All on Board: Corporate Governance and Co-Determination

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Draft: March 26, 2026

I examine a model of corporate behavior under shared governance, or co-determination, in the form of employee-elected representatives on a firm's board of directors. Employee and shareholder representatives engage in sequential bargaining over the firm's labor, capital, production, and financing decisions. If the firm has market power and as long as employee representatives (e.g., a union) have an interest in increasing labor, a limited increase in employee representation on the board will result in an increase in labor and output, an ambiguous and small effect on capital expenditures, and a decrease in monopoly deadweight loss with no effect on wages, which is in line with previous empirical estimates of the effect of co-determination. In the presence of risk of costly default and tax advantages of debt, limited employee control can reduce socially inefficient reliance on debt over equity. However, if employees elect most or all of the board representatives, then the firm will instead choose to increase wages and may not be able to commit to repay equity, increasing the proportion of debt in its capital structure.

The social optimality of the corporate form has long been subject to debate. On one side stands the belief in the social efficiency of the shareholder corporation, advocated by Jensen and Meckling (1979) and others, and perhaps evidenced by its ubiquity. On the other side of the debate are proponents of a range of

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alternative organizational structures, such as the so-called labor-managed firm, in which all control rights are held by employees rather than shareholders, and the co-determined firm, in which employees have limited control rights in the form of elected representatives.

Recent empirical studies based on European policy experiments of the 1990s paint a starkly different picture of the co-determined firm than Jensen and Meckling predicted – one in which co-determination policies have had little to no statistically significant effect on wages and, if anything, a weakly positive impact on investment (Jäger, Schoefer, and Heining 2020; Harju, Jäger, and Schoefer 2021). As Jäger, Noy, and Schoefer (2021) put it,

> *The evidence indicates that the European model of codetermination is neither a panacea for all the problems faced by 21st-century workers, nor a destructive institution that appears obviously inferior to shareholder control.*

These empirical results prompt questions such as why the behavior of a co-determined firm is so similar to a shareholder corporation and what the optimal behavior of a co-determined firm looks like. This paper provides a model aiming to answer these questions.

First, I present a model of supervisory board decision-making based on consensus among coalitions of players with group-specific payoffs. The key implication of the bargaining model is that under consensus bargaining outcomes must be on the Pareto frontier. In addition, the bargaining model shows a tractable way to model the effect of coalition size on the relative bargaining powers and outcomes.

The bargaining model can be applied in a corporate context to model control structures other than co-determination, including providing control rights to other non-shareholder stakeholders, as well as application beyond the firm.

The outcomes of the bargaining process are applied to multiple market structures, including monopoly and oligopoly, with firms making decisions related to labor, accumulation of production capital, and financing. The model demonstrates why

employee representatives might find it optimal to increase the amount of labor rather than negotiate higher wages, which aligns with the empirical evidence. The model also demonstrates that depending on market conditions co-determination could be either beneficial or detrimental to capital accumulation.

The increase in production resulting from co-determination can reduce deadweight loss from monopoly market power in a way that can enhance antitrust policy. Indeed, a monopolistic firm operating in the interest of shareholders would not increase quantity beyond the amount maximizing profits, because the marginal costs of doing so, in the form of labor and capital expenditures, would exceed the marginal benefit, i.e., revenue. From the point of view of employee representatives however, labor expenditures may themselves be seen as a benefit rather than a cost, potentially resulting in an expansion of the workforce. This increase in labor corresponds to a higher quantity and a lower price, similar to what competition would bring and exactly what an antitrust authority would be hoping to achieve. The effect is stronger when firms are more profitable, i.e., when the market is less competitive, thus compensating for lapses in antitrust oversight.

Finally, the model addresses the concerns that greater employee control can lead to expropriation of shareholder equity. I demonstrate that greater employee control can indeed create incentives for shareholders to push for the issuance of debt rather than equity, even if debt comes with risk of a costly default. Similar to some models of investor expropriation by entrepreneurs, the effect is a result of the conflict between old and new investors and the change in bargaining power that comes with issuing new equity without allocating corresponding board control. Debt then acts as a commitment device increasing the bargaining power of existing shareholders in future negotiations (Jensen and Meckling 1976; Jensen 1986).

