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## A Theory of Delegated Contracting

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# A THEORY OF DELEGATED CONTRACTING

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## Abstract

Delegated contracting describes a widely observable vertical contractual relationship where a top principal (program designer) hires an intermediary to offer a pre-designed screening contract to a downstream agent who should produce a quantity depending on his true marginal cost type. The principal has no direct access to the downstream agent and utilizes budgeting in the sequence of contracts.

This paper proposes a general theory of delegated contracting where information acquisition is limited to the (sub-)contract offer stage. To reach delegation proofness, the principal designs information rents accordingly. The solution concept follows the convexity of rent profile. The paper shows that the optimal contract is fully separating over the subcontracting interval, leading to strictly decreasing output targets.

*JEL classification:* D23, D73, L51.

*Keywords:* Delegated Contracting, Vertical Hierarchies, Adverse Selection, Delegation Proofness, Ex-ante Rents, Countervailing Incentives in Multi-Agent Setups.

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# 1 Introduction

Managing global value chains involves relying on contracts with manufacturers abroad. To carry out production of a specific component, a multinational firm's top management will typically set up operations through a division manager (intermediary) located in the respective country as the latter is supposed to possess some institutional knowledge about a local input provider (firm, agent), thus gaining information through offering a (sourcing) sub-contract to the latter.

Endowing an intermediary with sub-contracting power is a double-sided sword. It is a well-known fact in the literature on cost accounting that vertical hierarchies are plagued by suboptimal decision making practices that follow from delegation.<sup>1</sup> This relates to a property inherent to many hierarchies: on one side, the intermediary's access to information occurs naturally when approaching the agent with the contract offer. On the other, information itself is difficult to verify for the principal, and the intermediary may use his information to deviate from the optimal schedule he should implement, so typically increasing the principal's risk to not have any production carried out.

This power to deviate is the source of additional information rents that may render it optimal to design additional distortions in the output targets. This, according to an important seminal paper by Faure-Grimaud and Martimort (2001, FGM hereafter) constitutes a specific loss of control. CEOs of multinational firms can typically implement performance budgeting, which permits such design, as several case studies on supply chain management reveal.<sup>2</sup> The present paper sets out to offer a generalized approach to tackle delegated contracting with continuous agent types.

Plethora of examples illustrate delegated contracting as a specific agency mode. Consider the case of delegated procurement where the director of an agency delegates the task of contracting to an internally located bureaucrat who may have more information about a firm's cost than the top principal. An even more prominent example is the delegation of a public policy from an elected politician to the administration, where the

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<sup>1</sup>See Horngren et al. (2003).

<sup>2</sup>In the view of supply chain management, performance budgeting practices can be used to best manage production while overall limiting the costs that a long supply chain may impose. See Horngren et al. (2003) as well as HBS (1992) and (2000).

latter would deal directly with the economic agent. Financial intermediation is another case, with investors approaching financial intermediaries that have access to profitable entrepreneurial projects; knowledge that the investor himself would, typically, lack.

A last and rewarding parallel to this research is the optimal design of an auction in a setup with an auctioneer being empowered to cut off a lower subset of bidder types, so increasing the probability for a high knock-down price while raising the risk of the item's owner to not find a buyer at all.<sup>3</sup>

The literature on type-dependent participation constraints has been addressed in seminal papers by Lewis and Sappington (1989) and in Maggi and Rodriguez (1995a, MR hereafter). Note also that Jullien (2000), in a generalized buyer-seller version of the procurement/production model used here has offered a generalized treatment of countervailing incentives. In Laffont and Sappington (1989), the clash between the agent's outside option and his marginal cost that leads to countervailing incentives where the participation rent profile is strictly concave. In the present paper, there are three players, and the intermediary's participation constraint emerges as an ex-ante rent because of the existing information rent to be offered to the downstream productive agent. The rent profile is convex as it follows the downstream agent's rent structure. The solution concept that this paper offers involves type-dependent participation constraints to satisfy delegation proofness with a screening sub-contract. In this way, the paper turns out to be quite distinct from classic treatments of adverse selection. To quote Jullien (2000, p. 1):

“Standard contract theory, as exposed by Baron and Myerson [ ], Guesnerie and Laffont [ ], or Maskin and Riley [ ], derives the optimal contract under the assumption that the agent's informational rent (what he gets above his reservation utility) grows with the agent's private information parameter (his type): better types get higher rents. When the reservation utility is type dependent, this property may fail.”.

