DISCUSSION PAPER SERIES

No. 2573

COMPETING FOR OWNERSHIP

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INDUSTRIAL ORGANIZATION

Centre for **E**conomic **P**olicy **R**esearch

www.cepr.org

ISSN 0265-8003

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Discussion Paper No. 2573
October 2000

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CEPR Discussion Paper No. 2573

October 2000

ABSTRACT

Competing for Ownership*

We provide a simple framework for analysing how organizations are designed in a competitive economy. We focus on the allocation of rights of control and show that in the presence of liquidity constraints, transferring authority can serve as an effective means of transferring surplus, although this may entail some efficiency loss. The efficiency and organizational structure of a typical firm will depend on the liquidity of the 'marginal' agent in the market and not just on the liquidity and technology of the members of the firm. Liquidity changes in a small fraction of the population can lead to restructuring of ownership throughout the economy.

JEL Classification: D23, D31, G34 and L22
Keywords: contract theory, mergers, ownership and shocks to distribution

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*Revised version of a paper circulated under the title 'Competing for Ownership with Liquidity Constraints'. We thank Philippe Aghion, Patrick Bolton, Mathias Dewatripont, Oliver Hart, Bengt Holmstrom, Jean-Jacques Laffont, Janet Mitchell, Lars Stole, Julie Wolf and especially Patrick Rey for helpful conversations and for comments on the earlier drafts. This Paper is produced as part of a CEPR research network on The Evolution of Market Structure in Network Industries, funded by the European Commission under the Training and Mobility of Researchers Programme (Contract No ERBFMRX-CT98-0203). Patrick Legros also benefited from the financial support of the Communauté française de Belgique (projet ARC 98/03-221).

Submitted 19 July 2000

NON-TECHNICAL SUMMARY

We provide a simple supply-and-demand framework for analysing how organizations are designed in a competitive economy. We focus on the allocation of rights of control and show that in the presence of liquidity constraints, transferring authority can serve as an effective means of transferring surplus, although this may entail some efficiency loss.

In our model, there is no capital to be financed; finance is used solely as a means of transferring surplus, either to attract a partner or to reassign control rights. In effect, finance facilitates trading control rights. Our investigation therefore differs from the financial contracting literature, which focuses on the trade of control rights to facilitate financing. The model is particularly suited to studying mergers and acquisitions or employment contracting in competitive settings, where financing has little to do with real investments.

Our goal is not to derive the optimal contract in a given firm but rather to derive the equilibrium allocation of control in the economy. It turns out that the market plays a key causal role in determining such internal organizational choices as the assignment of control and the degree of integration. The efficiency and organizational structure of a typical firm will depend on the liquidity of the *marginal* agent in the market and not just on the liquidity and technology of the members of the firm.

The model has several implications for the determination of ownership structure and for understanding economy-wide organizational change. For instance, agents with greater market power (in the sense of being more scarce) will have a greater degree of control; within and across firms, agents with larger shares of surplus get greater degrees of control; and having greater liquidity (weakly) increases the amount of control one has in the firm. Liquidity changes in a small fraction of the economy's population can lead to restructuring of ownership throughout the economy. The model therefore provides the basis for a theory of merger waves.

We derive a number of comparative static results relating the distribution of liquidity to the degree of centralized control and aggregate economic performance. Decreasing interest rates and certain first-order stochastic dominant shifts in the distribution of liquidity both may lead to increases in centralized control and decreases in aggregate performance. On the other hand, greater equality in the distribution among existing firms may increase performance and lead to greater decentralization.

1 Introduction

Organizations use a variety of instruments to provide incentives and allocate resources. Some of these instruments, such as compensation schemes, are pecuniary; others, such as control rights, are nonpecuniary. It is now well understood that these instruments are not perfectly substitutable and that neither dominates the other. Quite generally, pecuniary and nonpecuniary instruments allow varying degrees of *transferability.* It is well known—but widely underappreciated—that under limited transferability, competition will not necessarily select control structures that are "efficient" in the sense that they maximize total surplus or increase the profitability of firms.

For example, the popular view that mergers and takeovers increase profitability by transferring control of assets to more efficient or "disciplined" managers has at best weak empirical support.[1] But this should come as no surprise: the mere fact that control rights are used to provide incentives suggests that the parties do not have the ability (or do not want) to use purely pecuniary instruments. Perfect transferability doesn't apply here, and one cannot presume that the organizational choice, even if it is Pareto optimal, will be surplus maximizing. Since the degree of transferability will depend on the availability of the most liquid instruments (e.g. cash), merger activity must be linked to the ability and willingness of agents to exchange liquidity for the other instruments.

A reasonable conjecture might then be that if two parties have more liquidity, they have less reason to exchange control rights. Hence, merger activity should be negatively related to the level of liquidity, at least for these two agents. How far can we push this conjecture to understand merger activity at the economy-wide level? Not very far. The partial equilibrium conjecture ignores the fact that more transferability between two agents creates a pecuniary spillover effect: the increased surplus that one partner can offer the other may force *all other agents* in the economy to pay higher surpluses to their partners as well. It is therefore perfectly possible for economy-wide increases in liquidity to be associated with *greater* exchange of control rights, i.e. more mergers.

In this paper we investigate how liquidity at the individual and aggregate level affects the design of organizations and their interaction with aggregate economic performance when asset holders compete to attract holders of complementary assets. The model we study is inspired by the work of Grossman and Hart (1986), Hart and Moore (1990), and Hart (1995) in that ownership

[1]See Baldwin (1995), Golbe and White (1988), Marris and Mueller (1980), Mueller (1995) and the references herein.

(and authority) are defined in terms of residual rights of control. However, rather than focus on a hold up problem with purely private costs and benefits, we take a "complete contracts" approach and consider a standard production environment in which output, but not all of the costs involved in producing it, can be contracted upon, and in which the decisions, because they are unobservable, are not contractible.

In the model, complementarities in production require the use of two different assets. Some agents in the economy (think of them as upstream firms) initially control one type of asset (say asset 1, auto body factories) and some other agents (downstream firms) control another type of asset (asset 2, car factories). If an agent has control over an asset, he can decide (in a non observable way) on how to use this asset. (Think of assets as machines and of decisions as the way the machine is set.) The decisions made affect the probability that a high output is realized and the disutility of work of the agents. Then agents work and output is realized. If asset 2 is not used with asset 1, its next best use yields his owner a fixed return. We assume that there are more asset 2 owners than asset 1 owners. In this setting, competition among asset 2 owners ensures that the marginal asset 2 owner does not get any surplus and that asset 1 owners are able to obtain high levels of surplus, which will be determined by the ability to pay of the marginal asset 2-owner.

Two sorts of instruments can be used in contracting. *Control instruments* simply specify who will make the (non observable) decisions on the assets. We distinguish among *financial instruments* as a function of the time at which transfers are made: liquidity (e.g., cash) is used for ex-ante transfers, inside finance (a share of output) is used ex-post, and outside finance involves a contingent payment in both periods. Different types of inefficiencies are linked to each instrument : control entails a loss of specialization,[2] outside finance creates a debt overhang effect and inside finance changes the marginal benefits of decisions.

The model adheres to the methodological precept that the way monetary and control instruments are bundled (debt and equity do so differently, for instance) should be endogenous; there is indeed no economic rationale in imposing exogenously a relationship between financial instruments and control rights. Rather all possible combinations of control rights and financial instruments are allowed a priori, but only certain combinations appear in equilibrium.

Since ex-ante transfers do not affect incentives,[3] liquidity is the "best"

[2] We also consider the possibilty that centralization reduces the incentive problem when centraliztion requires consolidation of assets.

[3] Asset holders are risk-neutral. With risk-aversion, ex-ante transfers would change the

financial instrument; absent liquidity problems, the outcome of competition would then be "efficient" in the sense that ex-ante asset holders would agree on a control structure that maximizes the total surplus. Under liquidity constraints however, the liquidity positions of the partners in a relationship will help determine the way they organize their firm, and which types of financial instruments they use. We might be tempted to conjecture that "more liquidity" is therefore "better" from an efficiency point of view. As we will show this conjecture is basically incorrect.

Indeed, the liquidity of the two agents in a relationship is important since it determines their *ability* to transfer surplus ex-ante from one to the other. However, the equilibrium surplus that each will ask in order to enter into a given contract is determined in the market by the *marginal* agent. If the marginal agent's liquidity increases, the surplus that his potential partners will ask on the market will increase; this might make other agents *less* able to pay this price, even if their own liquidities increase as well. Consequently, there will be changes to the control and financing structures of the "inframarginal" agents, possibly at the cost of efficiency. It is in fact easy to show that a first order stochastic shift in the liquidity distribution may result in a *decrease* in average welfare. This illustrates the dangers of ignoring general equilibrium effects when modeling the competitive choice of control structures (or of organizations in general). *Local changes* in liquidity can generate *global restructuring* in the economy: the local change in liquidity modifies the "price" that must be paid and might require *all* other firms to change control and finance structures. Our theory could therefore be a starting point for modelling merger waves.[4]

A large theoretical literature on the connection between wealth distribution and economic performance suggests that this relationship cannot typically be characterized by simple (e.g. monotonic) relationships between standard measures of inequality (like first and second order stochastic dominance) and welfare. Our model is no different in this regard, but we do provide some necessary and sufficient conditions for shocks to the distribution to yield welfare improvements. These conditions help underscore the importance of two relevant features of the distribution: the liquidity level of the marginal asset

incentive problem; however, in this case, finance tends to create even stronger distortions.

[4]Our comparative statics results also suggest that there is no obvious relationship between merger activity and the business cycle (assuming that peaks correspond to more liquidities for asset holders). This is consistent with the amibguity in the empirical findings: some like Steiner (1975) and Golbe and White (1988) found that mergers were procyclical, others like Becketti (1986) found that mergers were negatively influenced by real GNP and others like Nelson (1959), Guerard (1985) found insignificant relationship between mergers and GNP.

holder, and the distribution of liquidity among infra-marginal agents.

The model also suggests a way to draw connections between market power and power in organizations; and between the level of control and the share of the enterprise surplus accruing to an agent. Specifically, in this model, agents with greater market power (in the sense of being more scarce) will have greater degree of control. Moreover, within and across firms, agents with larger share of surplus get greater degree of control. Finally, having greater liquidity weakly increases the amount of control one has in the firm. All of these predictions seem to accord with the stylized facts.

Since finance and control instruments are bundled endogenously, our approach enables us to understand when particular financial instruments are used in combination with certain control structures. A first result is that whenever the control structure is decentralized, i.e., whenever each asset holder keeps the control of his asset, outside finance is dominated by inside finance. Indeed, outside finance involves an ex-ante transfer to the other party and an ex-post transfer to the lender. Therefore outside finance reduces the *effective* share that the borrower uses in computing her marginal benefits from decisions without a concomitant increase in the recipient's; complementarities in production then imply that both agents are better off if they instead modify the inside finance level of the recipient's, who will then get an increased marginal benefit of decisions.

Whether or not outside finance is dominated by inside finance when there is centralization depends on how we model centralization. We consider two alternatives, which represent the presence or absence of consolidated assets.

In the case of nonconsolidation, the agent in control can choose different decisions for each asset, and the logic of the decentralization case applies: the agent in control will have greater incentives to "work" if the transfer is made via inside finance than by outside finance, and outside finance is dominated (at least weakly) by inside finance. Hence in our model, whenever mergers do not yield consolidation of assets, we should not observe the use of outside finance.

In the consolidation case, the same decision has to be made for the two assets. We have in mind here situations in which headquarters are consolidated and the corporate culture has to be the same; in this case decisions made by the consolidated headquarters will affect in the same manner all agents in the firm, i.e., there is a "common cost" structure. We show that outside finance will be now used, at least if the agent making the transfer has little liquidity. Indeed, when agent 1 controls the two assets, and when both agents have the same inside finance, their marginal benefits are identical. Hence, with equal inside finance, the agent in control makes the efficient decision. The agent will indeed agree to equal inside finance only if the other agent is able to give him ex-ante a large enough payment: outside finance can always be used to do so since it does not distort ex-post the incentives of the agent in control (whose effective inside finance is the same as his contracted inside finance) or of the other agent (who has a lower effective inside finance but who has no control). So the analysis suggests that when mergers are accompanied by consolidations (so that the decisions are more public) we should see more outside financing.

