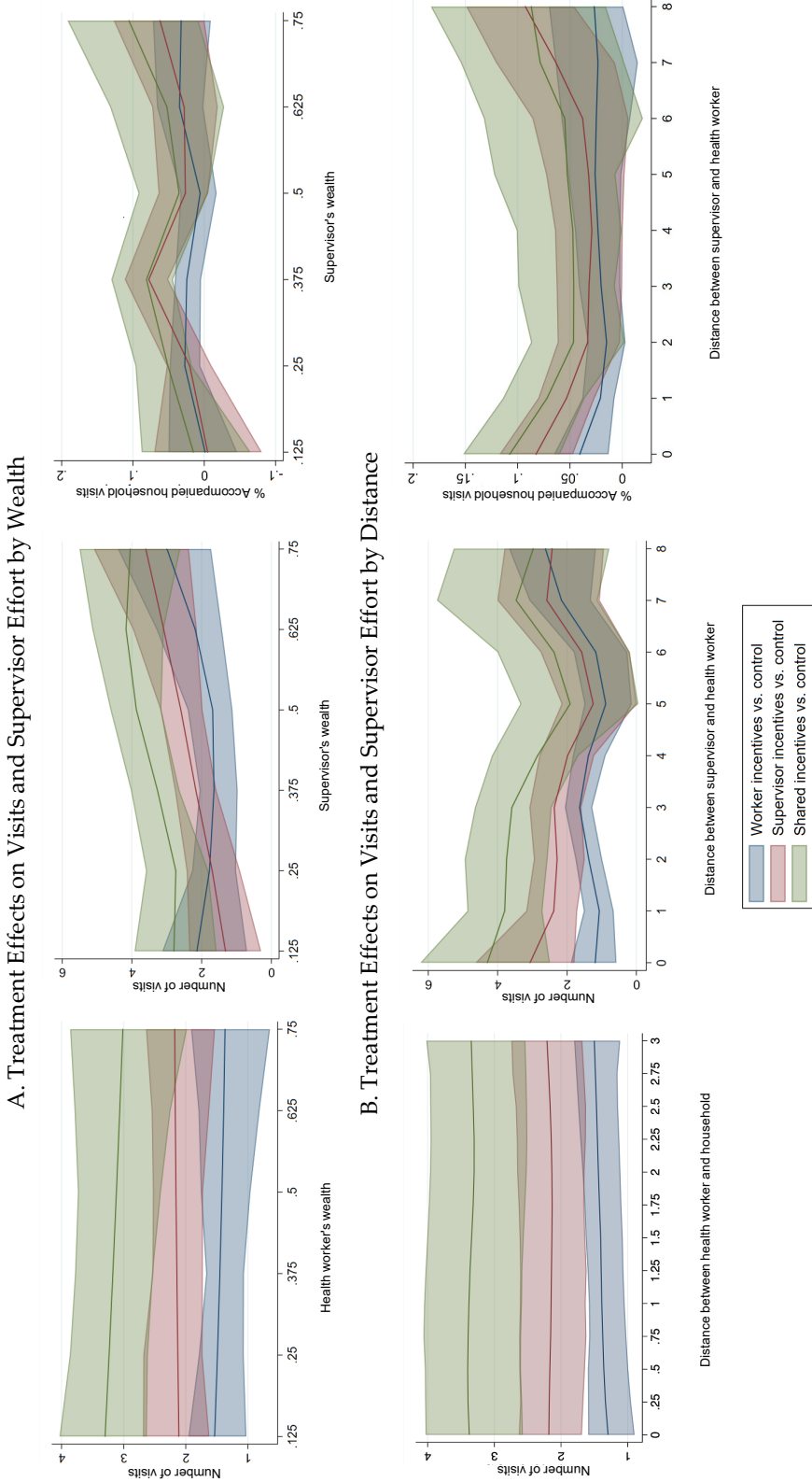
Notes: The figure plots the difference in the number of SMS reports between each treatment group and the control group. The coefficients are estimated from a regression of the number of SMS reports in each single month on the treatment dummies, controlling for the stratification variables and with standard errors clustered at the PHU level. Bars are 95% confidence intervals.

Figure A.4: Mediation Analysis



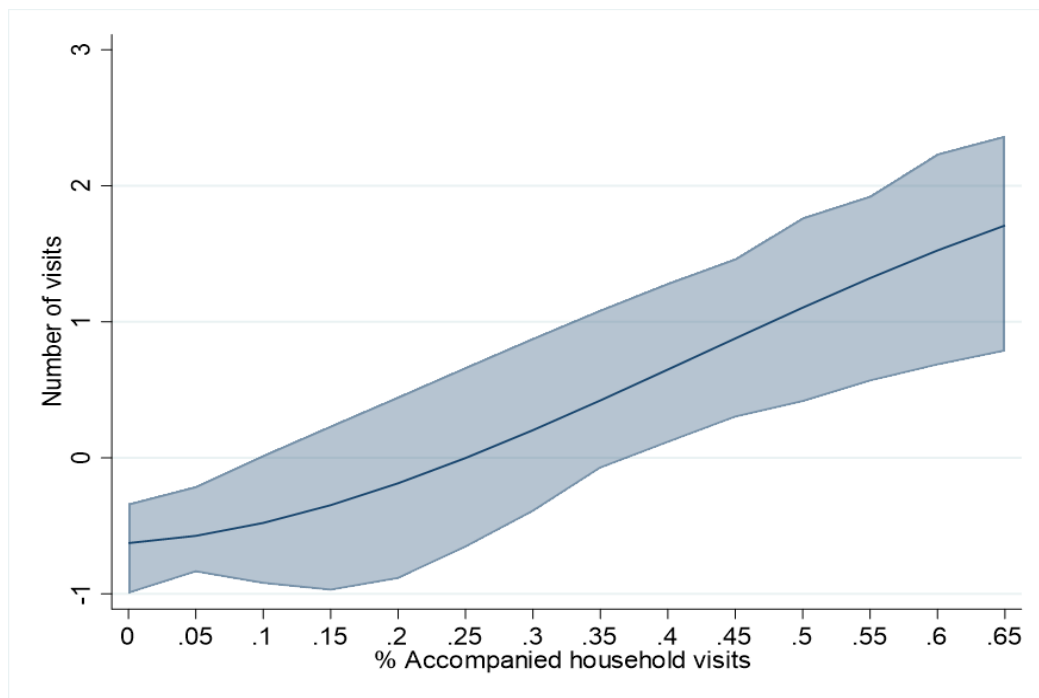
Notes: This figure plots the controlled direct effect (CDE) of the worker incentives treatment on the number of visits provided by a health worker for different values of supervisor's effort, measured differently in the two figures.

Figure A.5: Non-Parametric Estimates of Visits and Supervisor Effort by Wealth and Distance



Notes: The figure plots non-parametric estimates of the treatment effects on the number of visits (left and middle figures) and on the supervisor effort index (right figures) by wealth score and by distance. Standard errors are bootstrapped for each value of the x-axis, with 100 repetitions and the re-sampling is with replacement. 95% confidence intervals presented in the figures. In the right figure of Panel B, the “distance between health worker and household” is measured at the household level and the analysis is performed at the household level. In all the other figures, the analysis is performed at the health worker level.

Figure A.6: Non-Parametric Estimates of Visits by Supervisor Effort



Notes: The figure plots non-parametric estimates of the fraction of accompanied household visits (supervisor effort) on the number of visits provided by the health worker. Standard errors are bootstrapped for each value of the x-axis, with 100 repetitions and the re-sampling is with replacement. 95% confidence intervals presented in the figure.

Table A.1: Balance Checks (Continued)

	P-values from Pairwise Treatment Comparisons					
	(1)	(2)	(3)	(4)	(5)	(6)
	Worker Incentives = Supervisor Incentives	Worker Incentives = Shared Incentives	Supervisor Incentives = Shared Incentives	Worker Incentives = Control	Supervisor Incentives = Control	Shared Incentives = Control
<b>A. Characteristics of the supervisors (N=372)</b>						
Male = {0, 1}	0.823	0.869	0.957	0.923	0.750	0.796
Age (in years)	0.664	0.151	0.074	0.615	0.370	0.371
Completed primary education = {0, 1}	0.399	0.454	0.109	0.592	0.748	0.195
Completed secondary education = {0, 1}	0.395	0.671	0.199	0.473	0.883	0.249
Wealth score (0 to 8)	0.901	0.285	0.215	0.371	0.295	0.888
Number of health workers responsible for	0.375	0.450	0.904	0.054	0.304	0.253
<b>B. Characteristics of the health workers (N= 2,970)</b>						
Male = {0, 1}	0.912	0.218	0.170	0.678	0.749	0.102
Age (in years)	0.472	0.338	0.838	0.009	0.067	0.088
Completed primary education = {0, 1}	0.812	0.329	0.201	0.405	0.528	0.059
Completed secondary education = {0, 1}	0.944	0.708	0.738	0.666	0.590	0.397
Wealth score (0 to 8)	0.915	0.138	0.112	0.835	0.736	0.094
Number of households responsible for	0.532	0.353	0.711	0.291	0.138	0.096
Distance to supervisor (in km)	0.043	0.443	0.228	0.204	0.443	0.636
<b>C. Characteristics of the female household respondent, aggregated to village level (N=2,970)</b>						
Age (in years)	0.851	0.477	0.388	0.099	0.080	0.347
Completed primary education = {0, 1}	0.072	0.257	0.440	0.065	0.923	0.469
Completed secondary education = {0, 1}	0.924	0.776	0.712	0.669	0.755	0.470
Wealth score (0 to 8)	0.785	0.581	0.324	0.122	0.141	0.015
Distance to health worker (in km)	0.727	0.907	0.818	0.184	0.327	0.225
<b>D. Characteristics of the village (N=372)</b>						
Accessible road to health facility= {0, 1}	0.784	0.511	0.361	0.809	0.991	0.400
Phone network available	0.715	0.341	0.210	0.361	0.222	0.955
Phone network is reliable	0.604	0.368	0.666	0.052	0.122	0.280
<b>E. Services provided by local health facilities per month (N=372)</b>						
Number of pregnant women services	0.669	0.539	0.811	0.311	0.467	0.637
Number of institutional births	0.749	0.740	0.565	0.229	0.432	0.206
Number of fully immunized infants	0.358	0.983	0.319	0.520	0.817	0.488
Number of malaria cases treated	0.345	0.102	0.458	0.076	0.368	0.860
Number of diarrhea cases treated	0.674	0.383	0.746	0.379	0.727	0.973

Notes: Each row presents p-values from pairwise treatment comparisons. These are calculated from a regression, where the variable is regressed on an indicator for worker, supervisor and shared incentives treatment. All regressions include stratification variables. Standard errors are clustered at the PHU level in worker/village level regressions and we use robust standard errors in PHU/supervisor level regressions.