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<sup>3</sup>See e.g. Celik and Yilankaya (2009), as well as Menezes and Monteiro (2000).

Because of the specific delegation of a screening contract and the way this setup makes informational rents accrue along the timeline, delegated contracting exhibits some generalizable features that this paper is set out to characterize. Delegated Contracting is a specific subfield of agency theory, initially envisaged by seminal papers such as Williamson (1967) and Calvo and Wellisz (1978). In its current form within it has become a part within the larger literature of multiplayer contracting where the top principal's options to the design of optimal contracts are limited in a considerable way.

## 1.1 Related literature

Narrowing down the multiplayer contracting literature leaves two seminal papers that genuinely deal with delegated contracting described so far, namely McAfee and McMillan (1995), and Faure-Grimaud and Martimort (2001) (FGM hereafter). FGM describes some of the agency costs of delegated contracting (or “intermediated contracting” as they call it) in a setup where the intermediary would be able to costlessly observe an extremely inefficient type to which he never should offer a contract.<sup>4</sup> This feature gives their model a peculiar twist, determining information acquisition as part of the contract offer happening at the interim stage. Without this property, much of their findings boil down to the model offered in McAfee and McMillan (1995). In that paper, given the specific form of ex-post contract acceptance, it is the limited liability of the intermediate principal that leads to an extreme form of a double marginalization of rent. McAfee and McMillan (1995), while highlighting the issue of limited liability, do not provide any further discussion of the interplay between information and incentives that would follow a necessarily more endogenous treatment of rents, while FGM have indeed provided an important step toward such an endogenization, albeit in limited form as their model has

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<sup>4</sup>To avoid a common misunderstanding about delegated contracting: this option in FGM is *neither the reason* for the intermediary being hired nor a peculiar informational advantage that may result from a specific capacity by which the intermediary might be endowed. With this aspect, delegated contracting differs from the core literature on information gathering as discussed at the end of my paper. The intermediary could use any out of equilibrium contract to learn something about the agent's type from the agent's refusal or acceptance.

three discrete types of agents, of which only two are real types and should be given a contract.

In a nutshell, FGM's intermediary is hired to offer a screening contract to two efficient (or low-cost) agent types, while excluding a third, inefficient (high-cost) type. Given that the top principal cannot offer the contract himself, the intermediary's informational advantage follows his power to not include a fictitious high-cost type while this type can - given the stochastic structure - be safely assumed to be filtered out with a positive probability by the intermediary at the contract offer stage. Since incentives between principal and intermediary are aligned whenever a screening contract is offered, this offer generally comes with the detection of the most inefficient type. Yet, the intermediary can threaten the top principal to offer a suboptimal contract that would exclude more than the extremely inefficient type and so make the principal bear a risk to end up without production. In FGM, this peculiar contract is a shut-down contract, accepted only by the type of agent with lowest marginal cost. Indeed, should this most efficient type appear and accept the contract, the intermediary then pockets the virtual costs: a shut-down subcontract remains incentive feasible without any information rent forwarded to the most efficient type. The rent included in the budget is then simply pocketed by the intermediary.

Still, nothing is said about types that would arguably exist *between* the intermediate type and the most efficient cost type. While FGM's discrete type model enables an illustration of the link between rents and the way information rents accrue when the intermediary is risk averse, their model still awaits a concept beyond binary choices that are made as no other agents are present. Indeed, to assume a type distribution concentrated solely around two types at the borderline of the contracting space precludes the model from reaching more general conclusions on the optimal contract and on the nature of countervailing incentives that are pertinent to delegated contracting.

The research envisaged in this paper aims at delivering a novel explanation for agency costs, by characterizing a contractual setup for a specific vertical hierarchy. Delegated

Contracting addresses a nontrivial issue. While describing the “loss of control in hierarchies”<sup>5</sup>, it approaches the issue from a new perspective. The goal herewith is to lift delegated contracting onto a new level of generality.