Moreover, the use of outside finance adds another "general equilibrium" effect: increases in aggregate liquidity will increase the degree of centralized control in the economy, even though this may not be efficiency enhancing. The reason is that under consolidation, centralization has the advantage of *flexibility in the distribution of surplus* relative to decentralization: the latter becomes very inefficient if the shares are not approximately equal, while centralization, because it allows use of non distortionary outside finance, can provide an unequal distribution of surplus without sacrificing its performance. When liquidity increases, interest rates decrease and this comparative advantage of centralization increases. Since the short side of the market will capture all the surplus, there will be a switch to centralization. Efficiency may actually decrease if the returns to specialization are high. Similarly, external forces yielding to a decrease in the interest rate will increase the degree of centralization in the economy and will decrease efficiency.[5]

We believe that our approach provides a fresh perspective on the role of authority in organization, i.e., as a means of transferring surplus. By showing that the organization of all firms depends on the liquidity of the marginal firm, we are led to new comparative static predictions that will relate types of data that have not entered empirical investigation of firm structure. For instance, based on Grossman-Hart-Moore, we are led to look at complementarity of assets, importance of individual firm member's contributions, etc., all of which are difficult to verify in practice. By contrast, data on interest rates, liquidity distributions, volume of trades, mergers and acquisitions, and financial regulations are relatively easy to come by.

There is obviously a large literature on control and financial structures.[6] The fact that limited liquidity affects the efficiency of a *given* enterprise is well known and the general agenda of the literature has been to find the second best "optimal" financial structure. Built in these models is a need for finance in order to produce (i.e. capital requirements); control rights are assigned to "outside" parties in order to help with the efficiency of financing

[5]This result is consistent with the finding of Melicher, Ledolter and D'Antonio (1983) that there is a negative relationship between interest rate and merger activity.

[6]For instance, Jensen-Meckling (1976), Aghion-Bolton (1992), Dewatripont-Tirole (1994), Holmstrom-Tirole (1997).

(e.g., correct for ex-post incentives to default on repayment). In short, *trading control rights facilitates financing.*

We depart from that literature in two ways.

First, in our model, there is no capital to be financed; finance is used solely as a means of transferring surplus, either to attract a partner or to re-assign control rights. In effect, *finance facilitates trading control rights.* The model is therefore particularly suited to studying mergers and acquisitions, franchising arrangements, and employment contracting in competitive settings where financing seems to have little to do with real investments. As we mentioned, a methodological corollary to this is that we do not prejudge the issue and initially associate allocations of control rights to particular allocations of return-stream rights, but rather allow them to emerge endogenously (e.g. outside finance goes with centralized but not decentralized control).

Second, our goal is not to derive the optimal contract in a given firm but rather to derive the equilibrium allocation of control in the economy. As we have already emphasized, the contract for a given relationship does not depend on what is surplus maximizing for that relationship but depends on the contractual terms used in the marginal relationship. Thus the market plays a key causal role in determining such internal organizational choices as the assignment of control and the degree of integration.

The rest of the paper is organized as follows. In the next section we introduce our model and describe the set of surpluses that a pair of agents can achieve when contracts specify control structures and financial instruments. We then consider the competitive equilibrium of the economy and analyze how liquidity shocks affect the efficiency of the equilibrium. In our model "more efficiency" is equivalent to "less control" and we are able to analyze how liquidity shocks impact on the degree of centralization in the economy.

2 A Model of Control

Consider an economy with two types of assets that are complementary in production. There is a measure $n < 1$ of agents of type 1 and a measure 1 of agents of type 2. An agent of type i owns asset i and is also needed for the asset to be used in a productive way. Production is conducted in enterprises consisting of one type-1 and one type-2 agent and both types of assets. The liquidity of an agent of type i will be denoted l_i ($l_i \geq 0$) and the distribution of liquidity among agents of type i is given by F^i. For ease of exposition, we make the following assumption:

Assumption H0 F^i is continuous and has a convex support.[7]

Agents are risk neutral. If an agent is not matched with an agent of the other type, he cannot produce anything and his utility is equal to the value of his liquidity.[8] For this reason, the relevant concept of payoff is the *surplus*, that is the utility payoff in excess of the value of the initial liquidity.

How much production can be realized and how much surplus each agent obtains depend on the *contracts* that are signed, in particular on the allocation rights of control over the assets, and on the allocation of the revenues and costs from production. The nature of the trade-offs may depend on the exact specification of the model, but the main point of the paper, that local shocks to liquidity generate global restructuring and recontracting in the economy, is quite general.

2.1 The Feasible Set

Consider two risk neutral agents who can jointly engage in production. Each agent has a specific skill to use an asset, agent of type i is needed to operate the asset i. There are benefits from joint production only if one asset of type 1 is combined with one asset of type 2. Agent of type i has liquidity l_i (think of liquidity as cash). We will evaluate payoffs for the agent at the end of their relationship. If the interest rate is r, $r \geq 0$, a dollar transferred at the beginning of the relationship has therefore a utility value of $1 + r$.

Joint production yields a stochastic output. With probability p, there is an output $R > 0$, with probability $1 - p$ there is an output of 0; p depends on certain "tailoring" decisions that will be taken later in the relationship. Output is publicly observable, so contracts will be written contingent on it. However, the decisions themselves are only observed by the agent who undertakes them and are therefore *never* contractible (the riskiness serves to prevent inferences from being made about the decisions). These decisions might be about what exactly needs to be done to produce or about the way particular assets have to be modified or about conditions under which

[7] This assumption allows us to define an equilibrium in the market for ownership in terms of a of the liquidity levels of agents rather than in terms of the individual agents themselves. It also avoids possible indeterminacies in the equilibrium "price" of control. It is straightforward, if slightly cumbersome, to treat the general case.

[8] It is not hard to extend this model to the case in which the agent receives a positive payoff from autarchy; if these payoffs differ across agents, one obtains an upward sloping rather than vertical supply in Section 4, and one can dispense with the assumption that there are unequal measures of type 1 and type 2 agents.

production will be carried out.[9] We denote by $q_i \in [0, \bar{q}]$ the decision on asset i. We assume that the probability of success p is a strictly increasing and concave function of q_1 and q_2 that satisfies the Inada conditions $\partial p / \partial q_i = \infty$ at $q_i = 0$ and $\partial p / \partial q_i = 0$ at $q_i = \bar{q}$ and the complementarity condition $\frac{\partial^2 p}{\partial q_1 \partial q_2} > 0$. Since p is a probability, we also have $p(q) \leq 1$ for all $q = (q_1, q_2)$. We will furthermore assume symmetry, i.e., that $p(q_1, q_2) = p(q_2, q_1)$.[10]

Even if holder of asset i does not have control over q_i, he is needed for production and his "effort" is required for output to be produced. Agents are risk neutral in the income which accrues from the enterprise and from any financial transactions. Of course, more income is better.

Tailoring asset i to q_i generates costs for the agent of type i. We will consider an extreme form of this cost (which we will refer to as the private cost structure) and assume that it falls entirely on the agent who originally held the asset, regardless of who makes the decision. For example, a worker may have to work on an assembly line; the plant manager decides how fast it will go, how polite to be, etc., all of which affects him (but for simplicity not the plant manager). These same decisions also affect (say in opposite ways) the success of the enterprise. To simplify notation we also assume that the two types of agents have the same cost function. The cost is of the form $\phi(q_i)$, which is a strictly increasing and convex function of q_i satisfying $\phi(0) = \phi'(0) = 0$. This is a simple way to capture the idea that the decision that are made by agent in control will affect other members of the enterprise in ways which he may not take into account.

Note that the agent who incurs the cost will be able to infer what action was taken. However, by the time he learns this it is too late – output is realized at the same time. Thus no message games can be used.[11] In this sense, we are using a complete contract framework to study authority (as in for instance Aghion-Dewatripont-Rey, 1999; Legros-Newman, 1999a; Tirole, 1999).

Although the costs do not depend on who makes decisions, not so the output. We assume that there are gains to specialization: agent i is better at controlling asset i than he is at controlling asset j. A simple way to capture this idea is to suppose that the success probability is equal to $\sigma p(q)$ when i controls asset j, where $\sigma < 1$ (if the agents were to "swap" assets, then the probability would be $\sigma^2 p(q)$). This leads to a trade-off: centralization

[9] Since the right to take decisions is transferable, the reader should not think of these decisions as "effort variables" but rather as actions that affect the work environment.

[10] The symmetry assumption is only for expositional purpose.

[11] All decisions are sunk at this point, so if they were to play such a game, both agents' preferences would be independent of the actual state, which prevents a mediator from extracting any further information.

is effective at overcoming free riding ("coordination") while decentralization takes advantage of the gains from specialization.

As in the incomplete contracting literature (Grossman-Hart) the allocation of control rights affects the efficiency of the relationship. An allocation of control rights is identified with a partition $\boldsymbol{\alpha} = (\alpha^1, \alpha^2)$ of the set of assets $\{1, 2\}$ between the two agents. For instance, $\boldsymbol{\alpha} = (\{1\}, \{2\})$ corresponds to a situation in which each agent retains control of his asset, which we will call *decentralization* while $\boldsymbol{\alpha} = (\{1, 2\}, \varnothing)$ corresponds to a situation in which agent of type 1 controls both assets, which we will call *centralization*. There are three (pure) ownership structures of interest:

- *decentralized control* : agent of type i has control of asset i, for $i = 1, 2$.[12]
- *centralized 1-control* : agent of type 1 controls both assets.
- *centralized 2-control* : agent of type 2 controls both assets.

For centralization, we will consider two situations depending on whether it requires a consolidation of assets or not. Without consolidation of assets, the agent in control is free to choose any $(q_1, q_2) \in [0, \overline{q}]^2$. With consolidation of assets, the agent in control must choose the same decision for each asset, i.e., must choose an element of the diagonal of $[0, \overline{q}]^2$.

Each control structure generates inefficiencies since the agent in control does not internalize the externality created by his decision: with decentralization, agents do not internalize the effect on the total expected revenue, with centralization, the agent in control does not internalize the cost imposed on the other agent. However, despite these inefficiencies, allocating control rights might be the only instrument for transferring surplus from one agent to the other. Whether or not this is the case depends on the ability that agents have in allocating surplus by using financial instruments.

Here, there are three ways of transferring surplus from one agent to the other within a firm:

- *Cash* or *liquidity* (t)*:* an ex-ante transfer of liquidity from agent 2 to agent 1 with no ex-post obligations.
- *Inside finance* (s)*:* a financial arrangement with only ex post obligations; each agent receives a zero share if production fails and agent 1 receives a share s and agent 2 receives a share $R - s$ if production succeeds.

[12] There is another DC possibility, namely when type 1 controls asset 2 and type 2 controls asset 1, i.e. the assets are swapped; but this possibility is dominated by asset retention since $\sigma^2 < 1$.

- *Outside finance* (f^i) *:* an ex-ante transfer B^i is made from an outside lender to agent i who then passes it on to his partner; agent i then has an ex post obligation to pay the lender D^i in case output is high.[13] The market for outside finance is competitive and lenders must make a zero profit.

In contrast with the incomplete contracting literature we are not as a matter of definition associating particular allocations of control rights with the financial instruments; they are instead defined only in terms of *when* the transfers are made and when the obligations are due (with only two states of the world, more refined definitions are not possible). Later we shall show that different financial instruments will *endogenously* be associated with different allocations of control rights. For instance, outside finance will only be used in financing centralized control, never decentralized control (it will always be dominated by inside finance in the latter case).

The sharing rules we examine are of the form s to the type 1, $R-s$ to the type 2 in case the venture succeeds, 0 to both otherwise. With risk neutrality and budget balance, this is without loss of generality,[14] except insofar as we have imposed true limited liability: the liquidities cannot be put at stake as part of the sharing rule. As long as no third-party contracts which give the third party an incentive to destroy the venture's output are allowed, this too is without loss of generality.[15] Not only is this a plausible restriction, but it also has an important simplifying consequence for the computation of the market equilibrium.

Even in this risk neutral world, outside finance may have certain advantages relative to inside finance and certain drawbacks. On the downside,

[13] Outside finance entails use of an outside lender: if an agent were to "borrow" B from his partner rather than an outside lender, this would be indistinguishable from first receiving a cash transfer B from him and increasing the corresponding equity share by B/p).

[14] More generally, we could allow the agents to put part of their liquidity in escrow. If the total escrow is L (where $L \leq l_1+l_2$ for feasibility) the revenue is $R+L$ with probability p and L with probability $1-p$. Feasible inside equity arrangements are then for 1 to get a share $s_H \in [0, R+L]$ with probability p and a share $s_L \in [0, L]$ with probability $1-p$. Therefore, from a strategic point of view only the share differential $s_H - s_L$ is relevant for agent 1 and only the share differential $R-(s_H-s_L)$ is relevant for agent 2. In the case of decentralization, this is strategically equivalent to a situation without an escrow. A slightly different argument can be used for the case of centralization.

[15] For instance, each partner might agree that in case of failure, their liquidities would be forfeited to a third party, which would strengthen their incentives. But the third party would then be better off if the firm fails than if it succeeds.

Even with such contracts, though, our main point, that the design of an organization will be influenced by the liquidity distribution in the economy as a whole, will still stand. It would just add some complexity to the analysis of the model.

the borrower's incentives are weakened, (similar to the familiar "debt overhang" problem). Moreover, since the recipient of the outside finance receives his compensation ex ante, there is no effect on his incentives. This may be disadvantageous relative to inside finance under the private cost structure, because the borrower would actually benefit from giving his partner stronger incentives. However, under the common cost structure we consider in Section 3.3, there is an upside to this "neutrality" of outside finance as a means of transferring surplus, if the recipient has full control; otherwise there will be an efficiency loss.