Table A.2: Visits (Aggregated to Entire Village)

Dep. Var.	(1)	(2)	(3)
	Total number of visits provided by the health worker to sampled households per month	Total number of visits provided by the health worker in the entire village per month	Total number of visits provided by all health workers in the PHU per month
Worker incentives	0.982*** (0.245)	17.725*** (4.429)	173.143*** (40.189)
Supervisor incentives	0.998*** (0.229)	18.007*** (4.139)	154.653*** (38.853)
Shared incentives	1.414*** (0.214)	25.505*** (3.862)	215.047*** (35.299)
Unit	Worker	Worker	Supervisor
Observations	2,926	2,926	372
Mean dep. var.	3.154	56.906	448.434
Mean dep. var. in Control	2.275	41.040	303.529
p-value Worker = Supervisor	0.957	0.957	0.709
p-value Supervisor = Shared	0.110	0.110	0.184
p-value Worker = Shared	0.116	0.116	0.369

Notes: Col. (2) divides the total number of household visits provided by the health worker to sampled households per month (col. 1) by the share of households in the village sampled. All regressions include stratification variables. Standard errors are clustered at the PHU level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table A.3: Visit Type

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. Var.	% households who received [visit type] from the health worker in the past 6 months							
Visit Type	Natal-related				Disease-related			
	Accompanied		Pre and post-natal visit		Index (cols. 1-3)	Routine visit	Treatment/referrals of under-5 children	Follow-up visit of under-5 children
Worker incentives	0.037** (0.016)	-0.005 (0.007)	0.027 (0.017)	0.069 (0.049)	0.068** (0.033)	0.053** (0.025)	0.042* (0.022)	0.155*** (0.060)
Supervisor incentives	0.027* (0.016)	0.004 (0.008)	0.037* (0.019)	0.092* (0.051)	0.089*** (0.030)	0.071** (0.028)	0.031 (0.024)	0.178*** (0.061)
Shared incentives	0.064*** (0.017)	0.008 (0.008)	0.051*** (0.017)	0.168*** (0.051)	0.151*** (0.029)	0.111*** (0.024)	0.079*** (0.020)	0.324*** (0.056)
Unit	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker
Observations	2,926	2,926	2,926	2,926	2,926	2,926	2,926	2,926
Mean dep. var.	0.179	0.041	0.132	0.000	0.517	0.504	0.201	0.000
Mean dep. var. in Control	0.145	0.038	0.103	-0.087	0.437	0.443	0.162	-0.171
p-value Worker = Supervisor	0.543	0.193	0.604	0.650	0.540	0.527	0.669	0.733
p-value Supervisor = Shared	0.037	0.660	0.455	0.154	0.046	0.143	0.046	0.024
p-value Worker = Shared	0.132	0.069	0.151	0.056	0.014	0.020	0.094	0.008

Notes: The index in col. (4) [resp., col. (8)] estimates an equally weighted average of the z-scores of variables in cols. (1)-(3) [resp., cols. (5)-(7)]. All regressions include stratification variables. Standard errors clustered at the PHU level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.



Table A.4: Household Targeting

Dep. Var.	(1)	(2)	(3)	(4)	(5)
	Household's wealth score (0 to 8)	Household's distance to health worker (in km)	Household's respondent is a family member of the health worker = {0, 1}	Household's respondent is a friend of the health worker = {0, 1}	Household received no visit accompanied by the supervisor = {0, 1}
Worker incentives	2.118*** (0.555)	2.002*** (0.673)	2.113*** (0.568)	2.080*** (0.587)	1.661* (0.912)
Supervisor incentives	2.129*** (0.509)	1.972*** (0.584)	1.889*** (0.505)	1.932*** (0.505)	0.670 (0.806)
Shared incentives	3.385*** (0.492)	3.632*** (0.695)	3.515*** (0.540)	3.461*** (0.523)	2.227*** (0.859)
X	0.046 (0.095)	-0.333*** (0.097)	2.583*** (0.595)	0.261 (0.581)	-3.285*** (0.460)
Worker incentives * X	-0.208 (0.158)	0.206 (0.198)	-0.353 (0.828)	0.244 (1.010)	0.368 (0.822)
Supervisor incentives * X	0.042 (0.134)	0.199 (0.152)	0.474 (0.772)	1.629 (1.073)	1.594* (0.867)
Shared incentives * X	-0.000 (0.138)	0.072 (0.142)	-0.836 (0.853)	-1.066 (0.977)	1.118 (0.829)
Unit	Household	Household	Household	Household	Household
Observations	8,559	5,538	8,601	8,601	8,459
Mean Dep. Var.	7.314	7.314	7.314	7.314	7.314
Mean Dep. Var. in Control	5.360	5.360	5.360	5.360	5.360
Mean X	0.000	1.465	0.308	0.112	0.793
p-value Worker*X = Supervisor*X	0.151	0.974	0.275	0.261	0.221
p-value Supervisor*X = Shared*X	0.783	0.441	0.096	0.028	0.634
p-value Worker*X = Shared*X	0.232	0.519	0.566	0.246	0.447

Notes: All regressions include stratification variables. Standard errors clustered at the PHU level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table A.5: Services Provided by the Health Facility

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Pre- and post-natal care at the health facility in the past month			Disease treatments at the health facility in the past month			
Dep. Var.	Index (cols. 2-4)	Number of pregnant women services	Number of institutional births	Number of fully immunized children	Index (cols. 6-7)	Number of malaria cases treated	Number of diarrhea cases treated
Worker incentives	0.108 (0.094)	5.001 (5.511)	0.895 (1.020)	2.302 (1.553)	0.175* (0.099)	9.857* (5.839)	4.309** (2.102)
Supervisor incentives	0.097 (0.083)	4.799 (4.220)	1.731 (1.090)	0.852 (1.352)	0.187** (0.094)	10.104* (5.767)	2.420 (2.231)
Shared incentives	0.244* (0.126)	13.918* (7.283)	2.552* (1.389)	3.042* (1.625)	0.223* (0.132)	9.455 (6.621)	6.309* (3.269)
Unit	PHU	PHU	PHU	PHU	PHU	PHU	PHU
Observations	371	371	371	371	371	371	371
Mean dep. var.	0.000	41.889	13.776	12.406	0.000	57.464	18.936
Mean dep. var. in Control	-0.110	36.063	12.513	10.892	-0.155	49.595	15.582
p-value Worker = Supervisor	0.916	0.971	0.483	0.386	0.908	0.967	0.494
p-value Supervisor = Shared	0.269	0.209	0.584	0.203	0.800	0.923	0.291
p-value Worker = Shared	0.323	0.263	0.246	0.690	0.733	0.953	0.569

Notes: The index in col. (1) [resp., col. (5)] estimates an equally weighted average of the z-scores of variables in cols. (2)-(4) [resp., cols. (6)-(7)]. The number of observations is 371 instead of 372 because of one missing variable. All regressions include stratification variables. Robust standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

Table A.6: Reporting by Network Availability

Dep. Var.	(1)	(2)
	Reporting rate = number of reports/number of visits	
<b>A. Treatment effects for villages <u>without</u> phone network</b>		
No network * Worker incentives	0.080 (0.059)	0.098 (0.070)
No network * Supervisor incentives	0.011 (0.045)	0.006 (0.055)
No network * Shared incentives	0.022 (0.044)	0.020 (0.054)
<b>B. Treatment effects for villages <u>with</u> phone network</b>		
Network * Worker incentives	0.238*** (0.046)	0.252*** (0.052)
Network * Supervisor incentives	0.063* (0.036)	0.072* (0.041)
Network * Shared incentives	0.101** (0.039)	0.111*** (0.042)
Network	0.014 (0.027)	0.006 (0.032)
Unit	Worker	Worker
Extra Controls	No	Yes
Observations	2,532	2,222
Mean Dep. Var.	0.177	0.177
Mean Dep. Var. in Control & No Network	0.080	0.080
<b><i>Treatment comparisons in Panel A (No network)</i></b>		
p-value Worker=Supv	0.186	0.106
p-value Worker=Shared	0.257	0.157
p-value Supv=Shared	0.748	0.708
<b><i>Treatment comparisons in Panel B (Network)</i></b>		
p-value Worker=Supv	0.001	0.002
p-value Worker=Shared	0.010	0.015
p-value Supv=Shared	0.389	0.425
<b><i>Treatment comparisons across Panels (No network vs. network)</i></b>		
p-value for Worker incentives	0.016	0.040
p-value for Supervisor incentives	0.239	0.205
p-value for Shared incentives	0.078	0.091

Notes: The table reports coefficients from a fully interacted model in which the treatment dummies are interacted with a dummy for whether the network is available in the village. Cols. (2) control for the village characteristics that are significantly correlated with network availability ( $p < .1$ ). All regressions include stratification variables. Standard errors are clustered at the PHU level. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

Table A.7: Supervisor Effort – More Outcomes

Dep. Var.	(1)	(2)
	Difference in health workers' health knowledge between baseline and endline	Supervisor ever helped health worker with SMS reporting = {0, 1}
Worker incentives	0.152 (0.119)	-0.018 (0.032)
Supervisor incentives	0.073 (0.117)	-0.007 (0.035)
Shared incentives	0.238* (0.126)	-0.059** (0.029)
Unit	Worker	Worker
Observations	2,927	2,813
Mean dep. var.	0.651	0.158
Mean dep. var. in Control	0.538	0.181
p-value Worker = Supervisor	0.470	0.717
p-value Supervisor = Shared	0.164	0.075
p-value Worker = Shared	0.477	0.120

Notes: The outcome variable in col. (1) reports the difference in health worker knowledge between baseline and endline. Health knowledge is measured through a test that counts the number of correct or almost correct answers out of 7 questions asked to the health worker. The outcome variable in col. (2) is reported by the health worker. All regressions include stratification variables. Standard errors are clustered at the PHU level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

Table A.8: Correlations

	(1)	(2)	(3)	(4)	(5)	(6)
	Number of years of experience of the health worker	Health worker has high experience (above median of 4 years) = {0, 1}	Supervisor's observability of output [Correlation between actual and perceived ranking]	Supervisor has low observability of output = {0, 1} [Correlation between actual and perceived ranking is in bottom decile]	Difference between supervisor and health worker hourly pay in other job	Supervisor has higher hourly pay than health worker in other job = {0,1}
Unit of Observations	Worker	Worker	Supervisor	Supervisor	Worker	Worker
Mean	5.039	0.473	0.067	0.144	-0.958	0.514
S.D.	4.481	-	0.425	-	18.358	-
<b>A. Characteristics of the health workers</b>						
	Male = {0, 1}	0.129***				
	Age (in years)	0.166***	0.119***		-0.028	0.006
	Completed primary education = {0, 1}	-0.024	0.178***		0.026	0.045
	Completed secondary education = {0, 1}	0.022	-0.051***		-0.002	-0.038
	Wealth score (0 to 8)	-0.052***	-0.006		0.027	-0.064
	Number of households responsible for Distance to supervisor (in km)	0.017	-0.073***		-0.070*	-0.048
		0.069***	0.007		0.020	-0.002
			0.084***		-0.018	0.013
<b>B. Characteristics of the supervisors</b>						
	Male = {0, 1}		-0.013	0.066		
	Age (in years)		0.044	-0.061		
	Completed primary education = {0, 1}		0.086	-0.008		
	Completed secondary education = {0, 1}		-0.098*	0.016		
	Wealth score (0 to 8)		0.032	-0.067		
	Number of health workers responsible for Average distance to supervisor (in km)		0.086	-0.245***		
	% health workers > 1 km away		-0.020	0.092*		
			-0.038	0.133**		

Notes: This table presents summary statistics for each column variable, and pairwise correlations of the column variable with the raw variable. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

Table A.9: Heterogeneity by Worker Experience

	(1)	(2)	(3)	(4)
Dep. Var.	Number of visits		Supervisor effort: % Accompanied household visits	
<b>A. Treatment effects for workers with experience below the median:</b>				
Low experience * Worker incentives	2.054*** (0.628)	2.412*** (0.697)	0.030 (0.025)	0.029 (0.026)
Low experience * Supervisor incentives	2.576*** (0.598)	2.726*** (0.649)	0.067*** (0.029)	0.068** (0.029)
Low experience * Shared incentives	4.022*** (0.684)	4.332*** (0.748)	0.092*** (0.026)	0.103*** (0.026)
<b>B. Treatment effects for workers with experience above the median:</b>				
High experience * Worker incentives	2.246*** (0.780)	2.128*** (0.778)	0.030 (0.031)	0.032 (0.032)
High experience * Supervisor incentives	1.720** (0.669)	1.638** (0.650)	0.045 (0.030)	0.038 (0.031)
High experience * Shared incentives	2.583*** (0.608)	2.536*** (0.660)	0.030 (0.030)	0.021 (0.032)
High experience	1.057** (0.532)	1.201** (0.565)	0.017 (0.025)	0.034 (0.027)
Unit	Worker	Worker	Worker	Worker
Extra Controls	No	Yes	No	Yes
Observations	2,909	2,552	2,902	2,547
Mean Dep. Var.	7.296	7.296	0.204	0.204
Mean Dep. Var. in Control & Low experience	4.749	4.749	0.131	0.131
<i>Treatment comparisons in Panel A (Low experience)</i>				
p-value Worker=Supv	0.455	0.571	0.226	0.200
p-value Worker=Shared	0.011	0.637	0.029	0.009
p-value Supv=Shared	0.057	0.050	0.431	0.610
<i>Treatment comparisons in Panel B (High experience)</i>				
p-value Worker=Supv	0.551	0.682	0.643	0.864
p-value Worker=Shared	0.684	0.026	0.990	0.740
p-value Supv=Shared	0.234	0.231	0.632	0.258
<i>Treatment comparisons across Panels (Low vs. High experience)</i>				
p-value for Worker incentives	0.824	0.749	0.994	0.928
p-value for Supervisor incentives	0.270	0.173	0.535	0.425
p-value for Shared incentives	0.094	0.054	0.086	0.039