Several recent papers build on contractual issues with an eye on more complex scenarios by making use of similar instruments, such as Goldlücke and Schmitz (2014) who introduce ex-ante private information to pin down specific features of vertical integration. Related thoughts to my paper can also be found in Rasul and Sonderegger (2013) who differentiate between ex ante and ex post outside options in a model of adverse selection and relationship-specific investment. Another very noteworthy paper that picks up on countervailing incentives in a related setup with a focus on multidimensional contracting is work by Szalay (2013).

Lastly, my paper relates also to other conceptualizations of intermediaries, such as given in Bond and Gresik (2011) as well as Gresik and Nelson (1994) who focus on partial delegation. Gresik and Nelson (2014) permit the intermediary to determine quantity targets depending on the institutional regulations in the subsidiary’s country. Bond and Gresik (2011) focus on the a combination of a “public component and a less-public nonlinear component.” What unites this paper with theirs is the separation of control of economic decision-making from the control of private information.

The paper is organized as follows. Section 2 presents the model including the specification of the intermediary’s ex-ante rent and his participation constraint as a function of the agent’s cost type. Section 3 concludes. The endogenous determination of the ex-ante rent paid to the intermediary is given in the appendix.

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<sup>5</sup>Williamson (1967), Calvo and Wellisz (1978)

## 2 Model

### 2.1 Primitives

There is a principal  $\mathcal{P}$ , an intermediary  $\mathcal{I}$ , and an agent  $\mathcal{A}$ . The agent is risk-neutral and has a utility function  $v = t - \theta q$ , where  $t$  is the monetary transfer he receives from the intermediary to produce an output target of  $q$ . The agent knows his type when accepting the contract and has a reservation utility normalized to zero.  $\mathcal{A}$ 's production costs are  $\theta q$ , with  $\theta$  being his known marginal cost of production. As typical for the contracting literature, I assume a concave utility function for  $\mathcal{P}$  of  $S(q)$ , with  $S(\cdot)$  being increasing and concave.

The type distribution is common knowledge and well behaved. I furthermore require that the monotone hazard rate condition holds. In other words,  $\frac{d}{d\theta} \left( \frac{F(\theta)}{f(\theta)} \right)$  is assumed to be nonnegative, with  $F(\theta)$  being the c.d.f. and  $f(\theta)$  the p.d.f., with the distribution being well defined and differentiable nearly everywhere.

As common to the literature, I also rule out a situation in which the intermediary can offer contracts composed of lotteries over quantities. Furthermore, any acceptance of the sub-contract by the agent implies that the agent commits to a production capacity before the intermediary reports to the principal.<sup>6</sup>

### 2.2 Information and rents

The timing of the contracting game is as follows:

- ( $t = 0$ ) Agent learns its type  $\theta$ .
- ( $t = 1$ )  $\mathcal{P}$  offers a Grand-Contract that specifies output targets and transfers to both the intermediary and the agent
- ( $t = 2$ ) The intermediary accepts or rejects the Grand-Contract.

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<sup>6</sup>See e.g. FGM, p. 79.



- ( $t = 3$ ) The intermediary offers a sub-contract to agent with pre-defined output targets and transfers.
- ( $t = 4$ ) Agent accepts or rejects.
- ( $t = 5$ ) Production and transfers take place. Outputs are observed by all players.  $\mathcal{I}$  observes outputs and reports. Game ends.

Any observation of agent types comes with the offer of the subcontract: approaching the agent with a (non-binary) screening contract will naturally deliver some information to the intermediary. The interplay between information and contract offer still follows the intuitive condition that it will in general be easier for the intermediary to detect inefficient types than types toward the efficient side of the agent's type set.

The intermediary is hired to forward a sub-contract to the agent. The agent's constraints are standard to any screening model of adverse selection.

### 2.2.1 Intermediary's rents

Because of the nature of delegated contracting, the intermediary is paid two different information rents.