The model therefore establishes a trade-off of labor control. On the one hand, increasing employee control can reduce deadweight losses from market power. On the other hand, it can exacerbate incentives to accumulate risky debt.

While the model is primarily aimed at the analysis of co-determination and,

more generally, control rights allocated to non-shareholder stakeholders, it can also shed some light on the behavior of conventional shareholder corporations. Specifically, the bargaining between shareholder and employee representatives can instead be interpreted as bargaining between shareholders and managers (e.g., the CEO) through their respective representatives. The model demonstrates that in situations where the CEO and other managers can exert control over the board, those managers will increase their payoff above that determined by the market at the expense of shareholder interests. Interestingly, an implication of the model in this context is that empire-building can be social welfare improving: if the CEO and other managers have an interest in increasing production, they may do so, offsetting the underproduction problem of a monopoly. If managers are purely financially motivated however, they will simply negotiate a pay raise.

Section I discusses the literature this paper aims to contribute to, Section II describes the main structure and timeline of the model, Section III presents a model of multilateral bargaining under consensus, Section IV applies the bargaining problem to a corporate setting, Section V presents the baseline model of a co-determined monopoly, Sections VI and VII demonstrate extensions related to capital acquisition, market structure and financing, and Section VIII concludes.

I. Related literature

The idea of the firms' governance structure affecting equilibrium outcomes in factor markets and a product market with imperfect competition is related to the broader literature connecting corporate control and financial market outcomes to the production side of the firm, such as Leland (1974) and Brander and Lewis (1986).

The theory literature connecting ESG policies, and specifically co-determination, to market outcomes is much more limited in scope. Most closely related to my paper is work done by Bond and Levit (2023) discussing how commitment to an ESG policy objective can affect the competitive incentives of a firm. In their

model, the ESG policy takes the form of a self-imposed minimum employee utility constraint on the firm's optimization problem. My paper demonstrates that such a commitment can be achieved through the redistribution of board seats, as long as decision-making on the board is made by consensus.

At the same time, there is a rapidly growing empirical literature documenting firm and market outcomes under co-determination (Jäger, Schoefer, and Heining 2020; Harju, Jäger, and Schoefer 2021). Using data from natural experiments in the form of selective European policy changes in the 1990s, those papers find that co-determination has a positive impact on the amount of labor hired by firms, firm production, a weakly positive and often insignificant impact on firm investment and no statistically significant effect on wages.

These empirical results contrast starkly with observed and predicted outcomes of bargaining between firms and labor unions (Farber 1986), indicating that there is a meaningful difference in incentives between employee representation through unions and through board representatives. While determining the causes underlying this difference is beyond the scope of my paper, the model can serve as a starting point of such an analysis. Specifically, the model outcomes align with the empirical results on co-determination as long as the employee representatives have some incentive to expand the workforce and the labor market is competitive.

My paper also contributes to the literature on board decision-making and within-board dynamics. A closely related paper by Chakraborty and Yılmaz (2017) concerns the effect of board composition on information flows in the presence of consensus decision-making. Firstly, Chakraborty and Yılmaz focus on advisory boards providing advice to a manager, while my paper concerns supervisory boards that have decision-making authority. Moreover, Chakraborty and Yılmaz model board composition as the weights the board puts on maximizing shareholders' and a manager's interests respectively. By contrast, I use a Rubinstein framework to show that consensus bargaining with a variable surplus should result in outcomes on the Pareto frontier which may not be achieved by maximizing a weighted-average

utility under risk-neutrality. I also provide a mapping between board control (i.e., the proportion of board seats elected) and surplus bargaining outcomes.

The equilibrium of the bargaining model under consensus given a variable surplus as well as the novel approach to modelling bargaining between opposing coalitions can both be applied more generally to any setting beyond the firm, and thus contribute to the broader literature on bargaining (Krishna and Serrano 1996).