Compensating through inside finance will weaken the incentives of the compensating partner while strengthening those of the recipient; whether the overall effect is to increase total surplus or decrease it (even if the decisions are strategic complements, which they will be if $p_{12} > 0$) will depend on the shares. Under some circumstances inside finance will dominate all other means of transferring surplus.

A *(pure) contract* is a triple $c = (\boldsymbol{\alpha}, s, \mathbf{f}, t)$, where $\boldsymbol{\alpha}$ is the (pure) allocation of rights of control over assets, t is the liquidity transfer, s is the inside finance and $\mathbf{f} = (f^1, f^2)$, $f^i = (B^i, D^i)$, is the outside finance. A contract defines a game between the agents, where the strategy for agent i is to choose decisions for the assets α^i over which he has control.

The strategies available and the surplus functions of the *game associated* to a contract $c = (\boldsymbol{\alpha}, s, \mathbf{f}, t)$ depend on the control structure. (Remember that in this model consolidation *is not* a matter of contractual choice but is a property of the environment.)

- Decentralized control: when $\boldsymbol{\alpha} = (\{1\}, \{2\})$. Agent i chooses $q_i \in [0, \overline{q}]$ and the payoff functions are

$$\begin{aligned} u_1(\mathbf{q}) &= p(\mathbf{q})\left(s - D^1\right) - \phi(q_1) + \left(B^2 + t\right)(1+r) \\ u_2(\mathbf{q}) &= p(\mathbf{q})\left(R - s - D^2\right) - \phi(q_2) + \left(B^1 - t\right)(1+r). \end{aligned} \tag{1}$$

- Centralized 1-control with no consolidation: when $\boldsymbol{\alpha} = (\{1,2\}, \emptyset)$. Agent 1 chooses $\mathbf{q} \in [0, \overline{q}]^2$ and the payoff functions are

$$\begin{aligned} u_1(\mathbf{q}) &= \sigma p(\mathbf{q})\left(s - D^1\right) - \phi(q_1) + \left(B^2 + t\right)(1+r) \\ u_2(\mathbf{q}) &= \sigma p(\mathbf{q})\left(R - s - D^2\right) - \phi(q_2) + \left(B^1 - t\right)(1+r). \end{aligned} \tag{2}$$

- Centralized 1-control with consolidation: when $\boldsymbol{\alpha} = (\{1,2\}, \emptyset)$. Agent 1 chooses $q \in [0, \overline{q}]$ and the payoff functions are

$$\begin{aligned} u_1(q) &= \sigma p(q,q)\left(s - D^1\right) - \phi(q) + \left(B^2 + t\right)(1+r) \\ u_2(q) &= \sigma p(q,q)\left(R - s - D^2\right) - \phi(q) + \left(B^1 - t\right)(1+r). \end{aligned} \tag{3}$$

Denote by $\mathbf{q}$ the unique Pareto optimal equilibrium associated to the contract c.[16] We shall often refer to it as "the equilibrium" of the contract. Feasibility requires[17]

$$\begin{aligned} t &\in [-l_1, l_2] \\ D^1 &\leq s + (1+r) B^2, D^2 \leq R - s + (1+r) B^1 \\ (1+r) B^i &= \begin{cases} p(\mathbf{q}) D^i & \text{if decentralization} \\ \sigma p(\mathbf{q}) D^i & \text{if centralization} \end{cases}, i = 1, 2. \end{aligned} \tag{4}$$

Let $\mathbb{C}(l_1, l_2; r)$ be the set of feasible pure contracts, i.e., the set of contracts that satisfy (4).Let $V(l_1, l_2; r)$ be the set of equilibrium surplus vectors:

$$V(l_1, l_2; r) = \left\{ v \in \mathbb{R}^2; \exists c \in \mathbb{C}(l_1, l_2; r), v = v(c) \right\}.$$

As will be apparent soon, the set $V(l_1, l_2; r)$ is not convex. While the nonconvexities do not pose problems (competitive equilibria will exist and our qualitative results will be the same), they introduce technical complications and a few non-robust predictions. For this reason, we will consider lotteries over pure contracts. It will be these "lotterized contracts" that will be traded on the market. The set $V^*(l_1, l_2; r)$ of surplus vectors attainable by lotteries is then the convex hull of $V(l_1, l_2; r)$

$$V^*(l_1, l_2; r) = coV(l_1, l_2; r).$$

Lotteries also give us a natural way to talk in terms of degrees of control.[18]

2.2 Market Equilibrium

The feasible set describes the way agents can combine financial and control instruments to allocate surplus from production. Which level of surplus an agent obtains depends on the opportunity cost and the ability of different agents of engaging into contracts with other agents. Our concept of market equilibrium corresponds to the following timing in the economy:

[16] That this $\mathbf{q}$ exists is trivial for 1- and 2-control, since it is chosen by a convex optimization problem. For decentralization, there may be several equilibria (if $p(0, \cdot) = p(\cdot, 0) = 0$, then $q_1 = q_2 = 0$ is always an equilibrium and there will be an equilibrium with positive levels of q as well), but under the complementarity and concavity assumptions they will always be Pareto ranked and form a compact set. We assume that the partners can coordinate on playing the Pareto optimum, which seems appropriate in a contracting environment.

[17] The first two conditions are limited liability conditions, the last condition is the zero profit condition for lenders.

[18] This can also be accomplished by allowing for a continuum of assets (or decisions) that may be allocated arbitrarily between the partners. This seems a technically more challenging approach, but worth exploring.

- Agents are matched together into pairs or are left alone. Without loss of generality we consider only matches between an agent of type 1 and an agent of type 2.
- If two agents match they sign a lottery contract that specifies: the liquidity transfer t from agent 2 to agent 1, a lottery between two pure contracts.
- Nature selects a pure contract and the corresponding property rights over assets are assigned.
- If the realized contract specifies outside financing, agents borrow and make the relevant transfers B^i.
- Agents make decisions $\mathbf{q}$.
- Nature selects the output.
- Agents obtain their inside finance and repay their loans.

Since type 2 agents are more numerous than type 1 agents, it is immediate from Assumption H1 that all agents of type 1 will be matched and that a measure $1-n$ of type 2 agents are not matched, hence obtain a surplus of zero. Because unmatched agents have a zero surplus, we define the equilibrium in terms of a matching function for agents of type 1 and surpluses of *matched* agents.[19]

Definition 1 *An equilibrium with exogenous interest rate r is a matching function $m : l_1 \longmapsto l_2$ and surplus maps $v_1^*(l_1; r)$ and $v_2^*(l_2; r)$ satisfying the conditions*

E1 *If* $l_2 = m(l_1), (v_1^*(l_1; r), v_2^*(l_2; r)) \in V^*(l_1, l_2; r).$

E2 $\forall l_i, v_i^*(l_i; r) \geq 0.$

E3 $\forall l_1, l_2, \forall (v_1, v_2) \in V^*(l_1, l_2; r), \exists i : v_i \leq v_i^*(l_i; r).$

E4 *If L_1 is a type-1 liquidity level, then* $F^1(L_1) = F^2(m(L_1)).$

[19] It is easy to verify that *matched agents* satisfy the equal treatment property: agents of the same type having the same liquidity have the same surplus. This property does not necessarily extend to unmatched agents. For instance, if only decentralization is possible, and if all agents of type 2 have no liquidity, the equilibrium surplus of matched type 2 agents is strictly positive while the equilibrium surplus of unmatched type 2 agents is zero, violating equal treatment.

E1 is the feasibility condition; E2 and E3 are the stability conditions (each agent must prefer being matched to not being matched, and two agents cannot find a strictly Pareto improving match); and E4 is a condition insuring that the matching between agents is consistent with the distributions.[20]

In Section 6.2 we discuss the possibility of endogenizing the interest rate by supposing that it is determined solely by the market for financing control. While it would be extreme to assume that this is how interest rates are determined in practice, it is equally extreme to assume that this market never has an effect, and so it is worthwhile analyzing this case. We therefore make the following definition.

Definition 2 *An equilibrium with endogenous interest rate is* r^*, *a matching function* $m : l_1 \longmapsto l_2$ *and surplus maps* $v_1^* (l_1; r)$ *and* $v_2^* (l_2; r)$ *such that*

(i) m *and* v_i^* *is an equilibrium with exogenous interest rate* r^*,

(ii) if $r^* > 0$, *the supply and demand of outside finance are equal.*

3 A Decomposition of the Feasible Set

A basic difficulty with equilibrium models of matching is the thinness of markets: if the feasible set depends on the liquidity of each agent in the firm, a "price system" cannot associate a "price" to an agent type without reference to the types of the other agents who are in the firm. We avoid this problem here since as we will show there is a well defined "price" for type 1 agent that is independent of their level of liquidity. This allows us to make simple demand-supply reasoning and to evaluate the effect of shocks to liquidity in a simple way.

Here we show that the feasible set for each firm can be described by a common set, up to 1-1 transfers of utility related to liquidity transfers. More surprisingly perhaps is the fact that this common set is independent of the interest rate. The level of interest rate affects the transfers of utility that can be made via outside finance and the level of borrowing.

The next proposition shows that a lottery between pure contracts can be replaced by a non-contingent ex-ante liquidity transfer and a lottery over two pure contracts that use only inside and outside finance.

We first note that liquidity transfers do not influence the equilibrium decisions.

[20] This is a measure consistency condition. For instance, the function $m(x) = 2x$ matches in a 1-1 fashion points in the interval $I = [1, 2]$ to the interval $J = [2, 4]$. However, if there is a measure 1 of agents in I and a measure 2 of agents in J, and if there is a uniform distribution in I and in J, then condition E4 is violated since $F^1(2) = 1 < 2 = F^2(4)$.

Lemma 1 *For any t, the games associated to the contracts $(\boldsymbol{\alpha}, s, \mathbf{f}, t)$ and $(\boldsymbol{\alpha}, s, \mathbf{f}, 0)$ have the same equilibria.*

Proof. Note that in (1), (2), (3) the equilibrium decisions depend only on $\boldsymbol{\alpha}$ on s and on $\mathbf{f}$. Hence two contracts that differ only in terms of the liquidity transfers are strategically equivalent. They are payoff equivalent up to the liquidity transfers. ■

Since there is a unique Pareto optimal equilibrium, there is a unique surplus vector $v(c)$ that we can associate to the contract $c \in \mathbb{C}(l_1, l_2; r)$.

Let $\mathbb{C}_0(r)$ be the set of pure contracts that do not involve liquidity transfers. From (4), for any (l_1, l_2), $\mathbb{C}_0(r) \equiv \mathbb{C}(0, 0; r) \subseteq \mathbb{C}(l_1, l_2; r)$.

Lemma 2 *$v \in V^*(l_1, l_2; r)$ if and only if there exists $t \in [-l_1, l_2]$, $\mu \in [0, 1]$ and two pure contracts $c = (\boldsymbol{\alpha}, s, \mathbf{f}, 0) \in \mathbb{C}_0(r)$, $c' = (\boldsymbol{\alpha}', s', \mathbf{f}', 0) \in \mathbb{C}_0(r)$ such that $v = \mu v(c) + (1 - \mu) v(c') + (t, -t)$.*

Proof. Note that (4) implies that $V^*(l_1, l_2; r)$ is compact. It follows that $V(l_1, l_2; r)$ is the convex hull of the extreme points of $V^*(l_1, l_2; r)$. Since $V^*(l_1, l_2; r) \subset \mathbb{R}^2$, this proves that $v \in V(l_1, l_2; r)$ if and only if there exist $c, c' \in \mathbb{C}(l_1, l_2; r)$, $\mu \in [0, 1]$ such that $v = \mu v(c) + (1 - \mu) v(c')$. Using Lemma 1, replacing $c = (\boldsymbol{\alpha}, s, \mathbf{f}, t)$ by $c_0 = (\boldsymbol{\alpha}, s, \mathbf{f}, 0)$ and $c' = (\boldsymbol{\alpha}', s', \mathbf{f}', t')$ by $c'_0 = (\boldsymbol{\alpha}', s', \mathbf{f}', 0)$ will not affect the equilibrium decisions. Therefore, $v(c_0) = v(c) - (t, -t)$ and $v(c'_0) = v(c') - (t', -t')$. The result follows since $v = \mu v(c_0) + (1 - \mu) v(c'_0) + (t_0, -t_0)$, where $t_0 = \mu t + (1 - \mu) t'$. ■

Let $V_0(r)$ be the set of surplus vectors attainable by contracts in $\mathbb{C}_0(r)$ and let $V_0^*(r)$ be the convex hull of $V_0(r)$. Finally, let $T(l_1, l_2)$ be the set of liquidity transfers from agent 2 to agent 1:

$$T(l_1, l_2) = \{(t, -t) \in \mathbb{R}^2 | t \in [-l_1, l_2]\}.$$

This proposition implies that the feasible set $V^*(l_1, l_2; r)$ is obtained by "shifting" the set $V_0^*(r)$ by $T(l_1, l_2)$:

$$V^*(l_1, l_2; r) = V_0^*(r) + (1 + r) T(l_1, l_2). \tag{5}$$

Figure 1 is an illustration of this decomposition. We will show that in this decomposition, $V_0^*(r)$ is independent of r (see Corollaries 1 and 2).