- **Ex-ante rent: ( $t=3$ )** To incentivize the intermediary to truthfully forward a screening contract according to the principal's will,  $P$  needs to pay an ex-ante participation rent to  $\mathcal{I}$ . Otherwise,  $\mathcal{I}$  would simply cut off a rightbound interval of agent types.
- **Ex-post rent: ( $t=5$ )** The intermediary is hired to offer a screening sub-contract over the entire interval plus truthfully report the agent type after observing it from the accepted contract and (forward) the output to  $P$ . That is, even if at  $t = 3$  the intermediary offered a screening contract, accepted by  $A$ ,  $I$  could either move mass from

leftbound types close to  $\hat{\theta}$ . To incentivize  $I$  to truthfully forward the sub-contract he is paid a participation constraint  $u(\theta)$ .

For any continuous contracting space for which  $\mathcal{P}$  hires  $\mathcal{I}$  to forward a screening contract,  $\mathcal{I}$ 's rent depends on the acceptance of a sub-contract.  $\mathcal{P}$  can always make the payment contingent on the truthful report of the agent and output delivered. This principle delivers a nonzero type space for which the  $\mathcal{P} - \mathcal{I}$  coalition has alignment of incentives. As in Maggi and Rodriguez (1995b) I assume that the revenue from production is always high enough so that the principal will induce the

$\mathcal{P}$  designs output targets according to his surplus function  $S \in \mathbb{R}^2$ , offering a budget including  $\mathcal{I}$ 's rent and the agent's transfer for a prescribed sub-contract to a leftbound type interval  $[\underline{\theta}, \hat{\theta}]$ , with  $\hat{\theta} < \bar{\theta}$ . This all is in line with standard properties of adverse selection models.

### 2.3 Grand Contract

The Grand Contract is carried out sequentially and reads as follow.

$$\max_{\{q(\theta), v(\theta), u(\theta)\}} (1-\varepsilon) \int_{\underline{\theta}}^{\hat{\theta}} [S(q(\theta), \theta) - \theta q(\theta) - v(\theta) - u(\theta)] f(\theta) d\theta + \varepsilon \int_{\hat{\theta}}^{\bar{\theta}} [S(q(\theta), \theta) - \theta q(\theta) - v(\theta) - u(\theta)] f(\theta) d\theta$$

where  $\varepsilon$  is the probability that the type of agent can be detected by the intermediary at the (sub-)contract offer stage,  $v$  is the agent's information rent, and  $u$  is the related information (ex-post) rent of the intermediary.

$$v^{SB}(\theta) = \int_{\underline{\theta}}^{\bar{\theta}} q^{SB}(\tau) d\tau.$$

Restricting attention to the “well-behaved” case for sub-contracts together with MRLP to reduce the setup to one important benchmark where the monotonicity constraint is slack over the entire production interval. With this in place, the solution concept involves a strictly convex rent profile for the total rent included in the budget. The intuition

behind is the following: since transfer  $s$  contains two information rents together with the ex-ante rent, the resulting rent profile results in being strictly convex, leading to the situation where now the intermediary instead of the agent has an incentive to understate any agent type close to  $\underline{\theta}$ , and to overstate types close to  $\hat{\theta}$ .

With this property in place, I now to focus on one peculiar extension. Simplifying the rent notation  $U = v + u$ , the Hamiltonian can be stated as follows:

$$\mathcal{H}(q, U, \mu, \theta) = [S(q) - \theta q - U]f(\theta) - \mu[\bar{u}'(\theta) + q]$$

with the f.o.c. of

$$S'(q, \theta) = \frac{\mu(\theta)}{f(\theta)}.$$

The Lagrangean can be written as

$$\mathcal{L} = \mathcal{H} + \tau$$

where  $U$  contains all the information rents contained in the budget. Because of convexity, this condition is sufficient (see Seierstad and Sydsaeter, 1977):

$$\frac{d\mu}{d\theta} = -\frac{\partial \mathcal{L}}{\partial U} = f(\theta) - \tau(\theta) \quad (\text{costate equation})$$

$$\frac{dU(\theta)}{d\theta} = -\bar{u}'(\theta) - q(\theta) \quad (\text{state equation})$$

The complementary slackness conditions read:

$$\tau(\theta)U(\theta) = 0 \quad ; \quad \tau(\theta) \geq 0 \quad ; \quad U(\theta) \geq 0.$$