II. Model setup and timeline

A. The market

Consider a set of N firms operating and interacting over T periods in the following markets:

- Product, characterized by a market structure and a demand function $P(Q)$;
- Labor, competitive with labor wage level w per unit of labor L;
- Production capital, competitive with rent costs r per unit of capital K;
- Financial, competitive with risk-free rate R_f.

Each firm is governed by its stakeholders who must make decisions in each of the markets. While the governance structure (i.e., board composition) is assumed to be exogenously fixed, the stakeholders' decisions can affect the identities of future stakeholders. For example, issuing equity in the financial market will potentially bring in new shareholders. If the firm's employees have representatives on the board, then adjusting the amount of labor the firm employs will also affect the firm's future decisions through the hiring of new (or termination of old) employees.

The model timeline is as follows.

B. Timeline

1) **Beginning of time:**

The firm enters the period with initial equity, labor, debt and production capital. The board composition is determined exogenously.

2) **Decision-making:**

The stakeholders (shareholders, employees) bargain over the financing, labor, capital investment and production decisions of the firm, according to the governance structure of the firm.

3) **Financing and capital investment:**

If decided as stage 2, the firm raises funding by issuing debt and/or equity, and uses the proceeds to acquire capital, bringing its total capital to K.

4) **Labor:**

The firm hires labor, bringing its total labor to L.

5) **Production:**

Production is realized according to a production function $F(K, L)$.

6) **Payoffs:**

The firm sells the produced consumption goods in the product market. Payoffs to stakeholders are realized according to their contracts.

In order to analyze a firm's behavior, I therefore first need to specify its governance structure, which will determine the decision-making process.

C. Governance structure

While skeptical of alternative organizational structures, Jensen and Meckling raise an important point in their 1979 paper,

> *Efforts to analyze the behavior of the codetermined firm face a serious problem just getting off the ground. We do not have a theory that will tell us how supervisory boards will behave, or at least none in which we have any confidence.*

Indeed, the most common method of reconciling the interests of different stakeholders is the addition of dedicated board seats. Countries with co-determination laws require board seats dedicated to employees on supervisory boards, while venture capital backed firms often have separate board seats for representatives of different shareholder groups.

Anecdotal evidence suggests that while boards are not legally required to make decisions by consensus, they often strive to do so (Gold 2011). Cooperative bargaining models would then suggest that, under complete information, if each board member has veto power, the number of board members representing each stakeholder group should be irrelevant – the outcome of the bargaining process on a board of 10 people should be the same whether the seats are split 1 to 9 or 5 to 5 between two stakeholder groups. On the other hand, simple majority voting on a board would result in individual board members representing a different stakeholder group having no effect on firm outcomes as long as the majority is unaffected.

However, empirical evidence shows that individual board members do have a significant impact on firm decisions, yet simultaneously not as significant as veto power in a cooperative bargaining system would imply (Jäger, Schoefer, and Heining 2020; Jäger, Noy, and Schoefer 2021; Harju, Jäger, and Schoefer 2021).

At the same time, most bargaining models focus on a problem where the surplus to be split between the participants is exogenous to the outcome of the bargaining process. This is not necessarily the case when the agents involved are stakeholders of a firm since the production decisions and outcomes may depend on the allocation of resources between stakeholders.

I therefore need a model of board decision-making that would exhibit two properties:

1) **Group consensus:** the bargaining is between groups of agents, allowing for between-group preference heterogeneity, and an equilibrium is achieved when all groups are in agreement.

2) **Variable surplus:** the surplus to be divided between participants may depend on the outcome of the bargaining process.

Such a model is presented in Section III, with Section III.A focusing on the group consensus property and Section III.B – on variable surplus. Section III.C combines the two models and presents some useful asymptotic results.

III. Consensus bargaining with variable surplus

A. Coalitional Rubinstein bargaining

Consider a standard Rubinstein bargaining model, in which two sides with discount rates $\bar{\beta}_1$ and $\bar{\beta}_2$ bargain iteratively over how to split surplus v, with the following adjustments:

- Each side represents a coalition of agents with identical payoffs rather than a single agent.
- Each agent within a group has veto power, i.e., bargaining continues until all agents in each group are satisfied with the outcome.
- Agents have heterogeneous discount factors: each agent's factor is independently drawn from a population with a continuous distribution of discount rates, described by a cdf $F(\beta)$.