Since the interest rate affects the cost of outside finance, (4) suggests that the utility levels in $V_0^*(r)$ depend in a trivial way on r. We show that this is not the case, whether or not centralization involves consolidation of assets. There is nevertheless an important difference between no consolidation and consolidation: outside finance is used only in the second case. We

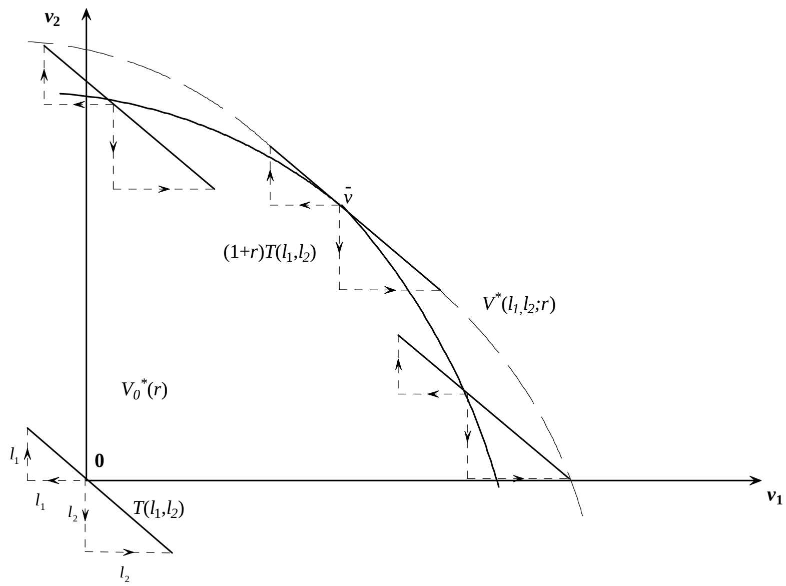

Figure 1: The decomposition

first compute the surplus sets obtained under "pure contracts" characterized by a given control structure, i.e., decentralization ($\boldsymbol{\alpha} = (\{1\}, \{2\})$) or centralization ($\boldsymbol{\alpha} = (\{1, 2\}, \emptyset)$).[21]

3.1 Decentralization

We first show that there is no role for outside finance under decentralization.

Proposition 1 *Suppose that there is decentralization,* $\boldsymbol{\alpha} = (\{1\}, \{2\})$. *Consider a contract* $c = (\boldsymbol{\alpha}, s, \mathbf{f}, \mathbf{0}) \in \mathbb{C}_{\mathbf{0}}(r)$ *such that* $\mathbf{f} \neq \mathbf{0}$ *and* $v(c) \geq 0$. *Then there exists* $c' = (\mathbf{a}, s', \mathbf{0}, 0)$ *such that* $v_i(c') > v_i(c)$ *for all* $i = 1, 2$.

Proof. For a contract $c = (\boldsymbol{\alpha}, s, \mathbf{f}, \mathbf{0}) \in \mathbb{C}_{\mathbf{0}}(r)$, the equilibrium decision is defined by (1) subject to the feasibility conditions (4). The surplus of each agent is given by

$$\begin{aligned} v_1(c) &= p(\mathbf{q})\left(s - D^1\right) + (1+r) B^2 - \phi(q_1) \\ v_2(c) &= p(\mathbf{q})\left(R - s - D^2\right) + (1+r) B^1 - \phi(q_2) \end{aligned} \tag{6}$$

[21] The case of centralization by type 2 agent is constructed in a way that is identical to centralization by type 1 agent.

where (4) requires

$$\begin{aligned}(1+r)\,B^i &= p(\mathbf{q})\,D^i, i=1,2 \qquad (7)\\ D^1 &\leq s \\ D^2 &\leq R-s \qquad (8)\end{aligned}$$

and where equilibrium conditions require

$$\begin{aligned}\frac{\partial p(\mathbf{q})}{\partial q_1}\left(s-D^1\right) &= \phi'(q_1) \qquad (9)\\ \frac{\partial p(\mathbf{q})}{\partial q_1}\left(R-s-D^2\right) &= \phi'(q_2)\,.\end{aligned}$$

Consider the contract $c' = (\boldsymbol{\alpha}, s', \mathbf{0}, 0)$ where

$$s' = s - D^1 + D^2.$$

The equilibrium decisions satisfy

$$\begin{aligned}\frac{\partial p(\mathbf{q}')}{\partial q_1}\left(s-D^1+D^2\right) &= \phi'(q_1)\\ \frac{\partial p(\mathbf{q}')}{\partial q_1}\left(R-s-D^2+D^1\right) &= \phi'(q_2)\,.\end{aligned}$$

Since $D > 0$, concavity of p together with the complementarity property imply that $\mathbf{q}' > \mathbf{q}$ and that $v(c') > v(c)$.

■

The set of surpluses attainable *by pure contracts* with decentralized control is illustrated by the curve in Figure 2. We have represented two iso-surplus lines as well as values of the inside finance at the intersection of an iso-surplus line and the feasible set. By symmetry, the surplus maximizing point is obtained at the contract for which the inside finance is $s = \frac{R}{2}$, i.e., for which there is equal sharing of the output. However, the surplus of type 1 with equal sharing is strictly less than what he could achieve with a larger share s (at the detriment of efficiency).

3.2 Centralization without Consolidation

Next consider centralized control with 1 as the owner and assume that there is no consolidation of assets. The owner solves

$$\max_{q_1,q_2} \sigma p(q_1,q_2)\left(s-D^1\right) + (1+r)\,B^2 - \phi(q_1)$$

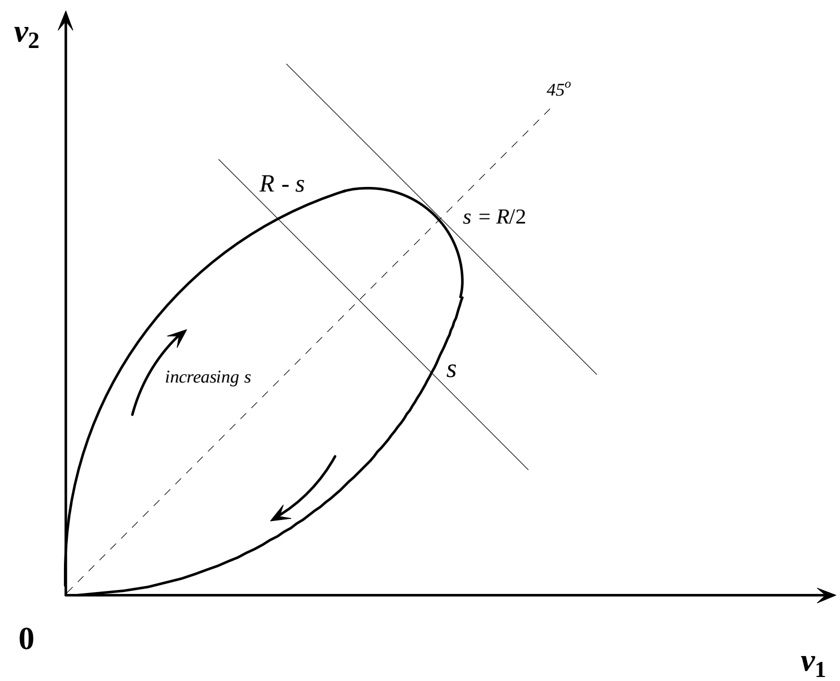

Figure 2: Set of surpluses under decentralization

while the subordinate is passive. Clearly, the owner sets the subordinate's asset at its highest level $\bar{q}$ and sets his own at $\arg\max \{\sigma p(q_1, \bar{q})(s - D^1) - \phi(q_1)\}$. Since agent 1 will choose the same decisions if instead of an inside finance s and an outside finance (D^1, B^1) there is a level of inside finance of $s' = s - D^1$ and no outside finance, we have

Proposition 2 *Under 1 control, outside finance and inside finance are equivalent means for 1 to transfer surplus to 2.*

This is basically the Modigliani-Miller theorem, except that financing is for surplus transfers rather than new investments. If there is even a small transaction cost of going to an outside lender, however, then outside finance will be dominated.[22]

Things are different if 2 is transferring to 1 under 1-control. An argument similar to the one in Proposition 1 shows that outside finance is dominated by inside finance.

[22] On the other hand, risk aversion may make outside finance more attractive than inside finance.

Proposition 3 *If a contract* $c = (\boldsymbol{\alpha}, s, \mathbf{f}, \mathbf{0}) \in \mathbb{C}_0(r)$ *has* $f^2 \neq \mathbf{0}$ *and* $v(c) \geq 0$, *then there exists* $c' = (\mathbf{a}, s', \mathbf{0}, 0)$ *such that* $v_1(c') > v_1(c)$ *and* $v_2(c') \geq v_2(c)$.

Proof. Consider the contract c' such that $s' = s - D^1 + D^2$ and $\mathbf{f} = \mathbf{0}$. Then, for a given $\mathbf{q}$, 1's payoff is $\max_{q_1} p(q_1, \overline{q})(s - D^1 + D^2) - \phi(q_1)$ and $2's$ payoff is $p(q_1, \overline{q})(R - s + D^1 - D^2) - \phi(q_2)$. Since at the equilibrium corresponding to c, feasibility requires that $p(\mathbf{q}) D^i = B^i$, the *value* of the two payoffs are the same at the previous equilibrium value of q_1. however, since the marginal revenue is greater for agent 1, q_1 and p increase. A revealed preference argument and strict concavity imply that agent 1 is strictly better off. Since the cost for agent 2 is constant, and since by feasibility $R - s + D^1 - D^2 \geq 0$, agent 2 is also better off. ■

The reasoning when there is centralization by agent 2 is similar. Combining the set of surpluses obtained with pure contracts under decentralization and under centralization, we obtain the set illustrated in figure 3; the dotted lines represent the set of surpluses attainable by pure contracts that do not involve liquidity transfers, i.e., is the set $V(0, 0; r)$ (where we assume that σ is not too large) and the heavy line is the frontier of the set obtained by considering lotteries over these pure contracts, i.e., the set $V_{\mathbf{0}}^*(r)$. In the figure, we do not make reference to the interest rate. The level of interest rate can affect the level of borrowing and therefore the amount of *effective* share of each agent. However, we show that the constraint on borrowing has no effect on the *utility transfers* that can be made via outside financing and that the strategic effect is at most nil and generally negative.

Corollary 1 *Suppose that there is no consolidation with centralization. Then in the decomposition (5), the set* $V_{\mathbf{0}}^*(r)$ *is independent of* r.

Proof. From Propositions 1, 2 and 3, the *frontier* of the set $V(0, 0; r)$ is obtained by considering contracts that do not involve outside financing. For such contracts, changes in the interest rate do not affect the levels of surpluses. Since $V_{\mathbf{0}}^*(r)$ is the convex hull of $V(0, 0; r)$, the result follows. ■

Thus in the private cost case, outside finance will (weakly) never be used as an instrument to finance restructuring. As we will argue soon, this conclusion changes if the decisions are "public," as when the same decision must be made for both partners: outside finance can then become strictly preferable to inside finance.

When gains to specialization are not too large (that is, when σ is close to 1), centralized 1-control can be more efficient than decentralized control, provided the owner receives an appropriately high share of the surplus: decentralized control suffers too much from free riding. Moreover, since the

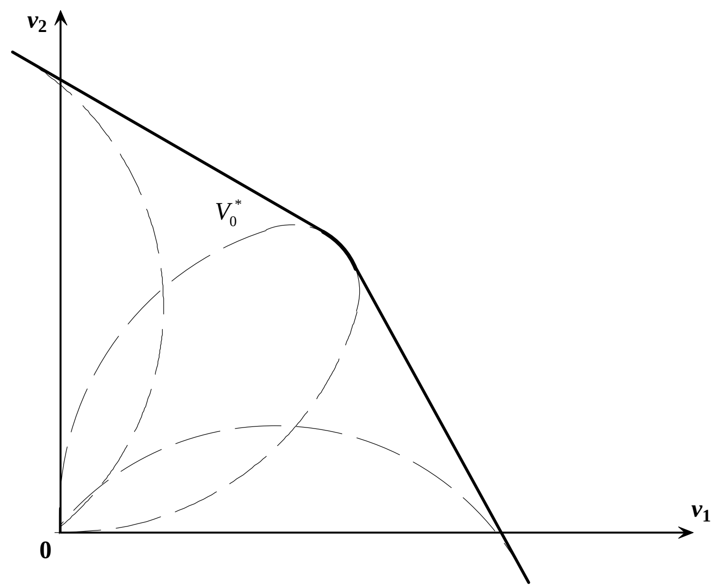

Figure 3: The feasible set when there is no consolidation

owner can't help himself from working the subordinate hard, it can be a good way for the latter to "commit" himself to high levels of q. There are limits to this – the subordinate will be overworked, which reduces efficiency.[23]

What is perhaps more important, though is that the surplus the owner can achieve for himself will exceed what he could achieve under decentralized control (when he has control, he could always choose the $\mathbf{q}$ that are chosen under decentralization). When gains to specialization are small, and in the absence of cash transfers, it is always best to be the owner of the firm.