Lastly, I state the transversality conditions as follows:

$$\mu(\underline{\theta})U(\underline{\theta}) = 0 \quad ; \quad \mu(\underline{\theta}) \leq 0 \quad ; \quad \mu(\hat{\theta})(U(\hat{\theta}) - k) = 0 \quad ; \quad \mu(\hat{\theta}) \geq 0,$$

where  $k$  is the ex-ante rent of the intermediary endogenously (see appendix). I define  $\hat{\mu}(\theta)$  to be the value of the costate variable such that  $U'(\theta) = 0$  with  $\hat{\mu}'(\theta) > f(\theta)$ . Note that  $k$  is always binding at the upper end of the contracting space, with  $\tau$  increasing for all information rents to the left.<sup>7</sup> This solution concept, extending properties in MR to a three-player setup now implies that the costate variable  $\mu$  is set to

$$\mu(\theta) = F(\theta) + \bar{\mu}.$$

With  $\bar{\mu}$  being constant, the solution is found by finding the optimal  $\bar{\mu}$  such that the respective output schedule  $\hat{q}(F(\theta) + \bar{\mu}, \theta)$  still satisfies the intermediary's PC while minimizing information rents overall. It is helpful to distinguish the following two cases.

**Case 1:**  $\hat{\mu}$  does not intersect  $F(\theta)$  nor  $F(\theta - 1)$ .

Assume that  $\bar{\mu} > F(\theta) \forall \theta$ . It is easy to see that  $\bar{\mu}$  is optimally set to zero to permit  $\mu(\theta)$  to take the value of  $F(\theta)$ . In this case, the PC is only binding at  $\hat{\theta}$ . The opposite case would require to set  $\bar{\mu} = -1$ .

**Case 2:**  $\hat{\mu}$  intersect either  $F(\theta)$  or  $F(\theta - 1)$ .

In this case,  $\bar{\mu}$  can vary between  $-1$  and  $0$ . To find the optimal solution, I define  $J(\bar{\mu})$  as the difference between the two borderline types  $\underline{\theta}$  and  $\bar{\theta}$ , that is

$$J(\bar{\mu}) \equiv \int_{\underline{\theta}}^{\bar{\theta}} U'(\theta) d\theta = \int_{\underline{\theta}}^{\bar{\theta}} [\bar{u}'(\theta) + \hat{q}(\bar{\mu} + F(\theta), \theta)] d\theta,$$

which is an increasing function and displays the utility differential between the borderline types when the costate variable follows  $\bar{\mu} + F(\theta)$ . For  $J(0) < 0$ , the standard case applies and  $\bar{\mu}$  is optimally set to zero and  $U(\theta) = 0$ , satisfying the transversality condition as well as PC. Instead, if  $J(-1) > 0$ ,  $\bar{\mu} = -1$  and  $U(\underline{\theta}) = 0$ .

Taking  $U'(\theta) = -\bar{u}'(\theta) - \hat{q}(\mu(\theta))$  permits to substitute

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<sup>7</sup>See also Maggi and Rodriguez (1995b) and Léonard and Long, Ch. 7.

$$U(\bar{\theta}) = U(\underline{\theta}) + J(\bar{\mu}).$$

Based on Lemma 4 in MR, I now state my result in the following proposition:

**Proposition 1.** *Optimal Contract for  $\hat{\mu}' > f(\theta)$  (strict convexity)*

The optimal contract entails:

- (i) a unique first-best production type  $\theta^*$  with  $q(\theta) = q^*(\theta)$ ,
- (ii) for any interior type  $\theta^*$  an upward distortion left of  $\theta^*$  with  $q(\theta) > q^*(\theta)$  for all types  $\theta \in [\underline{\theta}, \theta^*[$ ,
- (iii) and a second-best downward distortion right of  $\theta^*$ , with  $q(\theta) < q^*(\theta)$  for all types  $\theta \in ]\theta^*, \bar{\theta}]$ .

The optimal delegation proof contract is fully separating.<sup>8</sup>

An illustration of the optimal delegation contract for the standard benchmark is given in *Fig.1* below:<sup>9</sup>

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<sup>8</sup>Note that different from MR, the most balanced case with  $U(\underline{\theta}) = U(\hat{\theta}) = 0$  is not reached in this setup because of the strictly positive ex-ante rent  $k$ .