Given those additional assumptions, I can define each coalition's effective discount rate as:

$$\bar{\beta}_C = \max_{i \in C} \beta_i.$$

In other words, each coalition is as patient as its most patient member and increasing the number of members of a coalition can increase its bargaining power.

The solution to the bargaining problem then remains the same as in the standard Rubinstein model. Let $C = 1$ be the proposing coalition, then:

$$v_1 = \frac{1-\bar{\beta}_2}{1-\beta_1\bar{\beta}_2} v; \qquad v_2 = \frac{1-\bar{\beta}_1}{1-\beta_1\bar{\beta}_2} \bar{\beta}_2 v.$$

I can now map the proportion of representatives belonging to a given group to the share of the surplus obtained by that group.

Example III.1: Consider a game among 20 players with $\beta_i \sim \text{Beta}(18, 2)$, implying an average discount rate of 0.9, divided into two coalitions. Assume that each coalition has an equal chance of being the proposer.

Figure 1 shows that the surplus share of a coalition then, on average, increases with its proportion of board seats. The marginal benefit of an additional seat is non-monotonic. It is highest when a coalition has no representation and obtains a single seat and, symmetrically, when it only needs a single seat to achieve full control of the board. It is lowest when the two coalitions have roughly equal representation.

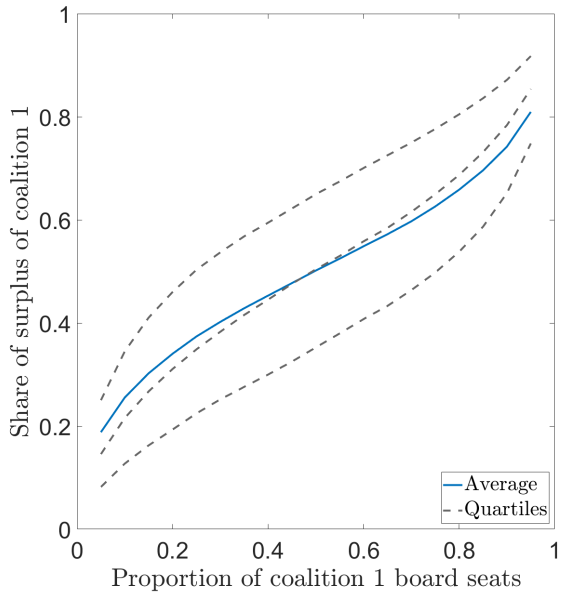


Figure 1. : Coalition payoff as a function of representation in Coalitional Rubinstein bargaining model

B. *Rubinstein bargaining with variable surplus*

The canonical Rubinstein bargaining model focuses on splitting a constant surplus between two negotiating parties. However, in the corporate context, the total surplus may depend on the payments to each party. For example, starting from a shareholder-controlled monopoly's optimal point, increasing production by hiring more employees would increase the size of the pie (revenue), but reduce the share of the pie that goes to shareholders (profits). I therefore need to describe how a Rubinstein-style bargaining process functions given a varying surplus.

Consider a game with two players and let $u_i(x)$ be each player i's utility as a function of some common parameters x, subject to constraints $C(x) \leq 0$. Assume that the players are engaged in a Rubinstein sequential bargaining process:

- In period 1 player 1 offers a feasible agreement x resulting in payoffs $u_i(x)$.
- Player 2 chooses whether to accept or reject the agreement:
  - If player 2 accepts, bargaining ends and x is implemented.
  - If player 2 rejects, bargaining continues with player 2 proposing the next period's allocation.

It is worth highlighting that in this game the players are not bargaining just about how to split the surplus. Rather, they are bargaining over some real variables (x) which jointly determine the size and the allocation of the surplus. In the example of the firm, x would include the amount of labor hired by the firm, the wages paid to employees and the output of the firm. The feasibility constraint $C(x) \leq 0$ would be a budget constraint dictating that the sum of wages going to the employees and profits going to the shareholders cannot be greater than the firm's total revenue.