This last point is important because it opens up the possibility that control rights will be offered as a means of surplus transfer when cash is not available. Rather than choosing the most efficient ownership structure and allocating the surplus with liquidity, a cash-constrained partner may grant ownership rights to the other because that may be the only means he has for giving her the level of surplus she commands in the market. Thus power becomes a medium of exchange, something which would not occur if everyone had sufficient liquidity.

For smaller values of σ, the trade-off between the two control structures depends more delicately on the distribution of the surplus. Provided σ is not

[23]This effect is strong enough that CC without consolidation may be less efficient then DC, even if $\sigma = 1$. However, in this case, with consolidation, CC weakly dominates DC, achieving the same surplus only when the inside shares are equal.

too small, decentralized control will tend to dominate where the surplus is to be divided roughly equally and centralized control will dominate when the division is more unbalanced (of course, σ might be so small that it may be *worse* to be the owner than to be under some form of decentralization; we shall ignore this case in what follows).

3.3 Centralization with Consolidation

Often a merger will be accompanied by some consolidation of resources. Stories abound of the uneasy mix of corporate cultures that accompanies a merger as two management teams are melded into one. Whereas previously there may have been separate decisions for each partner, with centralization of control it may be necessary that the effectively the *same* decision be taken for both partners. The theory of ownership has deliberately shied away from this aspect of mergers in order to emphasize the incentive effects derived from reallocation of decision rights. But it seems an inevitable part of the reality of restructuring that the way costs are incurred and the production function summarizing the firm's capabilities will change as well (indeed, in the old days this was thought to be *the* effect of merging two firms). From our perspective, the interest in this line is that it changes the types of financing that will be associated with mergers and therefore conclusions one can reach regarding the effects of aggregate liquidity shocks and/or financial deregulation.

A simple way to capture this sort of consolidation is to suppose that under centralized control a single decision that affects both parties equally must be taken. Thus under centralization, the decisions are $q_1 = q_2 = q \in [0, \bar{q}]$, while under decentralization we still have separate decisions q_1, q_2. Let $\hat{p}(q) = \sigma p(q, q)$. The cost functions are the same. We suppose that $\sigma < 1$ but that σ is "not too small."

Financing centralization is rather different now than in the case of no consolidation. The agent in control (suppose it is 1) will maximize $\hat{p}(\hat{q})s - c(\hat{q})$. Since the decisions must be the same for both partners, 2 will now not typically be forced to the highest level of q. Suppose that 1 wishes to transfer surplus to 2. Should he do so via outside finance or inside finance? If 1 uses outside finance and wants to transfer $B^1 = \hat{p}\frac{D^1}{1+r}$ to 2, his objective becomes $\hat{p}(q)(s - D^1) - \phi(q)$, while 2 receives $\hat{p}(q)(R - s) + (1 + r) B^1 - \phi(q)$. If 1 uses inside finance with $s' = s - D^1$ his marginal incentives are the same and he will therefore choose the same decision. So once again we get a Modigliani-Miller like theorem – *under 1 control, outside finance and inside finance are equivalent means for 1 to transfer surplus to 2.*

When it comes to transferring from the subordinate to the owner, however, things are reversed: outside finance will become the preferred means of doing so. To see this, observe that if 2 transfers $B^2 = \frac{\hat{p}D^2}{1+r}$ to 1 via inside finance, he suffers a loss from the increased level of q that results – 2's share is already smaller than 1's so he is not fully compensated by the increased success probability that results. But if he first borrows from an outside lender, transferring the money to 1 ex ante, then 1's decision is unaffected. The fact that 2 effectively gets a smaller share because he has to repay the loan has no effect on anything because he is making no decisions. Thus outside finance is now equivalent to cash as a means for 2 to transfer to 1 and dominates inside finance. It's not so much that outside finance is better than it was before (it isn't), it's that inside finance is worse because it imposes a less than fully compensated cost on 2 from the higher decision; before, there was no change in the decision because it was already as high as it could be. There is no reason in this model why the 2 should not be able to borrow as much as he likes (consistent with his budget constraint, of course). That is, imperfect outside financing by subordinate 2's can only arise if we impose it for reasons outside the model.

Proposition 4 *Consider the set of surpluses obtained with pure contracts under centralization with consolidation.*

(i) All surpluses on the Pareto frontier correspond to contracts for which there is equal sharing, $s = \frac{R}{2}$, and for which if $v_1 \neq v_2$ one agent uses outside financing.

(ii) The Pareto frontier is independent of r.

Proof. (i) *Fact 1:* We first show that the Pareto frontier is attained by contracts using outside financing when $s \neq \frac{R}{2}$. Formally, we show the following: consider a contract $c = (\boldsymbol{\alpha}, s, \mathbf{0}, \mathbf{0})$ where $\boldsymbol{\alpha} = (\{1,2\}, \emptyset)$ and $s \neq \frac{R}{2}$. Then there exists a contract $c' = (\boldsymbol{\alpha}, s', \mathbf{f}, 0)$, $f^1 = \mathbf{0}$, $f^2 \neq \mathbf{0}$ such that $v_i(c') > v_i(c)$ for all $i = 1, 2$.

Suppose first that $s > \frac{R}{2}$. For $c = (\boldsymbol{\alpha}, s, \mathbf{0}, \mathbf{0})$, agent 1 chooses $q(s)$ that solves $\hat{p}'(q)\, s = \phi'(q)$. Clearly, $q(s)$ is increasing in s. Now, the total welfare corresponding to s when there is no outside financing is $W(s) = \hat{p}(q(s))\, R - 2\phi(q(s))$, is maximum at $s = \frac{R}{2}$ with a maximum value of $W^* = \hat{p}\left(q\left(\frac{R}{2}\right)\right) R - 2\phi\left(q\left(\frac{R}{2}\right)\right)$. Note that $W(s)$ is decreasing in $s \geq \frac{R}{2}$. Let $u_1(s) = \hat{p}(q(s))\, s - \phi(q(s))$ and $u_2(s) = \hat{p}(q(s))(R - s) - \phi(q(s))$. For $s \geq \frac{R}{2}$, $\frac{du_1(s)}{ds} = \hat{p}(q(s))$ and $\frac{du_2(s)}{ds} = W'(s) - \hat{p}(q(s))$. Therefore, $\frac{du_2}{du_1} = \frac{W'(s)}{\hat{p}(q(s))} - 1 < -1$ since $W'(s) < 0$ for $s > \frac{R}{2}$. Hence, when the agents do not use outside finance, the marginal rate of substitution $\frac{du_2}{du_1}$ is strictly less than -1.

Consider a contract $c' = (\boldsymbol{\alpha}, s, \mathbf{f}, 0)$, $f^1 = \mathbf{0}$, $f^2 \neq \mathbf{0}$ such that $B = \frac{\hat{p}(q(s))D}{1+r}$. Then, agent 1 surplus function $\hat{p}(q)s + (1+r)B - \phi(q)$ is maximum at $q(s)$. Therefore ,

$$\begin{aligned} v_1(c') &= v_1(c) + (1+r)B \\ v_2(c') &= v_2(c) - (1+r)B. \end{aligned}$$

Hence, if agent 2 uses outside finance when his share is $R-s$,the marginal rate of substitution $\frac{dv_2}{d_{v_1}}$ is equal to -1. If $s < \frac{R}{2}$, the same logic shows that the marginal rate of substitution is less than -1 for surpluses attained when there is no outside finance, while it is equal to -1 when agent 1 uses outside finance. The result follows.

Fact 2: Feasibility (4) now requires that the amount of outside finance depends on the level of inside finance. Precisely, for a share of s, the maximum amount of repayment by agent 2 is $R-s$. Therefore, when inside finance is s, the maximum surplus attainable by agent 1 if agent 2 uses outside financing is $V_1(s) = \hat{p}(q(s))R - \phi(q(s))$. Since $q(s)$ is the optimal choice of agent 1 when inside finance is s, $\hat{p}'(q(s))s - \phi'(q(s)) = 0$ and therefore $V_1'(s) = \frac{\partial q}{\partial s}\{\hat{p}'(q(s))(R-s) - \phi'(q(s))\}$. Now, for $s \geq \frac{R}{2}$, $R-s \leq s$ and since $\frac{\partial q}{\partial s} \geq 0$, it follows that $V_1'(s) = \frac{\partial q}{\partial s}\{\hat{p}'(q(s))(R-s) - \phi'(q(s))\} \leq 0$. Hence, the maximum level of surplus for agent 1 is attained when $s = \frac{R}{2}$ and the agent borrows $B = \frac{\hat{p}\left(q\left(\frac{R}{2}\right)\right)\frac{R}{2}}{1+r}$.

Combining Facts 1 and 2 proves the result.

(ii) The Pareto frontier is subset of the iso-welfare line $v_1 + v_2 = W^*$ that is attainable by contracts satisfying (4). Now, from Fact 2 above, the right most point on this frontier is $v_1 = \hat{p}\left(q\left(\frac{R}{2}\right)\right)R - \phi\left(q\left(\frac{R}{2}\right)\right), v_2 = -\phi\left(q\left(\frac{R}{2}\right)\right)$ and the left most point is $v_1 = -\phi\left(q\left(\frac{R}{2}\right)\right), v_2 = \hat{p}\left(q\left(\frac{R}{2}\right)\right)R - \phi\left(q\left(\frac{R}{2}\right)\right)$. These extreme points are clearly independent of r. Note that while the attainable surpluses are independent of r, the financial contract needed to achieve a level of surplus depends on r. ■

Corollary 2 *When there is consolidation, $V_0^*(r)$ is independent of r.*

Proof. A direct consequence of Propositions 1 and 4 (ii). ■

Figure 4 illustrates the construction of the set V_0^*. The dotted line represents the Pareto frontier in Proposition 4. For later use we have also indicated the surplus maximizing vector $\overline{v}$, as well as the extreme points of the lottery segment $\left[v^C, v^D\right]$.

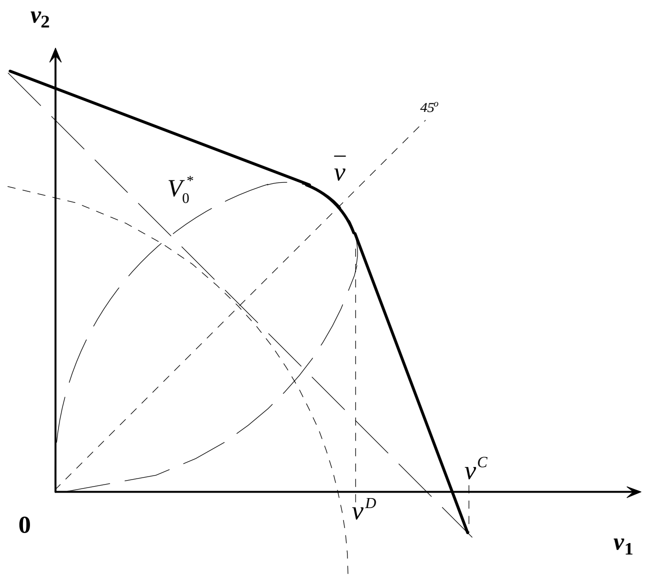

Figure 4: The feasible set with consolidation

4 The Equilibrium "Price" of Control

Some of the properties of the feasible set derived in the previous section, symmetry in particular, are specific to our environment. However, the properties of equilibria and the comparative static results hold whenever the feasible set satisfies the following properties (it is easy to see that the feasible set in our model satisfies these properties).

Definition 3 (Property F) *The feasible set can be written as* $V^*(l_1, l_2; r) = V_0^* + (1+r)\,T(l_1, l_2)$. *The frontier of* $V_0^* \cap \mathbb{R}_+^2$ *can be represented by a map* $\pi : v_1 \longmapsto v_2$ *satisfying the following properties:*

(i) π *is decreasing and concave.*

(ii) $\exists v_1^0, \pi(v_1^0) = 0.$

(iii) The surplus maximizing vector $\overline{v}$ *in* V_0^* *is attained at* $\overline{v}_1 > 0, \overline{v}_2 > 0.$

For computing the equilibrium in the market for ownership, a first observation is that there is no loss of generality in assuming that only agents of type 2 with liquidity in the upper tail of the distribution F^2 are matched in equilibrium. Indeed, since type 2 agents are in excess supply, unmatched type 2 agents will try to bid up the surplus of type 1 agents as long as they can attain a nonnegative surplus. The larger the liquidity of the type 2 agent, the larger is the surplus that he can offer to a type 1, since the set $T(l_1, l_2)$

is increasing in l_2. Thus, only agents with liquidity greater than l_{F^2} will be matched.