<sup>9</sup>A detailed graphical elaboration is available from the author.

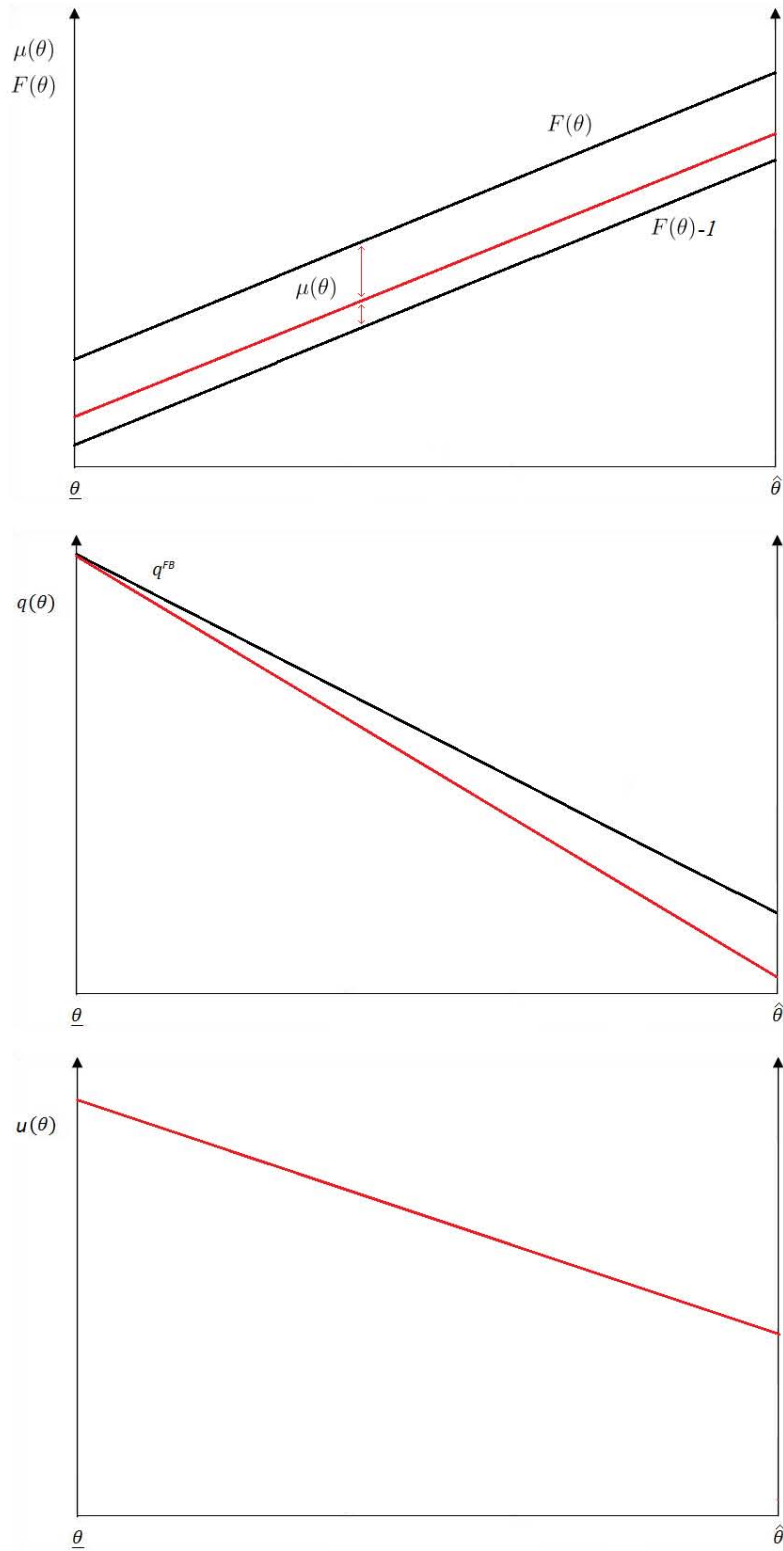


Fig. 1: The optimal delegation contract in the production space.