Notes: The table reports the coefficients from a fully interacted model in which the treatment dummies are interacted with a dummy for whether the worker's experience is high or low. "Low experience" is an indicator that takes value one if the health worker has less than the median number of experience (i.e., less than 4 years of experience) as a health worker at baseline. Cols. (2) and (4) control for the health worker characteristics that are significantly correlated with experience (gender, age, wealth score, distance to supervisor). All regressions include stratification variables. Standard errors clustered at the PHU level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

Table A.10: Heterogeneity by Output Observability

Dep. Var.	(1)	(2)
	Side-payment: Supervisor shared incentive with health worker = {0, 1}	
<b>A. Treatment effects for supervisors with low observability of output:</b>		
Low observability * Worker incentives	-0.028 (0.032)	-0.025 (0.035)
Low observability * Supervisor incentives	0.032 (0.065)	0.081 (0.076)
Low observability * Shared incentives	0.067 (0.089)	0.108 (0.090)
<b>B. Treatment effects for supervisors with high observability of output:</b>		
High observability * Worker incentives	0.009 0.009	0.009 (0.015)
High observability * Supervisor incentives	0.205*** (0.052)	0.237*** (0.058)
High observability * Shared incentives	0.107** (0.042)	0.156*** (0.053)
High observability	-0.008 (0.023)	-0.006 (0.025)
Unit	Worker	Worker
Extra Controls	No	Yes
Observations	2,915	2,915
Mean Dep. Var.	0.084	0.084
Mean Dep. Var. in Control & Low observability	0.000	0.000
<b>Treatment comparisons in Panel A (Low observability)</b>		
p-value Worker=Supv	0.370	<0.001
p-value Worker=Shared	0.305	0.164
p-value Supv=Shared	0.750	0.305
<b>Treatment comparisons in Panel B (High observability)</b>		
p-value Worker=Supv	<0.001	0.173
p-value Worker=Shared	0.021	0.007
p-value Supv=Shared	0.135	0.818
<b>Treatment comparisons across Panels (Low vs. High observability)</b>		
p-value for Worker incentives	0.315	0.380
p-value for Supervisor incentives	0.040	0.061
p-value for Shared incentives	0.680	0.619

Notes: The table reports the coefficients from a fully interacted model in which the treatment dummies are interacted with a dummy for whether the supervisor has high/low observability of output. "Low observability" is an indicator that takes value one if the correlation between the actual worker ranking (based on endline household data on visit) and the supervisor's perceived worker ranking at endline is in the bottom decile. Col. (2) also controls for the health worker characteristics that are significantly correlated with observability (supervisor completed secondary school). All regressions include stratification variables. Standard errors are clustered at the PHU level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

Table A.11: Workers with Higher Outside Option than Supervisors

	(1)	(2)
Dep. Var.	Number of visits	Side-payment: Supervisor shared incentive with health worker = {0, 1}
Sample:	Workers with higher outside option than their supervisor	
Worker incentives	0.453 (1.344)	-0.033 (0.065)
Supervisor incentives	2.303 (1.396)	0.248** (0.103)
Shared incentives	3.286** (1.322)	0.029 (0.080)
Unit	Worker	Worker
Observations	291	293
Mean dep. var.	7.641	0.116
Mean dep. var. in Control	5.848	0.044
p-value Worker = Supervisor	0.184	0.020
p-value Supervisor = Shared	0.498	0.088
p-value Worker = Shared	0.033	0.323

Notes: Workers with higher outside option than supervisor are workers with an average hourly earnings from any outside (secondary) job than their supervisor, conditional on both the worker and the supervisor being engaged in an outside job with a positive income. All regressions include stratification variables. Standard errors are clustered at the PHU level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.



Table A.12: Heterogeneity by Performance Ranking, Social Distance and Span of Control

Dep. Var.	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)		
	Number of visits	Supervisor effort: % Accompanied household visits	Side-payment: Supervisor shared incentive with health worker = {0, 1}	Number of visits	Supervisor effort: % Accompanied household visits	Side-payment: Supervisor shared incentive with health worker = {0, 1}	Number of visits	Supervisor effort: % Accompanied household visits	Side-payment: Supervisor shared incentive with health worker = {0, 1}	Number of visits	Supervisor effort: % Accompanied household visits	Side-payment: Supervisor shared incentive with health worker = {0, 1}	Number of visits	Supervisor effort: % Accompanied household visits	Side-payment: Supervisor shared incentive with health worker = {0, 1}	Number of visits	Supervisor effort: % Accompanied household visits	Side-payment: Supervisor shared incentive with health worker = {0, 1}	
<b>Panel A</b>																			
Effects for "Low Rank" workers who are ranked in the bottom half by the supervisor at baseline																			
Low X * Worker incentives	2.366** (0.692)	0.038 (0.026)	0.006 (0.016)	1.726*** (0.612)	0.010 (0.025)	0.004 (0.016)	0.004 (0.025)	1.828** (0.850)	-0.038 (0.034)	0.042 (0.040)	1.730* (1.003)	0.013 (0.041)	0.077 (0.049)	2.714*** (0.711)	0.004 (0.032)	0.107** (0.053)			
Low X * Supervisor incentives	2.356*** (0.583)	0.090* (0.028)	0.182*** (0.047)	2.322*** (0.616)	0.042 (0.030)	0.170*** (0.044)	0.042 (0.030)	2.448*** (0.589)	0.076*** (0.028)	0.218*** (0.062)	2.448*** (0.589)	0.076*** (0.028)	0.218*** (0.062)	3.722*** (0.634)	0.095** (0.027)	0.099* (0.052)			
Low X * Shared incentives	3.752*** (0.592)	0.078*** (0.026)	0.097** (0.038)	3.165*** (0.580)	0.052** (0.024)	0.108** (0.045)	0.052** (0.024)	3.722*** (0.634)	0.095** (0.027)	0.099* (0.052)									
Effects for "High Rank" workers who are ranked in the top half by the supervisor at baseline																			
High X * Worker incentives	1.939*** (0.626)	0.020 (0.026)	0.002 (0.016)	2.559*** (0.788)	0.064** (0.032)	0.007 (0.019)	0.064** (0.032)	2.350*** (0.700)	0.055** (0.027)	-0.007 (0.019)	2.350*** (0.700)	0.055** (0.027)	-0.007 (0.019)	2.448*** (0.589)	0.076*** (0.028)	0.218*** (0.062)			
High X * Supervisor incentives	1.589** (0.722)	0.033 (0.027)	0.173*** (0.048)	2.013*** (0.646)	0.086*** (0.030)	0.193*** (0.054)	0.086*** (0.030)	2.448*** (0.589)	0.076*** (0.028)	0.218*** (0.062)	2.448*** (0.589)	0.076*** (0.028)	0.218*** (0.062)	3.722*** (0.634)	0.095** (0.027)	0.099* (0.052)			
High X * Shared incentives	3.301*** (0.668)	0.044* (0.026)	0.110** (0.043)	3.592*** (0.752)	0.076** (0.032)	0.095** (0.043)	0.076** (0.032)	3.722*** (0.634)	0.095** (0.027)	0.099* (0.052)									
High X	0.515 (0.481)	0.009 (0.019)	0.004* (0.002)	-0.244 (0.519)	-0.065*** (0.024)	0.004 (0.010)	-0.065*** (0.024)	-1.120* (0.578)	-0.016 (0.031)	0.012 (0.036)									
<b>Panel B</b>																			
Effects for "Low Span of Control" PHU in which the supervisors are responsible for less than 7 health workers																			
Effects for "High Span of Control" PHU in which the supervisors are responsible for 8 health workers or more																			
<b>Meaning of X</b>																			
Unit	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker
Observations	2,696	2,689	2,685	2,915	2,908	2,904	2,904	2,926	2,919	2,915	2,926	2,919	2,915	2,926	2,919	2,915	2,926	2,919	2,915
Mean Dep. Var.	7.296	0.204	0.084	7.296	0.204	0.084	7.296	0.204	0.084	7.296	0.204	0.084	7.296	0.204	0.084	7.296	0.204	0.084	7.296
Mean Dep. Var. in Control	5.334	0.164	0.011	5.334	0.164	0.011	5.334	0.164	0.011	5.334	0.164	0.011	5.334	0.164	0.011	5.334	0.164	0.011	5.334
Mean Dep. Var. in Control & Low X	5.118	0.161	0.012	5.410	0.145	0.014	5.410	0.145	0.014	5.410	0.145	0.014	5.410	0.145	0.014	5.410	0.145	0.014	5.410
<i>Treatment comparisons in Panel A (Low X)</i>																			
p-value Worker-Supv	0.647	0.648	<0.001	0.420	0.455	0.001	0.420	0.455	0.001	0.420	0.455	0.001	0.420	0.455	0.001	0.420	0.455	0.001	0.420
p-value Worker-Shared	0.059	0.145	0.017	0.045	0.711	0.022	0.045	0.711	0.022	0.045	0.711	0.022	0.045	0.711	0.022	0.045	0.711	0.022	0.045
p-value Supv-Shared	0.038	0.717	0.145	0.237	0.736	0.303	0.237	0.736	0.303	0.237	0.736	0.303	0.237	0.736	0.303	0.237	0.736	0.303	0.237
<i>Treatment comparisons in Panel B (High X)</i>																			
p-value Worker-Supv	0.989	0.696	<0.001	0.494	0.312	<0.001	0.494	0.312	<0.001	0.494	0.312	<0.001	0.494	0.312	<0.001	0.494	0.312	<0.001	0.494
p-value Worker-Shared	0.072	0.405	0.012	0.242	0.107	0.040	0.242	0.107	0.040	0.242	0.107	0.040	0.242	0.107	0.040	0.242	0.107	0.040	0.242
p-value Supv-Shared	0.033	0.331	0.313	0.040	0.746	0.138	0.040	0.746	0.138	0.040	0.746	0.138	0.040	0.746	0.138	0.040	0.746	0.138	0.040
<i>Treatment comparisons across Panels (Low vs. High X)</i>																			
p-value for Worker incentives	0.523	0.505	0.214	0.312	0.121	0.807	0.312	0.121	0.807	0.312	0.121	0.807	0.312	0.121	0.807	0.312	0.121	0.807	0.312
p-value for Supervisor incentives	0.341	0.576	0.281	0.681	0.210	0.473	0.681	0.210	0.473	0.681	0.210	0.473	0.681	0.210	0.473	0.681	0.210	0.473	0.681
p-value for Shared incentives	0.538	0.246	0.161	0.627	0.490	0.757	0.627	0.490	0.757	0.627	0.490	0.757	0.627	0.490	0.757	0.627	0.490	0.757	0.627

Notes: The table reports the coefficients from a fully interacted model in which the treatment dummies are interacted with a dummy for whether the worker is ranked in the bottom /top half by the supervisor in cols (1)-(3), whether the worker is a friend /family member of the supervisor in cols (4)-(6), whether the span of control is high or low in cols. (7)-(9). All regressions include stratification variables. Standard errors are clustered at the PHU level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