Next, note that if the *marginal* type 2 agent (the one with l_{F^2}, where $F^2(l_{F^2}) = 1 - n$) has a positive surplus, a type 2 agent with liquidity slightly less than l_{F^2} could bid up the surplus to a type 1 which would contradict the equilibrium condition. Hence, the marginal type 2 agent has a zero surplus.

A second effect of competition is that all type 1 agents get the same level of surplus. This is because the 1's liquidity does not affect the level of total surplus that can be generated (at least in the region in which they equilibrium surplus division occurs). Thus all 1's are equally good as far as a 2 is concerned and they must therefore receive the same price.[24]

Since all 1's get the same surplus, the study of the equilibrium is amenable to a supply-and-demand type analysis where the traded commodity is the type 1's. We construct the equilibrium as follows. The amount of surplus a 2 is willing *and able* to transfer to a 1 depends on how much liquidity he has. The most he'd give is $\bar{v}_1 + \bar{v}_2$, which he could do provided his liquidity exceeds $\bar{v}_2$. Any 2, even if he has zero liquidity, can offer v_1^0 (this is typically accomplished by giving 1 a lot of control). Of course, the smaller is l_2, the less 2's willingness/ability to pay. So arranging the willingness to pay in order of decreasing liquidity gives rise to a (weakly) downward sloping "demand" schedule. The supply is vertical at the number of 1's. Equilibrium is at the intersection of the two curves. See Figure 5.

[24] This is where the assumption ruling out contracts with third parties that result in forfeiture of liquidity in case the venture fails comes in. Without it, the 1's liquidity would figure in generating the utility possibilities, and it would not generally be possible to treat them all the same. (More generally, this feature justifies the explicit analysis of the contracts and control structures we have performed here – an abstract analysis would not be able to rule out dependence of the equilibrium on the 1s' liquidity.) Although our main points would not be affected by this complication, the model would require a more complex analysis typical of matching models with imperfect transferability. See Legros-Newman (1999b) for an analysis of such models.

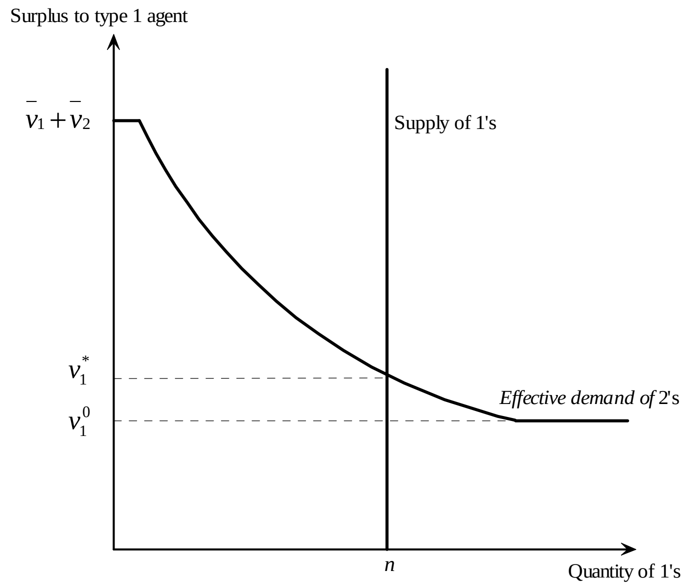

Figure 5: The market for ownership

The level of surplus v_1^* which the 1's get is critical to the determination of ownership. Looking back at Figures 3 and 4, 1 it should be clear that the higher is this number, the fewer type 2's will be able to afford decentralization – the only way they can generate the surplus $v_1^*(r)$ is to offer 1 a greater degree of control, which is less efficient.

The equilibrium surplus for the 1's is determined by the liquidity l_{F2} of the marginal 2. If this liquidity is low enough, the marginal 2 will be subordinate under centralization. Wealthier 2's will be able to afford greater degrees of control for themselves. But if the marginal 2 is a bit wealthier, the 1's will be getting higher equilibrium surplus and possibly very few partnerships will be decentralized, despite the fact that it is more efficient. The higher is $v_1^*(r)$, the higher is the "price of control," the amount of liquidity that is needed to pay the 1's ex ante and sustain decentralized control. Raising the wealth of the agents around the marginal 2 creates a pecuniary externality which may change the ownership structure of all the infra marginal firms, and with that, efficiency of the economy.

It is worth emphasizing that we are not merely pointing out that the wealth of the partners will affect the efficiency of their enterprise or the form it will take, although this is surely true. So of course will the technology they have to work with and the contracting possibilities at their disposal. Rather, the point is that in order to fully determine how a particular enterprise will choose to structure itself, we must have information about something *outside the enterprise,* namely the liquidity distribution. In this case it is enough to summarize the external environment of the firm by the value of the quantile function at n, but the general point is that what is going on inside the firm depends on what is going on around it.

This discussion is formalized in the following proposition.

Proposition 5 *(i) Consider an equilibrium with exogenous interest rate r. There exists another equilibrium with the same equilibrium surpluses having the property that an agent of type 2 is matched only if $l_2 \geq l_{F^2}$. Hence, there is no loss of generality in assuming that the matching function m is increasing.*

(ii) $v_2^*(l_{F^2}; r) = 0$.

(iii) All agents of type 1 are matched and have the same (positive) surplus. This surplus is

$$v_1^*(r) = \begin{cases} \overline{v}_1 + \overline{v}_2 & \text{if } l_{F^2} \geq \frac{\overline{v}_2}{1+r} \\ \pi^{-1}((1+r) l_{F^2}) + (1+r) l_{F^2} & \text{if } l_{F^2} < \frac{\overline{v}_2}{1+r}. \end{cases} \tag{10}$$

(iv) As long as $l_{F^2} < \frac{\overline{v}_2}{1+r}$, $v_1^*(r) < \overline{v}_1 + \overline{v}_2$ (so for a positive measure of l_2, $v_1^*(r) + v_2^*(l_2; r) < \overline{v}_1 + \overline{v}_2$: the equilibrium is inefficient).

Proof. We prove this proposition in a series of steps.

Step 1: we show that if l_2 is not matched but that $\hat{l}_2$ is matched with an agent of type 1 in equilibrium, then if $v^*\left(\hat{l}_2; r\right) > 0$, $l_2 \leq \hat{l}_2$. Suppose to the contrary that $l_2 > \hat{l}_2$. By feasibility we have $(v_1^*(l_1; r), v_2^*(l_2; r)) \in V\left(l_1, \hat{l}_2; r\right)$ and $v_2^*(l_2; r) = 0$ (since l_2 is not matched). Now, the decomposition result implies that $V\left(l_1, \hat{l}_2; r\right) \subset V(l_1, l_2; r)$ and since $v_2^*(l_2) > 0$, there exists $\varepsilon \in \left(0, v_2^*\left(\hat{l}_2; r\right)\right)$ such that $\left(v_1^*(l_1; r) + \varepsilon, v_2^*\left(\hat{l}_2; r\right) - \varepsilon\right) \in V(l_1, l_2; r)$ which contradicts the equilibrium assumption..

Step 2: Suppose that l_2 is not matched in equilibrium and that $\hat{l}_2 < l_2$ is matched. Step 1 and the fact that surpluses are non-negative imply that $v_2^*\left(\hat{l}_2; r\right) = 0$. Therefore, if $\hat{l}_2$ is not matched but l_2 is matched we have the same surpluses. This proves (i).

Step 3: Suppose that a type 1 is not matched. Then his equilibrium surplus is zero. Since there is a measure $1-n$ of unmatched agents of type 2 who also get 0, we obtain a contradiction since there exists $v \in V_0^*$ such that $v_1 > 0$ and $v_2 > 0$. Hence all type 1 agents are matched.

Step 4: The maximum surplus of a type 1 agent who is matched with the marginal type 2 agent is

$$v_1^*(r) = \max_{v \in V_0^*} [v_1 + \min\{(1+r) l_{F^2}, v_2\}]. \tag{11}$$

(larger transfers violate either the liquidity constraint of agent 2 or the equilibrium constraint that the agent has nonnegative surplus). If $l_{F^2} \geq \overline{v}_2$, the solution to (11) is $v_1^*(r) = \overline{v}_1 + \overline{v}_2$, otherwise the solution is

$$v_1^*(r) = \max_{v \in V_0^*,\, (1+r) l_{F^2} \leq v_2} [v_1 + (1+r) l_{F^2}];$$

the solution is obtained when v is such that $v_2 = (1+r) l_{F^2}$, i.e., when $\pi(v_1) = (1+r) l_{F^2}$ which leads to $v_1^*(r) = \pi^{-1}((1+r) l_{F^2}) + (1+r) l_{F^2}$. Note that since $\pi^{-1}$is a decreasing function, $(1+r) l_{F^2} < \overline{v}_2$ implies that $\pi^{-1}((1+r) l_{F^2}) > \overline{v}_1$. Now, since π^{-1} is concave decreasing, the slope of $\pi^{-1}((1+r) l)$ exists almost everywhere and is greater than -1 when $(1+r) l \leq \overline{v}_2$; therefore $\pi^{-1}((1+r) l) + (1+r) l$ is an increasing function of l when $(1+r) l \leq \overline{v}_2$ which establishes that $v_1^*(r) < \overline{v}_1 + \overline{v}_2$ when $(1+r) l \leq \overline{v}_2$.

Step 5: We show that v_1^* is the minimum surplus of type 1 agents. If $v_1^*(l_1; r) < v_1^*(r)$, there exists $\delta > 0$ such that

$$v_1^*(l_1; r) < \max_{v \in V} [v_1 + \min((1+r) l_{F^2} - \delta, v_2)].$$

Therefore an agent of type 2 with liquidity $l_{F^2} - \delta$ can offer to l_1 a surplus greater than $v_1^*(l_1; r)$ while obtaining a positive surplus for himself. This violates the equilibrium conditions. Hence, $v_1^*(l_1; r) \geq v_1^*(r)$.

Step 6: To show that $v_1^*(l_1; r) = v_1^*(r)$, suppose by way of contradiction that there exists l_1 such that $v_1^*(l_1; r) > v_1^*(r)$. Let l_1' be the liquidity of a type 1 agent who is matched with a marginal type 2 agent. We show that l_1' and l_2 can form a match and each obtain a strictly larger surplus. By (i) and Step 4, if l_2 is the match of l_1, $l_2 > l_{F^2}$. Now, letting $t \in [0, l_2]$ be the transfer of l_2 to l_1, $v_2^*(l_2; r) = \pi(v_1^*(l_1; r) - (1+r) t) - (1+r) t$. Since π is decreasing, $v_2^*(l_2; r) < \pi(v_1^* - (1+r) t) - (1+r) t$. Therefore, there exists $t' \in [0, t]$ such that if l_2 matches with l_1', they can each obtain surpluses greater than their equilibrium surpluses, which is the desired contradiction and proves (ii). Part (iii) now follows from Step 4. ■

5 Effects of Liquidity Shocks

To simplify the writing, in this section we will assume that $r = 0$ and suppress reference to it in the notation. All of the Propositions in this section are true as stated for any fixed value of r. We shall return to the general case in Section 6.

Distributional changes affect the value of the marginal liquidity and the average liquidity of the inframarginal agents. This gives rise to two effects.

First, an increase in the marginal liquidity l_{F^2} creates an *external effect* resulting in a shift away from monetary toward control instruments. Indeed from Proposition 5 (iii), the equilibrium surplus of the type 1 agents is increasing in l_{F^2}, i.e., the "price" that type 2 agents have to pay in order to be matched increases as the marginal liquidity increases. Since the surplus of the marginal type 2 agent is zero, and since a larger liquidity transfer is made, there must be more total surplus created by the marginal relationship. However, since inframarginal agents have to pay a higher price, with the same liquidity the external effect decreases the surplus of their match.

Second, increases in the liquidity of the inframarginal agents increases the ability to pay of these agents. All else the same, higher liquidity of a type 2 results in greater decentralization and higher efficiency. Obviously the exact changes in the total surplus depends on the interplay between these external and internal effects.

In light of Proposition 5, we ignore the distribution of type 1 agents, and therefore we simplify notation by denoting by F the distribution of liquidities of type 2 agents and by l the liquidity of type 2 agents.