## 2.4 Discussion

A remark on the robustness of the setup once the strict convexity condition would be violated is in order. A violation could e.g. happen once the intermediary's rent profile is affected by an internal control scheme.<sup>10</sup>

Assume that strict convexity of the rent profile is indeed violated. Then, there still exists a solution, but not a general one for the entire interval of types.  $\hat{\mu}$  is then decreasing and intersects  $F(\theta)$  from above say at  $\theta_1$ . The rent profile is no longer strictly convex, and the optimal output targets result in  $q(\underline{\theta}) = q^*$ , with decreasing output schedules toward  $\theta_1$ .<sup>11</sup>

To show this, let  $\hat{\mu}$  be the solution in  $\mu$  such that

$$\bar{u}'\theta + \hat{q}(\mu, \theta) = 0$$

where  $\hat{\mu}(\theta)$  is the costate variable ensuring that the agent's utility remains constant or  $U'(\theta) = 0$ . In this case, it is the slope of  $\hat{\mu}(\theta)$  that determines the optimal contract. Furthermore, if the participation constraint binds on a nondegenerate interval, then it must hold that

$$\mu(\theta) = \hat{\mu}(\theta).$$

Concerning slope,  $\tau$  would now rewrite into

$$\tau(\theta) = f(\theta) - \hat{\mu}'(\theta) \geq 0.$$

Thus, to guarantee an optimum it must hold that

$$\hat{\mu}'(\theta) \leq f(\theta).$$

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<sup>10</sup>I have presented such an extension in Gick (2008) to the discrete type model.

<sup>11</sup>In the area right of  $\theta_1$ , the former solution still applies. See in particular MR.

Furthermore,  $\mu^*(\theta) = F(\theta)$  with  $F(\theta) < \hat{\mu}(\theta)$ , and  $\bar{u}'' \geq 0 \forall \theta$  is the solution for a leftbound interval  $[\underline{\theta}, \theta_1]$ .

**Proposition 2.** *Optimal Contract under weak convexity.*

The optimal contract entails the following. There is a truncated contracting interval  $\theta \in [\underline{\theta}, \hat{\theta}]$  such that under weak convexity of the intermediary's rent profile  $\bar{u} \bar{u}'' \geq 0 \forall \theta$ , optimal output schedules under  $\hat{\mu}'(\theta^*) \leq f(\theta)$  entail the following results:

1) Nonincreasing output schedules and fully separating contracts for the agent:

$$\begin{cases} q(\theta) = q^F(\theta) & \text{for } \theta \in \{\theta_0, \theta^*, \theta_1\} \\ q(\theta) < q^F(\theta) & \text{for } \theta_0 < \theta < \theta^* \\ q(\theta) > q^F(\theta) & \text{for } \theta^* < \theta < \theta_1 \\ q(\theta) = 0 & \text{for } \theta > \hat{\theta}, \end{cases}$$

2) second-best targets with a downward distortion and  $q(\theta) < q^* \forall \theta$  if  $\hat{\mu}(\theta) > 0$ ,

3) second-best targets with an upward distortion and  $q(\theta) > q^* \forall \theta$  if  $\hat{\mu}(\theta) < 0$ ,

4) a binding PC for the intermediary for any  $\theta$  satisfying  $\hat{\mu}(\theta) = F(\theta)$ ;

5) full participation and full separation of agent types for  $\bar{u}'' > 0$ ;

6) pooling of agent types when  $\bar{u}'' = 0$ ;

7) as well as exclusion of rightbound types following the level of the ex-ante rent from right to left:

a) Let  $\mathcal{P}$ 's surplus function permit the contracting range to set  $\bar{\theta}$  into the rightmost subinterval:  $\underline{\theta} \in [\theta_2, \bar{\theta}]$ . Then, the optimal contract involves all three regions: a leftbound region with second-best output targets between  $\underline{\theta}$  and  $\theta_1$ , a middle region for  $\theta \in [\theta_1, \theta_2]$  with output schedules relatively increasing compared to the first region, which involves having less of a relative downward distortion, including the first-best solution followed by



an upward distortion until  $\theta_2$ , and a rightbound region with upward distorted production targets.

b) With increasing ex-ante rents for the intermediary and  $\bar{\theta} \in [\theta_1, \theta_2]$ , the optimal contract involves the two regions, namely  $\underline{\theta}$  and  $\theta_1$ , as well as  $[\theta_1, \theta_2]$ .

c) With even more increasing ex-ante rents for the intermediary, the principal wants the contract only be offered in the leftbound region with second-best output targets between  $\underline{\theta}$  and  $\theta_1$ .