Table A.13: Job Satisfaction

Dep. Var.	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)		(10)		(11)						
	Health worker is satisfied with [...] = {0, 1}				Supervisor is satisfied with [...] = {0, 1}				Health worker perceives the work environment as non-competitive				Health worker perceives self-identifies herself through her job = {0, 1}				Sample: Workers with "low" inequality aversion				Sample: Workers with "medium" inequality aversion				Sample: Workers with "high" inequality aversion		
	Incentives payments	Organization paying the incentives	Job	Incentives payments	Organization paying the incentives	Job	Incentives payments	Organization paying the incentives	Job	Incentives payments	Organization paying the incentives	Job	Incentives payments	Organization paying the incentives	Job	Incentives payments	Organization paying the incentives	Job	Incentives payments	Organization paying the incentives	Job	Incentives payments	Organization paying the incentives				
Worker incentives	0.344*** (0.032)	0.074*** (0.024)	-0.034 (0.035)	0.086 (0.056)	0.012 (0.049)	-0.067 (0.061)	0.012 (0.049)	0.086 (0.056)	0.012 (0.049)	-0.067 (0.061)	-0.046 (0.044)	0.006 (0.026)	0.006 (0.026)	1.982* (1.063)	2.359*** (0.571)	0.922 (1.257)	0.006 (0.026)	0.006 (0.026)	1.982* (1.063)	2.359*** (0.571)	0.922 (1.257)	0.006 (0.026)	0.006 (0.026)	1.982* (1.063)	2.359*** (0.571)	0.922 (1.257)	
Supervisor incentives	-0.003 (0.030)	0.014 (0.028)	-0.025 (0.037)	0.305*** (0.062)	0.082* (0.042)	-0.073 (0.062)	0.305*** (0.062)	0.082* (0.042)	-0.073 (0.062)	-0.025 (0.037)	-0.023 (0.043)	-0.019 (0.030)	-0.019 (0.030)	1.823*** (0.679)	2.419*** (0.598)	1.757 (2.064)	-0.019 (0.030)	-0.019 (0.030)	1.823*** (0.679)	2.419*** (0.598)	1.757 (2.064)	-0.019 (0.030)	-0.019 (0.030)	1.823*** (0.679)	2.419*** (0.598)	1.757 (2.064)	
Shared incentives	0.198*** (0.036)	0.048** (0.024)	-0.047 (0.036)	0.329*** (0.063)	0.092** (0.041)	-0.040 (0.059)	0.329*** (0.063)	0.092** (0.041)	-0.040 (0.059)	-0.047 (0.036)	-0.024 (0.043)	-0.018 (0.029)	-0.018 (0.029)	2.803*** (0.835)	3.675*** (0.572)	4.369** (1.831)	-0.018 (0.029)	-0.018 (0.029)	2.803*** (0.835)	3.675*** (0.572)	4.369** (1.831)	-0.018 (0.029)	-0.018 (0.029)	2.803*** (0.835)	3.675*** (0.572)	4.369** (1.831)	
Unit	Worker	Worker	Worker	Supervisor	Supervisor	Supervisor	Supervisor	Supervisor	Supervisor	Supervisor	Supervisor	Supervisor	Supervisor	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker	Worker
Observations	2,709	2,825	2,970	360	364	359	360	364	359	360	364	359	360	364	359	360	364	359	360	364	359	360	364	359	360	364	359
Mean dep. var.	0.357	0.870	0.768	0.311	0.909	0.738	0.311	0.909	0.738	0.311	0.909	0.738	0.311	0.909	0.738	0.311	0.909	0.738	0.311	0.909	0.738	0.311	0.909	0.738	0.311	0.909	0.738
Mean dep. var. in Control	0.219	0.837	0.795	0.132	0.860	0.787	0.132	0.860	0.787	0.132	0.860	0.787	0.132	0.860	0.787	0.132	0.860	0.787	0.132	0.860	0.787	0.132	0.860	0.787	0.132	0.860	0.787
p-value Worker = Supervisor	<0.001	0.023	0.800	0.001	0.098	0.929	0.001	0.098	0.929	0.001	0.098	0.929	0.001	0.098	0.929	0.001	0.098	0.929	0.001	0.098	0.929	0.001	0.098	0.929	0.001	0.098	0.929
p-value Supervisor = Shared	<0.001	0.186	0.559	0.738	0.757	0.605	0.738	0.757	0.605	0.738	0.757	0.605	0.738	0.757	0.605	0.738	0.757	0.605	0.738	0.757	0.605	0.738	0.757	0.605	0.738	0.757	0.605
p-value Worker = Shared	<0.001	0.254	0.717	<0.001	0.048	0.664	<0.001	0.048	0.664	<0.001	0.048	0.664	<0.001	0.048	0.664	<0.001	0.048	0.664	<0.001	0.048	0.664	<0.001	0.048	0.664	<0.001	0.048	0.664

Notes: A worker/supervisor is defined as unsatisfied with the incentive payment if she reports that the incentives she is paid per valid SMS report is "not fair" (too little). A worker/supervisor is defined as unsatisfied with the environment if she reports that the environment is competitive rather than cooperative. "Health worker perceives self-identifies herself through her job" is a dummy variable that takes value 1 if the health worker answers "community health worker" to the following question: "We have spoken with many people in Sierra Leone and they identify themselves to different groups. Some people self identify themselves as belong to an ethnic group, a language, a religion, etc. Others identify themselves describe themselves in terms of their job (in your case the health worker job). Besides being a citizen of Sierra Leone, which specific group do you feel you belong to first and foremost?". Such questions were not asked to the supervisor. The sample size changes across columns because a number of health workers and supervisors answered "don't know" to the questions. Columns (9) to (11) are restricted to workers indicated in the panel headings. Inequality aversion is measured by asking each health worker the following hypothetical questions: "There is a local farm that hires workers to help with the potato harvest. Sheka accepts a contract to work at the farm for 20,000 SLL per day. He arrives at work the next morning. The farm is very big and there is one supervisor for the 20 workers helping with the harvest. He learns that his supervisor gets paid [amount] SLL per day. Do you think Sheka will show up to work the next day?," and amount = {20,000; 30,000; 120,000}. Our measure of inequality aversion takes value 0 ("low") if the worker answers that Sheka would always show up to work, regardless of the amount; value 1 ("medium") if worker reports that Sheka would not show up only if amount=120,000 and would show up otherwise; value 2 ("high") if the worker reports that Sheka would not show up if amount > 30,000. All regressions include stratification variables. Standard errors clustered at the PHU level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table A.14: Parameter Estimates

	(1)
Complementarity $\gamma$	3.1
Contractual friction $z$	3.0
Worker unit cost of effort $c_1$	23.0
Supervisor unit cost of effort $c_2$	1610.9
Worker baseline incentive $b_1$	57.8
Supervisor baseline incentive $b_2$	19.0
$\alpha$	2.0
$\Delta$ in marginal product of worker effort (shared incentive)	36 %
$\Delta$ in marginal product of worker effort (control)	17 %
Total worker cost of effort (control)	69.0
Total supervisor cost of effort (control)	178.9

Notes: The first panel of the table shows parameter estimates obtained using minimum distance estimation. We use eight empirical moments: supervisor effort in each one of the four experimental groups, and the number of visits per month in each one of the four experimental groups. Supervisor effort is proxied by the proportion of households that receive a visit where the worker is accompanied by the supervisor. Costs are expressed in thousands of SSL. The second panel shows some quantities implied by the parameter estimates. To calculate the change in the marginal product of worker effort we take the derivative of the production function with respect to worker effort (i) with  $\gamma = 3.1$  and supervisor effort fixed at the level indicated in parenthesis, and (ii) with  $\gamma = 0$ . To calculate the total cost of an agent effort we multiply the unit cost of effort by the average effort exerted by the agent in the control group.

Table A.15: Moment Fit

Moments	Targeted real	Simulated
Supervisor effort in worker incentives treatment	0.198	0.159
Supervisor effort in supervisor incentives treatment	0.225	0.278
Supervisor effort in shared incentives treatment	0.228	0.230
Supervisor effort in control group	0.164	0.111
Output (visits) in worker incentives treatment	10.551	10.908
Output (visits) in supervisor incentives treatment	10.413	10.678
Output (visits) in shared incentives treatment	11.827	11.255
Output (visits) in control group	7.256	7.174
Side payment in worker incentives treatment (1,000 SSL)	0.088	0.000
Side payment in supervisor incentives treatment (1,000 SSL)	0.715	0.000
Side payment in shared incentive group (1,000 SSL)	0.428	0.000
Value loss function		64.9

Notes: The table shows the empirical moments used for estimation of the structural model and the moments that we simulated with our model using the estimated parameter values.

Table A.16: Heterogeneity by Promotion Incentives

Dep. Var.	Household visits provided by the health worker in the past 6 months						% households who trust the health worker as a health provider
	(1)	(2)	(3)	(4)	(5)	(6)	
	Number of visits	% households visited	Number of visit types	Average visit length	Number of health topics discussed per visit		
Worker incentives	1.635 (1.125)	0.094* (0.048)	0.305 (0.189)	1.221 (2.128)	0.006 (0.203)	0.005 (0.045)	
Supervisor incentives	1.664* (0.992)	0.063 (0.051)	0.414* (0.237)	2.116 (2.157)	0.386 (0.312)	0.064 (0.045)	
Shared incentives	3.335*** (1.186)	0.139*** (0.047)	0.611*** (0.190)	4.432** (2.041)	0.521** (0.238)	0.125*** (0.044)	
Meritocratic promotions	0.651 (0.766)	0.072* (0.042)	0.264 (0.163)	2.369 (1.730)	0.224 (0.190)	0.070* (0.039)	
Pay progression	-0.895 (0.844)	0.004 (0.048)	0.011 (0.182)	-1.980 (1.905)	0.026 (0.265)	0.020 (0.043)	
Meritocratic promotions + Info about supv. pay	0.272 (0.848)	-0.031 (0.044)	0.065 (0.163)	-0.914 (1.555)	0.080 (0.203)	-0.017 (0.048)	
Worker incentives * Meritocratic promotions	-0.784 (1.700)	-0.140** (0.068)	-0.485* (0.263)	-3.099 (2.765)	-0.216 (0.309)	-0.020 (0.061)	
Supervisor incentives * Meritocratic promotions	2.352 (1.429)	0.037 (0.066)	0.128 (0.307)	0.271 (2.761)	-0.194 (0.393)	-0.084 (0.062)	
Shared incentives * Meritocratic promotions	0.064 (1.533)	-0.068 (0.064)	-0.172 (0.270)	-2.104 (2.672)	-0.114 (0.389)	-0.158** (0.065)	
Worker incentives * Info about supv. pay	0.491 (1.427)	-0.010 (0.073)	-0.033 (0.263)	3.265 (2.829)	0.322 (0.356)	0.045 (0.065)	
Supervisor incentives * Info about supv. pay	-0.046 (1.248)	-0.018 (0.071)	-0.261 (0.293)	-1.068 (2.744)	-0.315 (0.412)	-0.068 (0.067)	
Shared incentives * Info about supv. pay	0.217 (1.376)	-0.045 (0.067)	-0.121 (0.259)	-0.481 (2.795)	-0.200 (0.356)	-0.082 (0.062)	
Worker incentives * Merit. + Info about supv. pay	2.157 (1.569)	0.059 (0.065)	0.292 (0.251)	2.954 (2.657)	0.521 (0.316)	0.102 (0.065)	
Supervisor incentives * Merit. + Info about supv. pay	-0.416 (1.303)	0.057 (0.070)	-0.233 (0.279)	-0.011 (2.559)	-0.354 (0.372)	0.017 (0.067)	
Shared incentives * Merit. + Info about supv. pay	-0.290 (1.510)	0.058 (0.064)	0.080 (0.253)	1.039 (2.475)	0.289 (0.337)	0.016 (0.064)	
Unit	Worker	Worker	Worker	Worker	Worker	Worker	Worker
Observations	2,926	2,926	2,926	2,926	2,926	2,926	2,926
Mean dep. var.	7.296	0.709	1.745	14.39	2.248	0.745	
Mean dep. var. in Control	5.334	0.637	1.448	12.32	2.015	0.707	

Notes: All regressions include stratification variables. Standard errors clustered at the PHU level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table A.17: Sample of Health Workers without Promotion Incentives

	(1)	(2)	(3)	(4)	(5)	(6)
	Household visits provided by the health worker in the past 6 months					
Dep. Var.	Number of visits	% households visited	Number of visit types	Average visit length	Number of health topics discussed per visit	% households who trust the health worker as a health provider
Worker incentives	2.357*** (0.815)	0.119*** (0.040)	0.345*** (0.132)	3.915*** (1.359)	0.330** (0.165)	0.051 (0.033)
Supervisor incentives	2.350*** (0.686)	0.138*** (0.038)	0.452*** (0.129)	1.988 (1.233)	0.362** (0.171)	0.048 (0.038)
Shared incentives	3.122*** (0.655)	0.154*** (0.037)	0.636*** (0.134)	4.267*** (1.251)	0.603*** (0.165)	0.060* (0.035)
Unit	Worker	Worker	Worker	Worker	Worker	Worker
Observations	960	960	960	960	960	960
Mean dep. var.	6.753	0.682	1.660	13.702	2.168	0.730
Mean dep. var. in Control	4.777	0.571	1.268	11.060	1.811	0.680
p-value Worker = Supervisor	0.993	0.600	0.425	0.147	0.868	0.928
p-value Supervisor = Shared	0.258	0.661	0.178	0.062	0.209	0.746
p-value Worker = Shared	0.344	0.330	0.036	0.794	0.146	0.780

Notes: Sample restricted to health workers who did experience any change in the promotion system. All regressions include stratification variables. Standard errors clustered at the PHU level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

## B Additional Material on the Context and Intervention

### B.1 Context

#### B.1.1 Pay of health workers and supervisors

In our sample, health workers report dedicating 18 hours per week to their health worker job and 22 hours to other jobs from which they earn another 127,000 SLL (\$14.85) per month. The hourly rate from the health worker job is thus comparable to their outside option. Throughout the draft, we use the January 2019 exchange rate: 1 USD = 8,550 SLL (Sierra Leonean Leones). On the other hand, supervisors report working 11 hours per week on the health program. They dedicate 21 hours to other jobs from which they earn another 156,000 SLL (\$28.1) per month. When a supervisor's position becomes available, one of the health workers in that PHU is promoted to take over the position.