Corollary 3 *Consider a distribution F of liquidities of type 2 agents and let l_F be the marginal liquidity, i.e., $F(l_F) = 1 - n$. Let v_1^* be the equilibrium surplus of type 1 agents as given in (10). Let $t(v_1^*)$ be the transfer from 2 to 1 for which the surplus maximizing point $\overline{v}$ is compatible with type 1 agent obtaining exactly their equilibrium surplus after transfer, i.e.,*

$$\overline{v}_2 = \pi\left(v_1^* - t\left(v_1^*\right)\right). \tag{12}$$

Then, the equilibrium surplus of a type 2 agent with liquidity l when the equilibrium surplus of type 1 agents is v_1^* is

$$v_2\left(l, v_1^*\right) = \begin{cases} 0 & \text{if } l \leq l_F \\ \pi\left(v_1^* - l\right) - l & \text{if } l \in \left[l_F, t\left(v_1^*\right)\right] \\ \overline{v}_2 - t\left(v_1^*\right) & \text{if } l \geq t\left(v_1^*\right). \end{cases} \tag{13}$$

Proof. By Proposition 5, the equilibrium surplus of a type 1 agent is v_1^* and this is what a type 2 agent with liquidity $l \geq l_F$ must give a type 1 agent in order to be matched. The type 2 agent will therefore find $v \in V_0^*$ and $t \in [0, l]$ such that $v_1 + t = v_1^*$ and such that $v_2 - t$ is maximum, i.e., solves the program

$$\max_{v \in V_0^*, t \in [0,l]} \pi\left(v_1^* - t\right) - t.$$

It is routine to verify that concavity of π implies the solution in the corollary. ■

For a *given match*, the total surplus depends on the *marginal* liquidity since the equilibrium surplus of the type 1 agent depends on this marginal liquidity. This implies that the total surplus of a given match is increasing in the liquidity of the type 2 agent and is decreasing in the liquidity of the marginal type 2 agent.

Lemma 3 *Let* $W(l, v_1^*) = v_1^* + v_2(l, v_1^*)$ *be the total equilibrium surplus for an equilibrium match with* $l \geq l_F$. *Then* W *is increasing and concave in* l, *and is decreasing and concave in* v_1^*.

Proof. Since π is concave and decreasing, both π' and π'' exist almost everywhere; we consider points of differentiability. Note that by definition $t(v_1^*)$ in 12 is linear in v_1^* and that $t'(v_1^*) = 1$. If $l > t(v_1^*)$, $\frac{dv_2\left(l,v_1^*\right)}{dl} = 0$ and therefore since $W = v_1^* + \overline{v}_2 - t(v_1^*)$, $W_1 = W_{11} = 0$ and $W_2 = 1 - t'(v_1^*) = 0$. If $l < t(v_1^*)$, $W(l, v_1^*) = v_1^* + \pi(v_1^* - l) - l$; therefore, $W_1 = -\pi'(v_1^* - l) - 1$, $W_{11} = \pi''(v_1^* - l)$, $W_2 = 1 + \pi'(v_1^* - l) = -W_1$, $W_{22} = W_{22}$. The Lemma follows from concavity of π and $\pi' \leq -1$ (since $v_1^* - l \geq \overline{v}_1$). ■

Remark 1 *The degree of decentralization in a firm can be measured by the probability* $\min\{\frac{v_1^C - v_1^* + l}{v_1^C - v_1^D}, 1\}$. *Observe that like* $W(\cdot,\cdot)$, *this is increasing concave in* l *and decreasing concave in* v_1^* *over the relevant range. Thus, statements made about the comparative statics of total surplus apply with equal force to the degree of decentralization.*

Equipped with these results we can derive simple comparative statics. Suppose that all agents receive the same positive shock ϵ to liquidity. Then from what we said in the previous section, equilibrium v_1^* increases by $\delta < \epsilon$. But since all agents are wealthier by ϵ, they could keep the same contract and transfer δ to their partners; in fact all those not already at the surplus maximizing contract can do strictly better and will decentralize slightly. We conclude that *increasing the wealth of all the 2's uniformly makes everyone better off and reduces the degree of centralization of all firms.* This is only a very simple example of how changes in liquidity alone can lead to changes in the organization of firms.

Proposition 6 *Suppose that the liquidity of each agent increases (multiplicatively or additively) by* $\varepsilon > 0$. *Then there is less centralization and more efficiency in equilibrium.*

Proof. Consider a distribution F of liquidities for type 2 agents. Let l_F be the marginal liquidity and v_1^* be the equilibrium surplus of type 1 agents. To simplify, assume that $l_F < \overline{v}_2$ and that $\varepsilon < \overline{v}_2 - l_F$. Consider an additive shock to liquidities, i.e., that each type 2 agent has liquidity $l+\varepsilon$. The marginal agent has now liquidity $l_F+\varepsilon$ and the "price " of type 1 agents is $v_1^{*\varepsilon} = \pi^{-1}(l_F+\varepsilon)+l_F+\varepsilon$. Therefore, the "price" of type 1 agents has increased by $v_1^{*\varepsilon} - v_1^* = \pi^{-1}(l_F+\varepsilon) - \pi^{-1}(l_F)+\varepsilon < \varepsilon$ since π^{-1} is decreasing. Now, inframarginal agents are able to choose $v_2(l+\varepsilon, v_1^{*\varepsilon}) > v_2(l, v_1^*)$ which proves the result. The same reasoning holds for multiplicative shocks. ■

Similar reasoning leads to the conclusion that if the shocks are increasing in initial liquidity, then all firms become more decentralized. Of course negative shocks will have opposite effects.

Uniform shocks to liquidity are rather special. Equally compelling are heterogeneous shocks. Macroeconomists have paid a great deal of attention lately to how shocks to one sector of the economy can be amplified and propagated by financial markets. The focus there is usually on levels of investment and/or aggregate economic activity. This model also provides a mechanism by which "local" shocks may end up being felt throughout the economy and will manifest themselves by organizational restructuring throughout. We thus have the basis for a theory of merger waves, brought on by changes in the liquidity distribution.

The key to the analysis as we indicated above is the marginal agent: increase in his liquidity that are not accompanied by sufficient increase in the liquidity of the agents above him will raise the price of the type 1's, thereby increasing the price of control. Inframarginal agents may then find themselves forced to centralize and/or adopt less efficient sharing rules in order to attract their partners. Thus, though the marginal agent may be better off, most of those above him may be worse off: raising this agent's liquidity leads to an aggregate efficiency loss and a palpable "wave" of reorganization.

The external effect generated by shocks in the neighborhood of the marginal agent may be strong enough that *increases in liquidity, even in the sense of first order stochastic dominance, may reduce overall performance*, raising the degree of centralization. Suppose that the partnerships with the wealthiest 2's are generating the maximum surplus $\bar{v}_1 + \bar{v}_2$. Consider a distribution G^l obtained from F by reallocating a small probability mass in a neighborhood of l to the top of the distribution. If this shifts occurs at l_F, then the marginal liquidity increases since $G^l(l_F) < F(l_F) = 1-n$. Therefore, v_1^* increases, and by Lemma 3 the total surplus for the inframarginal matches decreases; since the mass of losers is large relative to the mass of gainers, the total surplus for the economy decreases too. In fact, in this situation, adding wealth to the economy may actually lower the total $payoffs$, not just the surplus: adding wealth to the economy might make it poorer! Of course, if instead l is greater than l_F, then the marginal liquidity levels in

F and in G^l are the same and by Lemma 3, the average total surplus of the inframarginal matches increases.

Some sharper results are available. We consider in turn cases where the marginal agent does not change and where the marginal agent changes.

5.1 Same Marginal Liquidity

First, consider two distributions F and G and suppose that F crosses G once from below at l_F. Thus the v_1^* is the same for each distribution, but all matched 2's have greater liquidity under G. Then F will be less efficient than G. If in addition F and G have the same mean, then in fact G is a mean preserving spread of F. This is an instance in which *increasing inequality may raise efficiency.*

Now consider two distributions of type 2 liquidities F and G such that the corresponding quantile functions are equal at $1-n$. Thus $l_F = l_G \equiv l^*$, and it follows that the surplus that type 1 agents receive in equilibrium is also the same. Let F^* and G^* be the conditional distributions of F and G with respect to $l \geq l^*$.

An immediate consequence of Lemma 3 is the following.

Proposition 7 *Suppose there are two distributions F and G with $F(l^*) = G(l^*) = 1-n$. If the conditional distribution G^* second order stochastically dominates the conditional distribution F^*, total welfare is greater under G^* than under F^*.*

Proof. Variation in total welfare is $\Delta = \int_{l^*}^{\infty} W(l,p)\left[dG(l) - dF(l)\right]$. By definition of the conditional distributions, $\Delta = n\int_{l^*}^{\infty} W(l,p)\left[dG^*(l) - dF^*(l)\right]$. Since W is concave in l, second order stochastic dominance implies $\Delta \geq 0$. ■

Note that it is not enough to have G stochastically dominate F in the second order sense in order to have an unambiguous ranking of welfare, since G dominating F does not necessarily imply that G^* dominates F^*.

These two results may appear to contradict each other, but they are easily reconciled: while the single-crossing result refers to the distribution for the economy as a whole, Proposition 7 refers to the distribution *only among the existing partnerships.*

If one is interested in the optimal distribution of liquidity for the economy as a whole, it is clear that one wants the marginal agent to be as poor as possible, so that the equilibrium price will be as low as possible. But from the previous result, the distribution among the firms must be as equal as possible. And finally,one wants the inframarginal firms to have as much liquidity as possible so that they may organize as efficiently as possible. Taking these three factors into account, along the with the fact that the liquidity of the 1's has no effect on organization or efficiency, one concludes that the *optimal distribution of liquidity consists of two atoms: $1-n$ of the type 2's and all of the 1's get zero; the remaining n type 2's each get $1/n$ times the mean liquidity.*[25] This likely is a very unequal distribution indeed.

5.2 Different Marginal Liquidity

The previous result is of interest since it implies that *controlling for the marginal type 2 agent,* more inequality in liquidity levels among type 2 agents decreases welfare. However, we should expect that shocks to liquidity will also affect the liquidity of the marginal agent. We now develop necessary and sufficient conditions for improvements in welfare as a result of shocks to liquidity.

Consider two distributions F and G on $[0, L]$ with marginal liquidities l_F and l_G, and assume that $\max\{l_F, l_G\} < \overline{v}_2$. From Proposition 5, the equilibrium surplus of type 1 agents are

$$\begin{aligned} v_1^{*F} &= p(l_F) = \pi^{-1}(l_F) + l_F \\ v_1^{*G} &= p(l_G) = \pi^{-1}(l_G) + l_G. \end{aligned} \tag{14}$$

It follows from Assumption H0 that there is a bijection $\psi : [l_F, L] \to [l_G, L]$ such that for each l,

$$F(l) = G(\psi(l)).$$

From this change of variable it follows that the total welfare when the distribution is G can be written

$$\int_{l_G}^{L} W\left(l, v_1^{*G}\right) dG(l) = \int_{l_F}^{L} W(\psi(l), p(\psi(l_F))) \, dF(l)$$

The difference in welfare going from F to G can then be written

$$\begin{aligned} \Delta &= \int_{l_G}^{L} W(l, p(l_G)) \, dG(l) - \int_{l_F}^{L} W(l, p(l_F)) \, dF(l) \\ &= \int_{l_F}^{L} \left[W(\psi(l), p(\psi(l_F))) - W(l, p(l_F))\right] dF(l). \end{aligned}$$

[25] This distribution doesn't satisfy Assumption HO, of course, but equilibrium is perfectly well defined nonetheless. It is true that there is an indeterminacy in the value of v_1^* with this distribution; the optimum is achieved at the lowest value, which is v_1^0.

5.2.1 A Global Condition when the Frontier is Linear

When the frontier of V_0^* is linear, we are able to obtain global necessary and sufficient conditions for welfare comparisons. Although strictly speaking the frontiers in our model are not linear, given the relative scarcity of type 1's, what really matters is the portion of the frontier below the 45° line, which consists of a linear portion generated by lotteries between 1-control and decentralized control, and a nonlinear part which may be ignored if L is not too large. Moreover, this case is useful to consider because it separates clearly the internal and external effects of changes in liquidity distributions discussed at the beginning of the section.

Proposition 8 *Assume that the frontier of V_0^* is linear with slope $\pi' = -\alpha$ ($\alpha > 1$). Consider two continuous distributions F and G, with marginal liquidity levels l_F and l_G and F^* and G^* the conditional distributions on $[l_F, L]$ and $[l_G, L]$. If μ_F is the mean liquidity with respect to F^* and μ_G is the mean liquidity with respect to G^*, total welfare improves when the distribution changes from F to G if and only if*

$$\mu_G - \mu_F \geq \frac{\alpha - 1}{\alpha}\left(l_G - l_F\right).$$

For instance, if the marginal agent loses liquidity ($l_G < l_F$), it is necessary that the mean liquidity of the other agents not decrease too much: otherwise the initial reduction in the equilibrium price—$p\left(l_G\right) < p\left(l_F\right)$—cannot translate into welfare gains, since the other agents are less able to pay the price on average. In addition to isolating the role of the internal and external effects of the change in distribution, the condition in Proposition 8 emphases the role of the *degree of inefficiency* in transferring surplus via control structure rather than via monetary transfers. Indeed, as α increases, the inefficiency (as measured by $\frac{\alpha-1}{\alpha}$) increases and for the *same* change in the liquidity of the marginal agent, the condition on the change in mean liquidity becomes less stringent (the decrease in the liquidity of the marginal agent can be accompanied by larger decreases in the mean liquidity level).