Proposition 1. *Consider a Rubinstein bargaining game with player utilities $u_i(x)$ and a variable surplus determined by a feasibility constraint $C(x) \leq 0$.*

Let $\hat{u}_i(u_j)$ describe the Pareto frontier available to the players, in other words:

$$\hat{u}_i(u_j) = \max_x u_i(x),$$

subject to

$$u_j(x) \geq u_j;$$

$$C(x) \leq 0.$$

Let u_i^j be the equilibrium utility that player i gets in equilibrium if player j is the proposer and assume that when indifferent, a proposer offers a Pareto-optimal allocation over a suboptimal one.
The bargaining game then has a unique SPNE. The equilibrium proposer payoffs can be found from the following system of equations:

$$\forall i,\ u_i^i = \hat{u}_i(\beta_{-i} u_{-i}^{-i}).$$

The payoff of player j under proposer i corresponds to a point on the Pareto-frontier:

$$u_j^i = \hat{u}_j(u_i^i).$$

Proof of Proposition 1 can be found in Appendix A.1.

C. Coalitional Rubinstein bargaining with variable surplus – asymptotics and connection to Nash bargaining

Consider the following special case, which combines the coalitional structure of the bargaining game with variable surplus:

- The N players are divided into two coalitions (types), such that any player i in coalition j has a payoff function $u_j(x)$. Let $\eta_j = \frac{N_j}{N}$ be the fraction of players belonging to each coalition.
- The two groups are bargaining over parameters x according to the Rubinstein

procedure over a variable surplus determined by constraint $C(x) \leq 0$.

- Each player's discount factor β_i is drawn, independently and identically across players, from a Beta distribution with parameters a and b. The distribution and realizations of β_i are public knowledge.

Once again, let $\bar{\beta}_j = \max_{i \in j}\{\beta_i\}$ be the effective discount factor of coalition j, and define the Pareto frontier as:

$$\hat{u}_j(u_k) = \max_x u_j,$$

subject to

$$u_k(x) \geq u_k;$$

$$C(x) \leq 0,$$

And keep the coalition proportions η_j be fixed. Then the following result holds for large N.

Proposition 2. *Consider a coalitional Rubinstein bargaining game with a variable surplus, i.i.d. Beta-distributed discount factors and constant coalition proportions η_j.*
In such a game, for any number of players, there is a unique SPNE for each realization of discount factors. For a large number of players, each equilibrium corresponds to the maximum of a weighted sum of the logs of the utilities:

$$\max_x \varepsilon \ln\left(u_1(x)\right) + \ln\left(u_2(x)\right),$$

subject to

$$C(x) \leq 0,$$

where the weight on the payoff of the second coalition is normalized to 1 without loss of generality. The weight ε, which I will refer to as bargaining power, is determined by the realization of discount factors and is the realization of an approximately

log-logistically distributed random variable $\mathcal{E}$*:*

$$\mathcal{E} \sim \textit{Loglogistic}\left(\left(\frac{\eta_1}{\eta_2}\right)^{\frac{1}{b}},\ b\right),$$

where b *denotes the second parameter of the Beta distribution of discount factors.*

The proof is presented in Appendix A.2.

In other words, the asymptotic bargaining outcome corresponds to the outcome of a Nash bargaining game with different weights on the surpluses of the two groups.

Example III.2: Consider a scenario closest to a standard Rubinstein bargaining game, with two coalitions and a fixed surplus of 1, $\hat{u}_1(u_2) = 1 - u_2$. In this case the equilibrium condition is simply:

$$\frac{u_1}{u_2} = \varepsilon.$$

Using the same parametrization as seen in Example III.2, i.e., $\beta_i \sim \text{Beta}(18, 2)$, each coalition's share of the surplus for large numbers of players indeed tends to increase with its proportion of players, as seen in Figure 2.

The distribution of payoff ratios and payoffs approaches the limit fairly quickly, as seen in Figure 3.