#### B.1.2 Checklists

Workers are expected to follow a checklist when they visit a household. The checklist differs depending on the type of visit the health worker conducts:

(i) Prenatal visits to a pregnant woman: Health workers are asked to visit expecting mothers at least four times over the course of a pregnancy. During these visits, health workers should first make sure not only the pregnant woman but also her husband or other decision-makers in the family are present. Second, they assess the pregnant woman for danger signs (e.g., convulsion or fever) that would require an immediate referral to the PHU. Third, they use the Mother, Newborn, and Child Health Card to assess previously agreed actions and current health practices related to the pregnancy with the family. Fourth, health workers present new visit-specific information to the family (e.g., helping with planning for the birth including arranging transportation so the woman can give birth at the PHU). Fifth, health workers and families identify barriers together and agree on an action plan until the next visit. Finally, health workers must fill a register that documents what they have done during the visit.

(ii) Accompanying a pregnant woman to the PHU for child birth: The health workers should accompany pregnant women to the PHU for giving birth. At the PHU, the health worker should help the family to obtain all necessary drugs and other supplies. In case a woman delivers at her home rather than the PHU, the health worker should assist during the birth, communicate the birth to the head of the PHU, and accompany the woman for a post-natal visit at the PHU as soon as possible after the birth.

(iii) Postnatal visits within one month of birth: Health workers are asked to visit mothers with newborn babies at least four times during the first month after birth. During these visits, health workers first assess the mother and baby for the presence of any danger signs (e.g., fever or convulsions) that would require a referral to the PHU. Second, they discuss with the family how well they were able to implement health practices agreed upon with the health worker during the previous visit. Third, health workers present new visit-specific information about health behaviors relevant to the mother and baby (e.g., telling the mother to keep the baby warm and only breastfeed the baby). Fourth, they go over a checklist of recommended health behaviors and check whether or not the family knows about and follows

them. Fifth, for the items on the checklist which the family does not follow yet, health workers discuss barriers and possible solutions with the family and make a new action plan to be discussed during the next visit. Finally, health workers fill a register that documents what they have done during the visit.

(iv) Child health checkup visits: Health workers are asked to visit mothers and their young children five times between the age of 1 - 15 months. During these visits, health workers first assess the child for danger signs (e.g., convulsions or being unable to breast feed) that would require an immediate referral to the PHU. Second, they use the Mother, Newborn, and Child Health Card to assess previously agreed actions and current health practices related to the pregnancy with the family. Third, health workers present visit-specific information to the mother (e.g., advising the mother how to transition from exclusive breast feeding to other foods after the age of 6 months or reminding the mother of scheduled vaccinations for the child). Fourth, health workers and families identify barriers together and agree on an action plan until the next visit. Finally, health workers must fill a register that documents what they have done during the visit.

(v) Visits in which a disease is diagnosed and the patient is either treated or referred to the health facility: The main focus of health workers is on children who are younger than 5 years. They are trained to identify whether a child has diarrhea, malaria, or pneumonia and to decide whether or not the child can be treated by the health worker or whether it needs to be referred to the PHU. First, health workers assess the child for general danger signs (e.g., convulsions or the child being unable to breastfeed or drink) which would require an immediate referral to the PHU. Second, they assess the child for the three conditions above (e.g., they count the breaths per minute and compare this to age-specific threshold values in order to assess a child for pneumonia) and decide whether or not the child requires treatment and whether or not the child needs to be referred to the PHU. Health workers also should always assess children for malnutrition.

(vi) Follow-up visits of sick patients: For sick children that were not referred to the PHU, health workers are supposed to do at least two follow-up visits at the child's home on the third and sixth days after the start of the treatment. During these follow-up visits, health workers re-assess the sick child following the same steps as during the initial visit. They also should discuss the condition of the child with the caregiver and counsel the caregiver on disease-specific steps they need to undertake as well as general recommended health behaviors (e.g., hand washing or bed net use).

(vii) Routine household visits: First, health workers introduce themselves and the purpose of the visit. Second, they use the Family Health Card and assess previously agreed upon actions as well as current household health practices with the family. Third, health workers present new health information (e.g., on topics like hand-washing and sanitation, bed net use, or family planning) to the family. Finally, health workers and families identify barriers together and agree on an action plan until the next routine household visit by the health worker.

### **B.1.3 Supervision**

Supervisors have three main tools to train and advise health workers:

(i) Monthly trainings: Supervisors host a monthly meeting at the PHU which all health workers under their supervision are supposed to attend. During these trainings, supervi-

sors provide information on health knowledge (how to prevent diseases, recognize dangerous signs). Central to these monthly meetings is the facilitation of mutual learning among health workers. They are asked to share both successes and barriers they experienced during their work in the previous month. Depending on the number of affected health workers, supervisors help them individually or collectively find solutions for the barriers that have been identified. This often involves re-training health workers on the checklists mentioned above or advising them on effective communication strategies health workers can use with households.

(ii) One-to-one trainings: Supervisors are asked to visit each health worker under their supervision in their village once per month. During these field visits, supervisors go through the records of health workers and randomly select three recent households the health worker provided a service to. For each of these three cases, supervisors ask the health worker about the detailed actions the health worker took and validate whether the steps on the checklists mentioned above have been followed. Supervisors then provide detailed feedback in which they identify gaps in the health worker’s knowledge and explain again in detail how to provide the health services correctly.

(iii) In-the-field supervision / direct observation: Supervisors are asked to accompany the health worker to household visits and directly observe how the health worker conducts the visit. During these household visits, supervisors identify both the strengths and weaknesses of the health worker and raise awareness about the importance of her work with the family. After the household visit, supervisors provide personal feedback to the health worker in private.

## **B.2 Intervention**

### **B.2.1 Choice of the treatments**

Theoretically, the set of possible splits an organization can select from is larger than the three splits in our design (100%-0%, 50%-50% or 0%-100%). An organization could for instance decide to give 25% of the incentive to the worker and 75% to the supervisor (or vice-versa). Due to the limited sample size of the experiment, we could not test the effect of a wider set of possible splits. We chose the 50%-50% split because informal discussions we had with supervisors (outside of our experimental areas) and government officials indicated that this split was the most natural in our setting. More precisely, we asked these informants how they would split an incentive of 2,000 SLL between supervisors and workers such that the number of visits provided in the PHU is maximized. 63% of the respondents answered that the supervisor should be assigned half of the incentive (1,000 SLL), 8% answered that they should be assigned 60% of the incentive (1,200 SLL), 21% answered that they should be assigned 75% of the incentive (1,500 SLL), and the remaining 8% chose another split. In line with this, our structural model confirms that the optimal split is indeed very close to the 50%-50% one.



## B.2.2 Location of the experiment

Our experiment takes place in 372 PHUs across six districts of Sierra Leone. One district is located in the south (Bo), one in the east (Kenema), three in the north (Bombali, Tonkolili and Kambia) and one in the west (Western Area Rural). Out of the existing 823 PHUs across the six districts, we excluded half because no up-to-date and verified list of health workers was available, and selected 372 PHUs from the remaining eligible PHUs to be part of the experiment.

## B.2.3 The reporting system

The reporting system works in three steps:

(i) Each time a household visit is provided, the health worker is asked to send an SMS to a toll-free number indicating the date of the service, the name and phone number of the patient, and a one-letter code corresponding to the service type. If the SMS does not include all the required information, the system returns an error message.<sup>43</sup> All health workers in our study (including those in the control group) are asked to report their visits. The incentive was only paid for household visits that fall in one of these categories: (i) prenatal visits to a pregnant woman, (ii) accompanying a pregnant woman to the PHU for child birth, (iii) postnatal visits within 1 month of birth, (iv) child health checkup visits (for children 1-15 months), (v) visits in which a disease is diagnosed and the patient is either treated or referring to the health facility, (vi) follow-up visits of sick patients, (vii) routine household visits (e.g., providing health education on how to prevent diseases).

(ii) The SMS information is automatically uploaded to a server from which the performance incentives are calculated on a monthly basis and are paid without delay.

(iii) The SMS information is continuously back-checked by a team of monitors who contact a random 25% of households each week either by phone or in-person (unannounced visits), and ask them to confirm the date and the type of the household visit.

All CHWs were promised a fixed bonus of SLL 10,000 conditional on truthful reporting at the end of the experiment. Despite this, we show in the paper that the reporting rate is low in all treatments.

## B.2.4 Promotion Incentives

A random sample of 2,081 health workers out of the 2,970 health workers in this study were part of a separate evaluation that involved a change in the promotion system. More specifically, six months after the start of the experiment which is the focus of this paper, the promotion system became meritocratic in a random half of the 372 PHUs while the rest of the PHUs kept the status-quo system (in which the promotion decision is at the discretion of the PHU in-charge). Variation in the promotion system was cross-randomized with PHU-level variation in whether information about supervisors' fixed wage was revealed or not to the health workers. See [Deserranno, Kastrau, and León-Ciliotta \(2021\)](#) for more details.

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<sup>43</sup>When the patient is a child, the health worker reports the name and phone number of the primary care giver. When the household does not have a phone, the health worker reports the phone number of a neighbor.

Table A.16 shows that our main treatment effects on visits are orthogonal to the random variation in the promotion system and orthogonal to providing information about the supervisor’s fixed wage. This is not surprising as the short-run incentives analyzed in this paper are paid by an external organization and have no role in the government promotion decision, nor do they influence the supervisor’s fixed wage. Table A.17 moreover shows that the effects of our incentives treatments persist if we restrict the analysis to the sub-sample of health workers that did not take part in this separate study.

## C Ethics Appendix

### C.1 IRB and Research Ethics

Following Asiedu et al. (2021), we detail key aspects of research ethics.

The project received IRB from the Universitat Pompeu Fabra (Parc de Salut MAR: 2018/7834/I), Northwestern University (ID: STU00207110) and from the Sierra Leone Ethics and Scientific Review Committee (no IRB number assigned by this local institution).

We obtained informed consent from all participants prior to the study. The consent form described the participants’ risks and rights, confidentiality, and contact information. Research staff and enumerator teams were not subject to additional risks in the data collection process. None of the researchers have financial or reputation conflicts of interest with regard to the research results. No contractual restrictions were imposed on the researchers limiting their ability to report the study findings.

The interventions under study did not pose any potential harm to participants and non-participants. The intervention rollout took place according to the evaluation protocol. Our data collection and research procedures adhered to protocols around privacy, confidentiality, risk-management, and informed consent. Participants were not considered particularly vulnerable (beyond some households residing in poverty). Besides individual consent from study participants, consultations were conducted with local representatives at the district levels. All the enumerators involved in data collection were aware about implicit social norms in these communities.

We plan to present the findings from the project to district and national level authorities in Sierra Leone in 2022. However, no activity for sharing results to participants in each study village is planned due to resource constraints. We do not foresee risks of the misuse of research findings.

### C.2 Pre-Analysis Plan

The study was pre-registered on the AEA RCT Registry with the number AEARCTR-0003345. We follow the pre-analysis closely. The outcomes variables we use in the paper were pre-registered.