### 3 Concluding Remarks

The emphasis of this contribution has been on the characterization of the optimal delegation proof Grand contract of delegated contracting when agent types are continuous. The solution characterized in the previous section has shown that typically, delegated contracting is a contractual form that permits a very intuitive solution, and this in particular for the case of a continuum of types.

Based on these findings, several new fields of research should become tractable. A first should be the applicability of internal control. For the discrete type setup in FGM, I have shown in Gick (2008) that threatening the intermediary with a Baron-Besanko style auditing scheme will always permit to reduce the information rent paid to the intermediary. For the continuous type setting the solution concept will resemble the slight convex case discussed above, involving subintervals in which the monotonicity constraint will become binding and pooling under full participation will apply. To present a generalized treatment including an internal control scheme for continuous types would, however, be beyond the task of the present paper.

A second field of investigation should be on the nature of information as it emerges in such setups. Primarily, delegated contracting, in its most direct sense, should be defined as revealing information to the intermediary as the player offering the contract, and this

through contracting the downstream productive agent through the contract offer. It may become rewarding to add another information gathering stage along the timeline. This would make information acquisition an additional task for the intermediary, which does not naturally emerge in delegated contracting. The particular literature is complementary to the paper and, given the information flow along the timeline, would require a substantial change in a setup as it would make the intermediary a supervisor (should she be hired to observe some characteristics of the agent *after* contract acceptance), or a source of additional information for an improved contract design, such as described for two-player setups in seminal work by Cr  mer and Khalil (1992) as well as Cr  mer, Khalil and Rochet (1998). Notably, also Compte and Jehiel (2002) have added a specific view to this field, by changing the multiagent contracting environment. To extend delegated contracting into such directions is left for future research.

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# Appendix

**Determining the intermediary's ex-ante rent to be included in the budget  $s$ .**

With the type distribution being common knowledge, there is an interior cutoff type  $\theta^C$  that determines the ex-ante rent  $k$  of the intermediary for any well-behaved distribution function over agent types. To incentivize the intermediary, the principal needs to include the maximum value of this rent  $k$  in the transfer schedule  $s$  that otherwise would the intermediary reap by reducing the agent's set of types to a leftbound subinterval  $[\underline{\theta}, \theta^C]$ .

$$k = \int_{\underline{\theta}}^{\hat{\theta}} \left( \int_{\theta}^{\hat{\theta}} q(\tau) d\tau \right) f(\theta) d\theta - \int_{\underline{\theta}}^{\theta^C} \left( \int_{\theta}^{\hat{\theta}} q(\tau) d\tau \right) f(\theta) d\theta - \int_{\theta^C}^{\hat{\theta}} \left( \int_{\theta}^{\hat{\theta}} q(\tau) d\tau \right) f(\theta) d\theta$$

By applying Fubini's theorem and integrating by parts, this expression can be rewritten into

$$k = \int_{\underline{\theta}}^{\hat{\theta}} \frac{F(\theta)}{f(\theta)} q(\theta) d\theta - \int_{\underline{\theta}}^{\theta^C} \frac{F(\theta)}{f(\theta)} q(\theta) d\theta - \int_{\theta^C}^{\hat{\theta}} \frac{F(\theta)}{f(\theta)} q(\theta) d\theta,$$

which is maximized following the agent's type distribution by finding the optimal cutoff  $\theta^C$ :

$$\max_{\{\theta^C\}} k = \int_{\underline{\theta}}^{\hat{\theta}} \frac{F(\theta)}{f(\theta)} q(\theta) d\theta - \int_{\underline{\theta}}^{\theta^C} \frac{F(\theta)}{f(\theta)} q(\theta) d\theta - \int_{\theta^C}^{\hat{\theta}} \frac{F(\theta)}{f(\theta)} q(\theta) d\theta.$$

A graphical representation is available from the author.