Proof. Since the frontier is linear, there exists $\alpha > 1$, $\beta > 0$, such that $\pi\left(u_1\right) = -\alpha u_1 + \beta$. Consider the bijection $\psi{:}[l_F, L] \to [l_G, L]$ where $F\left(l\right) = G\left(\psi\left(l\right)\right)$ for any $l \in [l_F, L]$. Welfare is $W\left(l, p\right) = \left(1 - \alpha\right)\left(p - l\right) + \beta$. Hence, change in welfare when going from F to G is

$$\Delta = \left(1 - \alpha\right)\int_{l_F}^{L}\left(p\left(\psi\left(l_F\right)\right) - \psi\left(l\right) - p(l_F) + l\right)dF\left(l\right).$$

From Proposition 5, $p(l_F)$ is

$$p(l_F) = \frac{\alpha - 1}{\alpha} l_F + \frac{\beta}{\alpha}.$$

It follows that

$$\Delta = (1-\alpha) \int_{l_F}^{L} \left\{ (l - \psi(l)) - \frac{\alpha - 1}{\alpha} (l_F - \psi(l_F)) \right\} dF(l)$$

$$= \frac{(1-\alpha)^2}{\alpha} (l_F - \psi(l_F))(1 - F(l_F)) + (1-\alpha) \int_{l_F}^{L} (l - \psi(l)) \, dF(l).$$

Note that $\mu_F = \int_{l_F}^{L} l \frac{dF(l)}{1-F(l_F)}$ and $\mu_G = \int_{l_F}^{L} \psi(l) \frac{dF(l)}{1-F(l_F)}$. Therefore, remembering that $\alpha > 1$,welfare increases, i.e., $\Delta \geq 0$ when

$$\mu_G - \mu_F \geq \frac{\alpha - 1}{\alpha} (l_G - l_F).$$

■

5.2.2 A Local Condition

Define $\psi_t(l) = t\psi(l) + (1-t)l$. Given ψ_t, there is a distribution F_t that is defined by $F_t(\psi_t(l)) = F(l)$ and a resulting equilibrium price $p(\psi_t(l_F))$. Note that $F_1 = G$ and that $F_0 = F$. We are interested in the variation in welfare between F and F_t in a neighborhood of $t = 0$. Let

$$\Delta(t) = \int_{l_F}^{L} \left[W(\psi_t(l), p(\psi_t(l_F))) - W(l, p(l_F)) \right] dF(l).$$

Then,

$$\begin{aligned} \Delta'(0) &= \int_{l_F}^{L} \left[(\psi(l) - l) W_1(l, p(l_F)) + (\psi(l_F) - l_F) p'(l_F) W_2(l, p(l_F)) \right] dF(l) \\ &= \int_{l_F}^{L} [(\psi(l) - l) - (\psi(l_F) - l_F) p'(l_F)] W_1(l, p(l_F)) \, dF(l), \end{aligned}$$

where the second line follows from $W_2 = -W_1$. Using (14),

$$p'(l_F) = 1 + \frac{1}{\pi'(p(l_F) - l_F)}.$$

Since

$$W_1(l, p(l_F)) = -\pi'(p(l_F) - l) - 1,$$

it follows that

$$\Delta'(0) = \int_{l_F}^{L} \left\{ (\psi(l_F) - l_F) \left(1 + \frac{1}{\pi'(p(l_F) - l_F)}\right) - (\psi(l) - l) \right\} (1 + \pi'(p(l_F) - l))\, dF(l). \tag{15}$$

Total welfare increases as a consequence of a small shock to the distribution of liquidities when $\Delta'(0) > 0$. Once again, two effects are at play. First, the changes in liquidity within partnerships generate an aggregate internal effect of

$$-\int_{l_F}^{L} (\psi(l) - l)(1 + \pi'(p(l_F) - l))\, dF(l);$$

this is similar to the type of comparison that we made in Proposition 7. Second, when the marginal agent changes, the equilibrium price changes, and the aggregate change in welfare due to this external effect is

$$\int_{l_F}^{L} (\psi(l_F) - l_F) \left(1 + \frac{1}{\pi'(p(l_F) - l_F)}\right) (1 + \pi'(p(l_F) - l))\, dF(l).$$

6 Interest Rate Effects

When there is a consolidation of assets with centralization, outside finance will be used, and there typically is a positive demand for outside finance. Changes in the liquidity distribution will lead to changes in this demand, as well as to the supply of finance, and we therefore have the potential to introduce an additional channel by which distribution will affect organizational form, namely through its effect on the interest rate. Before examining this, though, it is useful to consider how purely exogenous changes in the interest rate affect things.

6.1 Exogenous Change in the Interest Rate

By Propositions 5, 4 and Corollary 2, increasing the interest rate exogenously is equivalent to having a multiplicative shock to the liquidity of each type 2 agent.[26] The logic of Proposition 6 applies here and we can conclude that in the model with consolidation, an exogenous increase in the interest rate (e.g., via central bank intervention or via a lowering of inflation) will increase efficiency and will decrease the use of centralization in the economy. If "good times" go together with a low interest rate, then our model predicts that there

[26]Indeed, note that $(1+r)T(l_1, l_2) = T((1+r)l_1, (1+r)l_2)$ and use the decomposition result.

should be more centralization, which is consistent with some stylized facts in the merger literature.

High interest rate make transfers of liquidity *now* more valuable from *tomorrow's* point of view. Therefore, liquidity becomes more valuable as a means of transferring surplus than before. Notice that exogenous changes in r have these effects regardless of whether centralized control involves consolidation.

6.2 Endogenous Interest Rate

It is also possible to endogenize the interest rate by supposing that all loans are made for the purpose of financing consolidated centralized control. (Obviously, if centralized control is nonconsolidated, there is no demand for outside finance, and the only possible equilibrium interest rate would be zero. Of course, this leaves out the demand engendered by investment in capital, which is absent in this model).

We refer the reader to Figure 4. The Pareto frontier of V_0^* consists of a linear segment and a strictly convex part. The surpluses on the convex part are achieved by contracts with decentralization. Surpluses on the linear segment $\left[v^C v^D\right]$ are achieved by taking a lottery between the decentralization contract yielding surpluses v^D and the centralization contract yielding surpluses v^C. Points on this segment obey the relation

$$v_2 = -\alpha v_1 + \beta,$$
$$\alpha = 1 + \frac{W^D - W^C}{v_1^C - v_1^D}, \beta = \frac{W^D v_1^C - W^C v_1^D}{v_1^C - v_1^D},$$

where $W^D = v_1^D + v_2^D$, $W^C = v_1^C + v_2^C$.

Suppose that $l_F < \overline{v}_2$. If r is so large that $(1+r)\, l_F > v_2^D$, then all inframarginal agents will use a decentralization contract. But this means that the demand for outside finance is zero, which is a contradiction. We can therefore assume that $(1+r)\, l_F > v_2^D$. The equilibrium surplus of the type 1 agent is

$$v_1^*(r) = \pi^{-1}\left((1+r)\, l_F\right) + (1+r)\, l_F.$$

Each inframarginal agent solves

$$\max_{v \in V_0^*, t \in [0,l]} v_2 - (1+r)\, t \tag{16}$$
$$\text{s.t., } v_1 + (1+r)\, t = v_1^*(r).$$

We define two cutoff values:

$$\begin{aligned} l(r) &= \frac{v_1^*(r) - v_2^D}{1+r} \\ L(r) &= \frac{v_1^*(r) - \overline{v}_1}{1+r}. \end{aligned}$$

$l(r)$ is the liquidity of a type 2 that is just sufficient to choose a decentralization contract while giving the type 1 agent his equilibrium surplus; $L(r)$ is the maximum liquidity of a type 2 agent for which the solution of the program 16 is $t = l$. Agents with liquidity in $l \in [l(r), L(r)]$ use all their liquidity to "buy" decentralization and these agents are not active on the market for outside finance. Note that l and L are decreasing in r and are increasing in $v_1^*(r)$.

Agents with liquidity $l \in [l_F, l(r)]$ will use a centralized contract with probability $\eta(l; r)$, where[27]

$$\eta(l; r) = \frac{v_1^*(r) - v_1^D - (1+r)l}{v_1^C - v_1^D}.$$

Note that this probability is decreasing in r and l. These agents are net demanders of outside finance. Agents with liquidity $l > L(r)$ are net suppliers of liquidity since after paying $L(r)$ they retain some liquidity. Finally, type 1 agents are net suppliers of liquidity.

Therefore,

$$\begin{aligned} Demand(r) &= B(r) \int_{l_F}^{l(r)} \eta(l; r) \, dF^2(l) \\ Supply(r) &= \int_{L(r)}^{\infty} (l - L(r)) \, dF^2(l) + \int_0^{\infty} l dF^1(l). \end{aligned}$$

It is straightforward to show that an equilibrium exists (possibly at $r = 0$) and that, because $Demand(r)$ is decreasing and $Supply(r)$ is increasing in r, the equilibrium is unique.

Note that the liquidity of the type-1 agents plays a role for the first time. In particular, if they are more liquid, all else the same, r falls, and we get a *less* efficient allocation. Changes in the 2's liquidity distribution are more complex to analyze. Note, though, that the first order stochastic dominant shift in F^2 considered in Section 5 that led to increased centralization and reduced efficiency is now all the more likely to do so, since it also increase the

[27] For $l \leq l(r; v_1^*)$, the solution to (16) is $t = l$ and $v \in [v^C, v^D]$ where $v_1 + (1+r)l = v_1^*(r)$. Noting that $v_1 = \eta v_1^C + (1-\eta) v_1^D$ leads to the expression in the text.

supply of funds and therefore lowers r. Notice that these efficiency effects of changes in r are generally opposite to those usually understood. Again, this stems from the fact that interest rates are playing a very different role here: they serve to facilitate (nonproductive) transfers of surplus, not to transfer productive capital from those who have it to those who need it.

7 Conclusion

In our static market equilibrium model, exogenous changes to the liquidity position of a small subset of the agents can have potentially significant organizational effects on the rest of the economy. As we have suggested, this model could serve as the basis for understanding economy-wide organizational changes, such as merger waves. To do so in a dynamic context requires taking account of the endogenous evolution of the liquidity distribution itself; a full theory of merger waves could proceed along the lines of some recent papers in the macro literature (Bernanke-Gertler, 1989; Kiyotaki-Moore, 1997; Aghion-Banerjee-Piketty, 1999).

Beside the market, our framework can be used to study other "external" influences on organizational design, notably government regulation. Regulation will have two effects in this model. First, it affects the contracting possibilities of agents, which manifests itself in distortions of their feasible set. Second, it can affect the division of surplus. Both effects may increase or lower welfare. The opening of new markets, or globalization, can have similar effects.

As we have indicated, our model abstracts from real investment and in particular how it interacts with the interest rate. Generally, low interest rates are thought to be "good" for real investment. In the market for corporate control, though, low interest rates may be associated with high rates of (inefficient) centralization. Thus we are led to revisit the old questions of whether organizational restructuring may act as a substitute for real investment, whether antitrust policy might therefore usefully complement monetary policy, etc.

In the real world, we observe a rich variety of control rights married with rights to returns (Kaplan and Strömberg, 1999). Theory has not caught up to empirics in this regard because it has generally assumed as a modelling strategy at the outset particular associations of control rights and returns streams, rather than endogenizing them as we have done. Much more remains to be done on that score – if theory is to mimic the rich variety of financial instruments and innovations that we see, we will have to allow for more complex environments than what we have studied in this paper, especially with respect to the temporal unfolding of decisions and renegotiation.

Renegotiation itself has figured prominently in the literature on ownership, and we have omitted it entirely. Re-introducing it is relatively straightforward if one assumes that lock-in is sufficiently severe that the general equilibrium effects occur only at the initial matching stage (for models analyzing the effects of market conditions on the renegotiation process itself, see Ramey-Watson, 1998 and Baker-Gibbons-Murphy, 1999). One effect of liquidity constraints is to reduce the efficiency of bargaining at the renegotiation stage, which means that different allocations of decision rights will have different welfare properties even if all decisions are taken ex-post (i.e. even if there are no "ex-ante investments").

And corollary to the general point that efficient organizational structures are not necessarily the ones that deliver the division of surplus called for by market conditions, efficient renegotiation procedures (e.g. Aghion-Dewatripont-Rey, 1994) need not be chosen in worlds like the one we have examined. One benefit of having control (at least in a model where a decision is taken after some relevant state of the world is revealed) is that it has option value for the owner (Legros-Newman, 2000). In a liquidity constrained world, this may be an effective way to transfer surplus, more so than an efficient mechanism that requires a lot of commitment.

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