In the pre-analysis plan, we specified that we would study treatment effects on the number of hours that the workers self-report to dedicate to the health worker job per week, as a measure of their effort. We ended up not using this self-reported variable because it likely suffers from a reporting bias. Indeed, it does not correlate with the average number of

hours households report having been visited (number of visits  $\times$  average visit length): the correlation is -0.0185862 and is not statistically significant. Treatment effects on self reported hours are null.

## D Model Appendix

### D.1 Set up

This section solves the model under the assumption that  $b_1 = b_2 = 0$ ,  $c_1 = c_2 = c$ ,  $m = 1$  and  $\alpha = 1$ . We will later relax these assumptions.

We first quickly summarize the simplified set-up. A supervisor (player 2) and a worker (player 1) exert efforts  $e_1$  and  $e_2$  to produce output  $y$ , where  $y = e_1 + \gamma e_1 e_2$ . Thus, output depends on the efforts of players 1 and 2 and on the level of effort complementarity ( $\gamma$ ). Effort is costly to both the worker and the supervisor, and we assume that the cost of effort is quadratic:  $ce_i^2$  (with  $c > 0$ ). Before the start of the game, a principal offers to pay  $p$  to the worker and  $1 - p$  to the supervisor for every unit of output produced, where  $p \in [0, 1]$ . There are two time periods. In period 1, the supervisor chooses effort  $e_1$  and offers a side transfer  $s$  to the worker for every unit of output produced. Contractual frictions increase the cost of the side transfer to the principal by a factor of  $z$  ( $z > 1$ ). Transfers can only go from the supervisor to the worker:  $s \geq 0$ . In period 2, the worker observes  $e_1$  and  $s$ , and chooses  $e_2$ .

The payoff of the worker is as follows:

$$\pi_1 = (e_1 + \gamma e_1 e_2)(s + p) - ce_1^2$$

And the payoff of the supervisor:

$$\pi_2 = (e_1 + \gamma e_1 e_2)(1 - p - sz) - ce_2^2$$

.

### D.2 A Key Assumption

In what follows, we will make the following assumption about the strength of the effort complementarity:

**Assumption 1:**  $\frac{8c^2}{z} > \gamma^2$ ;  $c, \gamma \in \mathbb{R}^+$ .

As it will become clear in the next section, this assumption guarantees that both agents exert positive efforts. We can show that the following claim is true.

**Claim 0:** If assumption 1 ( $\frac{8c^2}{z} > \gamma^2$ ) holds; then, it is also true that:

- a)  $2c^2 - \gamma^2 p(1 - p) > 0$
- b)  $8zc^2 - \gamma^2(1 + p(z - 1))^2 > 0$

**Proof:**

The proof will be divided in two parts. First, we show that assumption 1 implies a). Then, we show that it also implies b).

*Part 1:* Consider the following maximization problem:

$$\max_{p \in [0,1]} p(1-p)$$

The solution is  $p = \frac{1}{2}$ , such that, at its maximum, the objective function attains the value of  $\frac{1}{4}$ . By the definition of maximum, we have that:

$$\frac{\gamma^2}{4} \geq \gamma^2 p(1-p) \quad \forall p \in [0,1]$$

By our assumption 1, we have that:  $\frac{2c^2}{z} > \frac{\gamma^2}{4}$ . Thus, by the above and the transitivity of the inequality this also implies that  $\frac{2c^2}{z} > \gamma^2 p(1-p)$ , and by  $2c^2 \geq \frac{2c^2}{z}$  implies  $2c^2 > \gamma^2 p(1-p)$  (what we wanted to show).

*Part 2:* First note that:

$$8zc^2 - \gamma^2(1+p(z-1))^2 > 0 \iff \frac{8zc^2}{(1+p(z-1))^2} > \gamma^2$$

Therefore, we want to show  $\frac{8zc^2}{(1+p(z-1))^2} \geq \frac{8c^2}{z}$  since it is sufficient to show that Assumption 1 implies b):

$$\frac{8zc^2}{(1+p(z-1))^2} \geq \frac{8c^2}{z} \iff z^2 \geq 1 + 2p(z-1) + p^2(z-1)^2$$

$$\iff z^2(1-p)(1+p) \geq 2zp(1-p) + (1-p)^2 \iff z^2(1+p) - 2zp - (1-p) \geq 0$$

The quadratic function  $z^2(1+p) - 2zp - (1-p)$  has roots  $z_1 = 1$  and  $z_2 = \frac{p-1}{p+1} < 0$ , taking negative values between the two (in  $(\frac{p-1}{p+1}, 1)$ ) and weakly positive elsewhere. Since  $z \geq 1$ , this means that for all values of  $z$ ,  $z^2(1+p) - 2zp - (1-p) \geq 0$  and so  $\frac{8zc^2}{(1+p(z-1))^2} \geq \frac{8c^2}{z}$ .

### D.3 The Model: Main Analysis

We solve the model by backward induction:

Period 2:

The maximization problem of the worker in the second period is:

$$\max_{e_1} (e_1 + \gamma e_1 e_2)(s+p) - ce_1^2$$

Thus, her optimal level of effort is:

$$e_1^* = \frac{(s+p)(1+\gamma e_2)}{2c}$$

Period 1:

Player 2 anticipates the optimal action of player 1 in period 2. Thus the maximization problem of player 2 is:

$$\max_{e_2, s} \frac{(s+p)(1-p-sz)(1+\gamma e_2)^2}{2c} - ce_2^2$$

Thus, the optimal effort and side transfer are:

$$e_2^* = \frac{\gamma(s+p)(1-p-sz)}{2c^2 - \gamma^2(s+p)(1-p-sz)}$$

$$s^* = \begin{cases} \frac{1-p(1+z)}{2z}, & p \leq \frac{1}{1+z} \\ 0, & p > \frac{1}{1+z} \end{cases}$$

Let us first focus on the case where  $p \leq \frac{1}{1+z}$ . In this case, the side transfer is strictly positive and the optimal effort of the supervisor is given by::

$$e_2^* = \frac{\gamma(1+p(z-1))^2}{8zc^2 - \gamma^2(1+p(z-1))^2}$$

Plugging  $e_2^*$  into  $e_1^*$ , we get:

$$e_1^* = \frac{2c(1+p(z-1))}{8zc^2 - \gamma^2(1+p(z-1))^2}$$

In this case, the output  $y$  is given by: is:

$$y = \frac{16zc^3(1+p(z-1))}{(8zc^2 - \gamma^2(1+p(z-1))^2)^2}$$

We then consider the case where  $p > \frac{1}{1+z}$ . Now the side transfer is censored at zero. Optimal efforts are given by:  $s = 0$  and:

$$e_2^* = \frac{\gamma p(1-p)}{2c^2 - \gamma^2 p(1-p)}$$

$$e_1^* = \frac{pc}{2c^2 - \gamma^2 p(1-p)}$$

And so output is given by:

$$y = \frac{2pc^3}{(2c^2 - \gamma^2 p(1-p))^2}$$

What level of  $p$  maximises output?

Suppose the principal wants to set  $p$  to the level that maximizes output. This maximization problem is divided in two parts: first, we maximize  $y$  assuming that  $p \leq \frac{1}{1+z}$ ; then, we maximize  $y$  assuming that  $p > \frac{1}{1+z}$ . We will refer to the first part of the problem as the “left-hand side” problem (or LHS problem for brevity), and to the second part of the problem as the “right-hand side” problem (or RHS problem for brevity). Also, we will use  $p_a^* = p^*(p \leq \frac{1}{1+z})$  to denote the level of  $p$  that maximizes output in the LHS problem and  $y(p_a^*)$  as the level of output when  $p = p_a^*$ . We will use  $p_b^*$  and  $y(p_b^*)$  symmetrically to denote

the level of  $p$  that maximizes output in the RHS problem, and the corresponding level of output. After solving the two problems, we compare  $y(p_a^*)$  to  $y(p_b^*)$ . If  $y_a^* > y_b^*$  ( $y_a^* < y_b^*$ ), the solution to the overall problem is given by  $p_a^*$  ( $p_b^*$ ).

We now solve the LHS problem:

$$\max_{p \leq \frac{1}{1+z}} \frac{16zc^3(1+p(z-1))}{(8zc^2 - \gamma^2(1+p(z-1)))^2}$$

The derivative of the objective function with respect to  $p$  is given by:

$$\frac{dy}{dp} = \frac{16zc^3(z-1)(8zc^2 + \gamma^2(1+p(z-1)))^2}{(8zc^2 - \gamma^2(1+p(z-1)))^3}.$$

Assumption 1 implies that this derivative is positive for any value of  $p$ . To see this, note that (i)  $c > 0$  and  $z > 1$  (which guarantee that the numerator is positive), and (ii) the second part of Claim 0 shows that Assumption 1 implies that  $8zc^2 - \gamma^2(1+p(z-1))^2 > 0$  for any  $p$ , such that the denominator is positive for any level of  $p$ .

This shows that, as long as  $p \leq \frac{1}{1+z}$ , output grows in  $p$ . Thus, the LHS problem is solved by choosing the largest possible value for  $p$ :  $p_a^* = \frac{1}{1+z}$ .

To find the solution to the RHS problem, we solve:

$$\max_{p > \frac{1}{1+z}} \frac{2pc^3}{(2c^2 - \gamma^2p(1-p))^2}$$

In this case, the optimal  $p$  is given by the solution to:

$$\frac{dy}{dp} = \frac{2c^3(2c^2 + \gamma^2p(1-3p))}{(2c^2 - \gamma^2p(1-p))^3} = 0$$

Claim 0 shows that Assumption 1 implies that  $2c^2 - \gamma^2p(1-p) > 0$ . Thus, in the RHS problem, the optimal  $p$  is given by the solution to:

$$3\gamma^2p^2 - \gamma^2p - 2c^2 = 0$$

The unique positive middle solution for the optimal  $p$  is then:

$$p_b = \frac{1}{6} + \frac{\sqrt{\gamma^2 + 24c^2}}{6\gamma}$$

Interestingly,  $p_b$  decreases with  $\gamma$ , as can be seen from the derivative of  $p_b^*$  with respect to  $\gamma$ :

$$\frac{dp_b}{d\gamma} = \frac{-4c^2}{\sqrt{\gamma^2 + 24c^2}} < 0$$

In order for  $p_b$  to be the global maximum of the RHS problem, we need to ensure that (i)  $\frac{d^2y}{dp^2} < 0$  (the second derivative is negative), (ii) that the objective function ( $\frac{2pc^3}{(2c^2 - \gamma^2p(1-p))^2}$ ) is continuous on  $p \in [\frac{1}{1+z}, 1]$  and (iii) that  $\frac{1}{6} + \frac{\sqrt{\gamma^2 + 24c^2}}{6\gamma} \leq 1$ . We tackle each one of these requirements in turn:

- A negative second derivative at  $p = \frac{1}{6} + \frac{\sqrt{\gamma^2 + 24c^2}}{6\gamma}$ :

$$\frac{d^2y}{d^2p} = \frac{2c^3\gamma^2((2c^2 - \gamma^2p(1-p))(1-6p) - 3(2c^2 + \gamma^2p(1-3p))(2p-1))}{(2c^2 - \gamma^2p(1-p))^4} < 0$$

$$\iff (2c^2 - \gamma^2p(1-p))(1-6p) - 3(2c^2 + \gamma^2p(1-3p))(2p-1) < 0$$

Note that  $p = \frac{1}{6} + \frac{\sqrt{\gamma^2 + 24c^2}}{6\gamma} > \frac{1}{2}$ . Now take the minimum of  $(2c^2 - \gamma^2p(1-p))(1-6p) - 3(2c^2 + \gamma^2p(1-3p))(2p-1)$  with respect to  $p \in [\frac{1}{2}, 1]$ .

As the first derivative of  $(2c^2 - \gamma^2p(1-p))(1-6p) - 3(2c^2 + \gamma^2p(1-3p))(2p-1)$  is negative, its minimum is achieved at  $p = \frac{1}{2}$ . At this point:  $(2c^2 - \gamma^2p(1-p))(1-6p) - 3(2c^2 + \gamma^2p(1-3p))(2p-1) = -\frac{1}{2}(8c^2 - \gamma^2) < 0$  since  $8c^2 - \gamma^2 > 0$  by Assumption 1 and  $8c^2 \geq \frac{8c^2}{z}$ .

- The objective function is continuous:

$$2c^2 - \gamma^2p(1-p) \neq 0 \iff p \neq \frac{1}{2} \pm \frac{\sqrt{\gamma^2 - 8c^2}}{\gamma^2}$$

A sufficient condition for this is to assume  $\gamma^2 < 8c^2$  (again, implied by Assumption 1 and  $8c^2 \geq \frac{8c^2}{z}$ ).

- The condition  $\frac{1}{6} + \frac{\sqrt{\gamma^2 + 24c^2}}{6\gamma} \leq 1$  is equivalent to  $c^2 \leq \gamma^2$ . That is, the complementarity has to be high enough for a two-sided incentive to be generate higher output compared to a one-sided incentive paid to to the worker.

To sum up, the possible candidates for the optimal  $p^*$  when  $c^2 \leq \gamma^2$  are:

$$p_a^* = \frac{1}{1+z}$$

$$p_b^* = \frac{1}{6} + \frac{\sqrt{\gamma^2 + 24c^2}}{6\gamma}$$

And the corresponding levels of output are:

$$y(p_a^*) = \frac{2c^3(1+z)^3}{(2c^2(1+z)^2 - \gamma^2z)^2}$$

$$y(p_b^*) = \frac{27c^3(\gamma + \sqrt{\gamma^2 + 24c^2})}{(24c^2 - \gamma(\gamma + \sqrt{\gamma^2 + 24c^2}))^2}$$

The optimal  $p$  is found by comparing  $y(p_a^*)$  to  $y(p_b^*)$ .

## D.4 Comparative Statics on the Advantage of Each Optimal Incentive Candidate

Let  $\mathcal{A}_{p,q}$  be the advantage of choosing the incentive that gives  $p$  to the worker and  $1-p$  to the supervisor compared to choosing the incentive that pays  $q$  to the worker and  $1-q$  to the supervisor. Using this tool we can compare different incentive schemes and analyze how certain parameters affect the advantage of one versus the other.

Comparing  $p = p_a^*$  and  $p = 1$ :

$$\mathcal{A}_{p_a^*,1} = y(p_a^*) - y(1) = \frac{2c^3(1+z)^3}{(2c^2(1+z)^2 - \gamma^2 z)^2} - \frac{1}{2c}$$

We have that:

$$\frac{d\mathcal{A}_{p_a^*,1}}{d\gamma} = \frac{8\gamma c^3 z(1+z)^3}{(2(1+z)^2 c^2 - \gamma^2 z)^3} > 0$$

since  $2(1+z)^2 c^2 - \gamma^2 z > 0$  by our previous assumption:  $2c^2 - \gamma^2 p(1-p) > 0$ .

In a similar fashion, comparing  $p = p_b^*$  and  $p = 1$ :

$$\mathcal{A}_{p_b^*,1} = y(p_b^*) - y(1) = \frac{27c^3(\gamma + \sqrt{\gamma^2 + 24c^2})}{(24c^2 - \gamma(\gamma + \sqrt{\gamma^2 + 24c^2}))^2} - \frac{1}{2c}$$

$$\frac{d\mathcal{A}_{p_b^*,1}}{d\gamma} = \frac{27c^3(\gamma + \sqrt{\gamma^2 + 24c^2})(24c^2 - \gamma(\gamma + \sqrt{\gamma^2 + 24c^2}) + 2\gamma + 2\gamma^2 \sqrt{\gamma^2 + 24c^2})}{(8c^2 - \gamma(\gamma + \sqrt{\gamma^2 + 24c^2}))^3 \sqrt{\gamma^2 + 24c^2}} > 0$$

again using  $8c^2 - \gamma(\gamma + \sqrt{\gamma^2 + 24c^2}) > 0$  by our previous assumption:  $8zc^2 - \gamma^2(1+p(z-1))^2 > 0$ .

This means that the advantage of choosing the optimal  $p^* \in (0, 1)$  compared to  $p^* = 1$  is increasing in  $\gamma$ : the larger  $\gamma$  is, the more harming it is (in terms of final output), to pay all the incentive to the worker.

Let us now try the analogous comparison between  $p = p_a^*$ ,  $p = p_b^*$  and  $p = 0$ .

For  $p = p_a^*$  versus  $p = 0$ :

$$\mathcal{A}_{p_a^*,0} = y(p_a^*) - y(0) = \frac{2c^3(1+z)^3}{(2c^2(1+z)^2 - \gamma^2 z)^2} - \frac{16zc^3}{(8zc^2 - \gamma^2)^2}$$

We have that:

$$\frac{d\mathcal{A}_{p_a^*,0}}{d\gamma} = \frac{8\gamma c^3 z(1+z)^3}{(2(1+z)^2 c^2 - \gamma^2 z)^3} - \frac{\gamma 64c^3 z}{(8zc^2 - \gamma^2)^3}$$

And comparing  $p = p_b^*$  with  $p = 0$ :

$$\mathcal{A}_{p_b^*,0} = y(p_b^*) - y(0) = \frac{27c^3(\gamma + \sqrt{\gamma^2 + 24c^2})}{(24c^2 - \gamma(\gamma + \sqrt{\gamma^2 + 24c^2}))^2} - \frac{16zc^3}{(8zc^2 - \gamma^2)^2}$$



$$\frac{d\mathcal{A}_{p^*,0}}{d\gamma} = \frac{2c^3(\gamma + \sqrt{\gamma^2 + 24c^2})(56c^2 + \gamma^2 + 2\gamma + 3\gamma\sqrt{\gamma^2 + 24c^2})}{(8c^2 - \gamma(\gamma + \sqrt{\gamma^2 + 24c^2}))^3\sqrt{\gamma^2 + 24c^2}} - \frac{\gamma 64c^3 z}{(8zc^2 - \gamma^2)^3}$$

As one can see from the derivatives, the effect of  $\gamma$  on the advantage of  $p = p^*$  with respect to  $p = 0$  is unclear and will depend on the specific value of  $\gamma$ , but also on the cost of effort of the players  $c$  and the contracting cost of the supervisor  $z$ . Intuitively, when  $z$  is small it is more likely that  $\gamma$  has a positive effect on the advantage of  $p = p^*$  with respect to  $p = 0$ ; while a large  $z$  makes  $p = 0$  more attractive and the increase in the advantage of  $p = p^*$  with respect to  $p = 0$  less responsive to  $\gamma$ .

## D.5 Special Cases

$$\underline{\gamma = 0, z = 1:}$$

In this case, the supervisor has no incentive to exert effort, since his effort is not leading to any rise in productivity  $\gamma = 0$ . Therefore, his optimal level of effort is  $e_2^* = 0$ . And, as in the general case, he chooses to pay a positive side payment ( $s \geq 0$ ) as long as  $p \leq \frac{1}{1+z}$ . As  $z = 1$ , this condition simplifies to  $p \leq \frac{1}{2}$ .

On the other hand, the worker exerts effort:

$$e_1^* = \frac{s + p}{2c}$$

Let us then analyze the maximization problem of the principal:

- If  $p \leq \frac{1}{2}$  and so  $s = \frac{1-2p}{2}$ , then  $y = \frac{1}{4c}$ . This is independent of  $p$ ; that is, any  $p \leq \frac{1}{2}$  would lead to the same output level  $y$ .
- If  $p > \frac{1}{2}$  and  $s = 0$ , the principal's problem becomes:

$$\max_p \frac{p}{2c}$$

The solution is  $p^* = 1$  since the objective function is increasing in  $p$ . Note that, in this case, as  $c > 0$ , we have that  $\gamma < c$  (unlike before).

Finally, the principal compares the two possible optimal  $p^*$ :

$$y(p^* \leq \frac{1}{2}) = \frac{1}{4c}$$

$$y(p^* = 1) = \frac{1}{2c}$$

And, as  $y(p^* = 1) > y(p^* \leq \frac{1}{2})$ , he chooses  $p^* = 1$ . This is intuitive given that the supervisor does not contribute directly to production.

$\gamma = 0, z > 1$ :

Again here, the supervisor chooses to exert no effort  $e_2^* = 0$  and offers a side payment of  $s = \frac{1-p(1+z)}{2z}$  if  $p \leq \frac{1}{1+z}$ , while the worker exerts effort  $e_1^* = \frac{s+p}{2c}$ .

The two-step maximization problem of the principal is now:

- When  $s > 0$  and  $p \leq \frac{1}{1+z}$ :

$$\max \frac{1 - p(1 - z)}{4zc}$$

solved by  $p^* = \frac{1}{1+z}$  as the objective function increases in  $p$ .

- When  $s = 0$  and  $p > \frac{1}{1+z}$ :

$$\max \frac{p}{2c}$$

just like in the previous case, maximized at  $p^* = 1$ .

Now, the principal would compare the output levels under the 2 candidate:

$$y\left(p^* = \frac{1}{1+z}\right) = \frac{1}{2c(1+z)}$$

$$y(p^* = 1) = \frac{1}{2c}$$

Again,  $p^* = 1$  turns out to be the optimal incentive from the point of view of the principal, since  $y(p^* = 1) > y(p^* = \frac{1}{1+z})$ . Indeed, the result above is nested in this example.

$\gamma > 0, z = 1$ :

Using the results above and plugging in for  $z = 1$  one can obtain:

- When  $p \leq \frac{1}{2}$  and so  $s > 0$ :

$$e_2^* = \frac{\gamma}{8c^2 - \gamma^2}$$

$$e_1^* = \frac{2c}{8c^2 - \gamma^2}$$

$$y = \frac{16c^3}{(8c^2 - \gamma^2)^2}$$

- When  $p > \frac{1}{2}$  and  $s = 0$ :

$$e_2^* = \frac{\gamma p(1-p)}{2c^2 - \gamma^2 p(1-p)}$$

$$e_1^* = \frac{pc}{2c^2 - \gamma^2 p(1-p)}$$

$$y = \frac{2pc^3}{(2c^2 - \gamma^2 p(1-p))^2}$$

The solution to the two-step principal's problem is given by one of the following  $p^*$ :

- When  $p \leq \frac{1}{2}$ , any  $p^* \in [0, \frac{1}{2}]$  would work.
- When  $p > \frac{1}{2}$ ,  $p^* = \frac{1}{6} + \frac{\sqrt{\gamma^2 + 24c^2}}{6\gamma}$ , as long as  $\gamma > c$

Finally, the optimum will be determined by comparing:

$$y \left( p^* = \frac{1}{6} + \frac{\sqrt{\gamma^2 + 24c^2}}{6\gamma} \right) = \frac{27c^3(\gamma + \sqrt{\gamma^2 + 24c^2})}{(24c^2 - \gamma(\gamma + \sqrt{\gamma^2 + 24c^2}))^2}$$

$$y \left( p^* \leq \frac{1}{2} \right) = \frac{16c^3}{(8c^2 - \gamma^2)^2}$$

The  $p^*$  generating the largest level of output  $y$  will be chosen and this will depend on the specific values of  $\gamma$  and  $c$ .

## D.6 Proof of Result 1

As before, we assume that Assumption 1 ( $\frac{8c^2}{z} > \gamma^2$ ;  $c, \gamma \in \mathbb{R}^+$ ) holds.

**Result 1:** When effort complementarity is lower than a threshold  $t$ , there is a unique optimal incentive scheme, which is one sided ( $p^* = 1$ ). When effort complementarity is larger than  $t$ , there is always a two-sided scheme which is optimal ( $p^* \in (0, 1)$ ). If there are contractual frictions, this optimal two-sided scheme is the unique optimal scheme. If there are no contractual frictions  $p^* = 0$  may also be optimal.

**Proof:** To prove this statement we will first separately prove the following claims (given assumption 1):

Claim 1. The interior solution to the left-hand side problem ( $\max_{p \leq \frac{1}{1+z}} y$ ) is strictly optimal when there are contractual frictions ( $z > 1$ ). Otherwise, any  $p \leq \frac{1}{1+z}$  leads to the same level of output.

Claim 2. When  $\gamma^2 > c^2$ , the principal's maximization problem always has an interior solution.

Claim 3. There exists a point  $t = \frac{2c^2((1+z)^2 - (1+z)^{\frac{3}{2}})}{z}$  such that for all  $\gamma$  such that  $c^2 > \gamma^2 > 0$ ,  $y(1) < y(\frac{1}{1+z})$  i.f.f.  $\gamma^2 > t$ ; while  $y(1) > y(\frac{1}{1+z})$  i.f.f.  $\gamma^2 < t$ .

*Proof of Claim 1:* When solving the model, we showed that the solution to the principal's left-hand side (LHS) problem, that is,  $\max_{p \leq \frac{1}{1+z}} y$  has a unique global solution  $p^* = \frac{1}{1+z}$  when  $z > 1$  and multiple solutions, namely any  $p \leq \frac{1}{1+z}$  when  $z = 1$ . This follows from the

derivative of the objective function ( $y$ ) with respect to  $p$ , which is increasing in  $p$  whenever  $z > 1$  and is flat and equal to 0 whenever  $z = 1$ :

$$\frac{dy}{dp} = \frac{16zc^3(z-1)(8zc^2 + \gamma^2(1+p(z-1))^2)}{(8zc^2 - \gamma^2(1+p(z-1))^2)^3}$$

*Proof of Claim 2:* As explained above,  $p^* = \frac{1}{1+z}$  is a global (not necessarily strict) solution to the principal's LHS maximization problem regardless the value of  $z$ . For the right-hand side (RHS) problem ( $\max_{p > \frac{1}{1+z}} y$ ) we found that there is an interior solution (which is also the global solution to the RHS problem) whenever  $\gamma^2 > c^2$ . Therefore, there will always be an interior value  $p^* \in (0, 1)$  that solves the principal's problem (since the overall solution follows from the comparison of the value of output achieved under the solution to the LHS and RHS maximization problems).

*Proof of Claim 3:* First, note:  $y(p=1) = \frac{1}{2c}$  and  $y(p = \frac{1}{1+z}) = \frac{2c^3(1+z)^3}{(2c^2(1+z)^2 - \gamma^2 z)^2}$ . Now we want to analyze when the following inequality is true:

$$y(p=1) > y\left(p = \frac{1}{1+z}\right) \iff \frac{1}{2c} > \frac{2c^3(1+z)^3}{(2c^2(1+z)^2 - \gamma^2 z)^2}$$

$$\iff (2c^2(1+z)^2 - \gamma^2 z)^2 > 4c^4(1+z)^3 \iff 4c^4(1+z)^3 - 4c^2(1+z)^2\gamma^2 + \gamma^4 z > 0$$

The LHS of the above inequality is a quadratic function in  $\gamma^2$ . Therefore, we solve for its roots to understand when it takes positive or negative values (that is, when the inequality holds) and we find the following two roots:

$$\gamma_1^2 = \frac{2c^2}{z}((1+z)^2 - (1+z)^{\frac{3}{2}})$$

$$\gamma_2^2 = \frac{2c^2}{z}((1+z)^2 + (1+z)^{\frac{3}{2}})$$

Then plugging in for some value of  $\gamma^2$  in the middle of the two roots, e.g.  $\frac{2c^2(1+z)^2}{z}$ , we see that the quadratic function takes negative values:

$$4c^4(1+z)^3 - 4c^2(1+z)^2 \frac{2c^2(1+z)^2}{z} + \left(\frac{2c^2(1+z)^2}{z}\right)^2 z = -\frac{4c^4(1+z)^3}{z} < 0$$

This means that  $4c^4(1+z)^3 - 4c^2(1+z)^2\gamma^2 + \gamma^4 z > 0$  i.f.f.  $\gamma^2 \in (-\infty, \gamma_1^2) \cup (\gamma_2^2, \infty)$  and, conversely,  $4c^4(1+z)^3 - 4c^2(1+z)^2\gamma^2 + \gamma^4 z < 0$  i.f.f.  $\gamma^2 \in (\gamma_1^2, \gamma_2^2)$ .

Finally, note that  $c^2 \leq \gamma_2^2$ , which is equivalent to  $1 \leq \frac{2}{z}((1+z)^2 + (1+z)^{\frac{3}{2}})$ , that is true for all  $z \geq 1$  since  $1 < \frac{(1+z)^2 + (1+z)^{\frac{3}{2}}}{z}$ . This implies that  $\forall \gamma^2 < c^2$  it is true that  $4c^4(1+z)^3 - 4c^2(1+z)^2\gamma^2 + \gamma^4 z > 0$  (and so  $y(1) > y(\frac{1}{1+z})$ ) i.f.f.  $\gamma^2 \in (-\infty, \gamma_1^2)$ . And by analogy,  $4c^4(1+z)^3 - 4c^2(1+z)^2\gamma^2 + \gamma^4 z < 0$  (and so  $y(1) < y(\frac{1}{1+z})$ ) i.f.f.  $\gamma^2 \in (\gamma_1^2, c^2)$ . Noting that  $\gamma_1^2 = t$  completes the proof of Claim 3.

We showed that if  $c^2 > t > \gamma^2$ , then  $y(1) > y(\frac{1}{1+z})$ . Since the only two candidates for

being the global optimum of  $y$  with respect to  $p$  when  $c^2 > \gamma^2$  and  $z > 1$  are precisely  $p = 1$  and  $p = \frac{1}{1+z}$ , under contractual frictions ( $z > 1$ ) the global optimum is attained when  $p = 1$ . In addition, since under  $z = 1$   $y(\frac{1}{1+z}) = y(0)$ , as shown in the special case in Section D.5;  $y(1) > y(\frac{1}{1+z})$  also implies that  $y(1) > y(0)$ , such that when  $c^2 > t > \gamma^2$  and  $z = 1$ ,  $p = 1$  is still the global maximum. This shows: “When effort complementarity is lower than a threshold  $t$ , there is a unique optimal incentive scheme, which is one sided ( $p^* = 1$ ).”

“When effort complementarity is larger than  $t$ , there is always a two-sided scheme which is optimal ( $p^* \in (0, 1)$ ).” follows from Claim 2 when  $\gamma^2 > c^2 > t$  and from Claim 3 when  $c^2 > \gamma^2 > t$ . On the other side, “If there are contractual frictions, this optimal two-sided scheme is the unique optimal scheme.” follows from the previous discussion together with Claim 1.

Finally, the last statement: “If there are no contractual frictions  $p^* = 0$  may also be optimal.” is directly proved in the special case in Section D.5 where  $z = 1$  and  $\gamma > 0$ .

## D.7 The Model with Heterogeneity

In this final section we extend the model to allow workers and supervisors to have different costs and benefits. Output is now given by:  $\alpha e_1 + \gamma e_1 e_2$ . Further, we assume that the cost of effort is given by:  $c(e_1) = c_1 e_1^2$ ,  $c(e_2) = c_2 e_2^2$ . Moreover, both players get a different benefit ( $b_1$  and  $b_2$ ) for each unit of production. Finally, the payment per unit of output is given by  $m$ .

The payoff of the worker will look as follows:

$$\pi_1 = (\alpha e_1 + \gamma e_1 e_2)(b_1 + mp + s) - c_1 e_1^2$$

And the payoff of the supervisor:

$$\pi_2 = (\alpha e_1 + \gamma e_1 e_2)(b_2 + m(1 - p) - sz) - c_2 e_2^2$$

Let us solve the model by backward induction:

### Period 2:

The maximization problem of the worker in the second period is:

$$\max_{e_1} (\alpha e_1 + \gamma e_1 e_2)(b_1 + mp + s) - c_1 e_1^2$$

Thus, the worker’s optimal level of effort is:

$$e_1^* = \frac{(b_1 + s + mp)(\alpha + \gamma e_2)}{2c_1}$$

### Period 1:

Anticipating the optimal effort of player 1, the maximization problem of player 2 becomes:

$$\max_{e_2, s} \frac{(b_1 + s + mp)(b_2 + m(1 - p) - sz)(\alpha + \gamma e_2)^2}{2c_1} - c_2 e_2^2$$

Thus, the optimal effort of player 2 and the optimal side transfer are:

$$e_2^* = \frac{\gamma\alpha(b_1 + s + mp)(b_2 + m(1 - p) - sz)}{2c_1c_2 - \gamma^2(b_1 + s + mp)(b_2 + m(1 - p) - sz)}$$

$$s^* = \begin{cases} \frac{(b_2+m)-zb_1-mp(z+1)}{2z}, & p \leq \frac{b_2+m-zb_1}{m(z+1)} \\ 0, & p > \frac{b_2+m-zb_1}{m(z+1)} \end{cases}$$

Let us first focus in the case where  $p \leq \frac{b_2+m-zb_1}{m(z+1)}$ . In this situation:

$$e_2^* = \frac{\gamma\alpha\eta^2}{8zc_1c_2 - \gamma^2\eta^2}$$

where  $\eta = b_1z + b_2 + m(1 + p(z - 1))$ .

And plugging  $e_2$  into  $e_1$ :

$$e_1^* = \frac{2\alpha\eta c_2}{8zc_1c_2 - \gamma^2\eta^2}$$

In this case, the output  $y$  as a function of  $p$  is:

$$y = \frac{16\alpha^2c_1c_2^2z\eta}{(8zc_1c_2 - \gamma^2\eta^2)^2}$$

In the case in which  $p > \frac{b_2+m-zb_1}{m(z+1)}$ , we will assume that  $s = 0$ :

$$e_2^* = \frac{\gamma\alpha(b_1 + mp)(b_2 + m(1 - p))}{2c_1c_2 - \gamma^2(b_1 + mp)(b_2 + m(1 - p))}$$

$$e_1^* = \frac{\alpha(b_1 + mp)c_2}{2c_1c_2 - \gamma^2(b_1 + mp)(b_2 + m(1 - p))}$$

And so the output is:

$$y = \frac{2\alpha^2c_1c_2^2(b_1 + mp)}{(2c_1c_2 - \gamma^2(b_1 + mp)(b_2 + m(1 - p)))^2}$$

### Implications

There are at least two implications of this model's extension. First, the condition for positive side payments is now  $p \leq \frac{b_2+m-zb_1}{m(z+1)}$ . This condition becomes harder to satisfy as  $z$  grows and as  $b_2 - b_1$  shrinks. Second, as long as side payments are positive, output is  $y = \frac{16\alpha^2c_1c_2^2z\eta}{(8zc_1c_2 - \gamma^2\eta^2)^2}$ . When  $z = 1$ , output is not a function of  $p$ : all levels of  $p$  result in the same level of output. On the other hand, when  $z > 1$ , output is a function of  $p$ .

## E Prediction Survey Appendix

In collaboration with the Social Science Prediction Platform,<sup>44</sup> we invited social scientists

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<sup>44</sup>See <https://socialscienceprediction.org>. This prediction platform enables the systematic collection and assessment of expert forecasts of the effects of untested social programs.

to forecast how our treatments affect household visits compared to the control group. The participants made their forecasts before the results of this study were made public. Participants were paid to participate in the survey. Out of the 29 participants, 90% are economists; 41% of whom are faculty members and 45% are graduate students.

Participants were asked to forecast the average number of household visits health workers conduct in  $T_{worker}$ ,  $T_{supv}$ , and  $T_{shared}$  after giving them a 700-word description of the study and informing them about the average number of household visits and its standard deviation for control group workers:

*“We are interested to hear your predictions about the effects of the different incentive schemes on the main outcome variable, the number of household visits conducted by the community health worker in the previous 6 months as reported by the household’s female primary caregiver during the endline household survey. Control Group Reference: As a reference point, community health workers in the control group conducted on average 5.3 visits per household in the 6 months preceding the endline survey, with a standard deviation of 5.6. We would like you to predict the number of visits that the CHWs conducted in the other three experimental conditions: How many visits do you think the CHWs carried out when the 2,000 incentive was paid in full to the community health worker? How many visits do you think the CHWs carried out when the 2,000 incentive was paid in full to the supervisor? How many visits do you think the CHWs carried out when the 2,000 incentive was shared equally between the community health worker and the supervisor?”*

The average forecasts for the number of household visits by survey participants are 7.73 in  $T_{worker}$  (compared to 7.42 we find in the data), 6.28 in  $T_{supv}$  (7.48), and 7.41 in  $T_{shared}$  (8.7). 52% of participants forecasted  $T_{worker}$  to be the most effective treatment in our paper, 4% chose  $T_{supv}$ , 28% chose  $T_{shared}$ , and 18% forecasted either two or all three treatments to have the same effect.