D. Outside option and firm-specific risk-aversion

Recall that the median of the log-logistic distribution is equal to the scale parameter, i.e., the median bargaining power of coalition 1 is:

$$\bar{\varepsilon} = \left(\frac{\eta_1}{\eta_2}\right)^{\frac{1}{b}}.$$

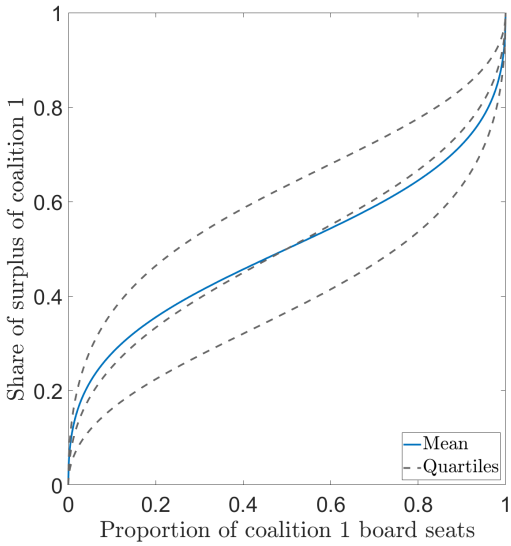


Figure 2. : Coalition payoff as a function of representation in game with large number of players

For the median outcome the Nash maximization problem can be written as:

$$\max_x \eta_1^{\frac{1}{b}} \ln(u_1(x)) + \eta_2^{\frac{1}{b}} \ln(u_2(x)),$$

subject to the usual feasibility constraint

$$C(x) \leq 0.$$

In other words, a large board making decisions under consensus behaves as if it were optimizing the weighted sum of the logs of the utilities of the groups, with each group's weight increasing in the proportion of seats representing that group.

Crucially, this is not equivalent to each group simply displaying aversion to risk. Indeed, the scope of the bargaining problem is defined by the hold-up ability of the parties, i.e., the relevant utility $u(x)$ is determined as any payoff that is directly affected by the cost of delay coming from the discount factor β. Any outside utility

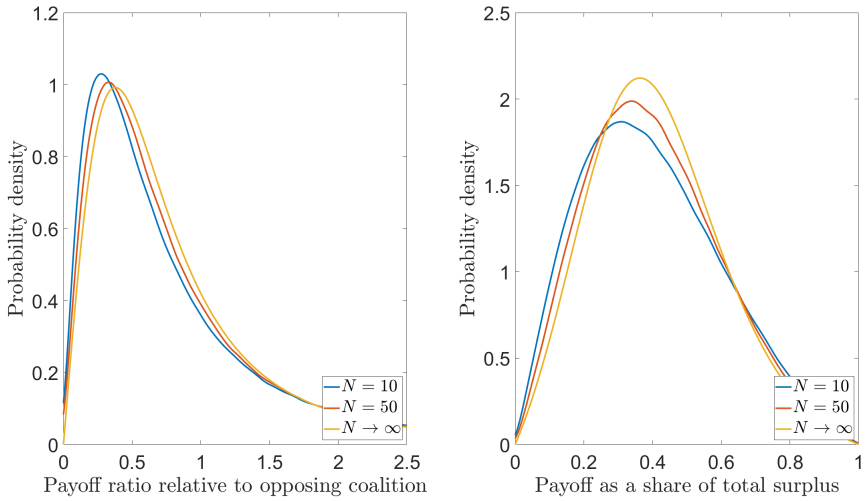


Figure 3. : Distribution of coalition payoffs for different N

that is not affected by the delay does not in turn affect the bargaining outcome.

Put in a corporate context, this feature makes the utility relevant to the bargaining problem project- or firm-specific. Take as an example a deep-pocketed investor that controls a fraction of the board of a small firm. They may display risk aversion over their entire portfolio, but if the firm is only a small part of that portfolio, they are approximately risk neutral with respect to cashflows from the firm, i.e., if x is the cashflow, then $u(x) \propto x$. Yet if the board makes decisions by consensus, the firm will behave as if the investor had log utility over the firm's cashflows, and ignore any outside portfolio. The board as a collective will therefore strive to avoid any decisions that disproportionately hurt any individual groups.

IV. The firm problem

Having determined the outcomes of the bargaining process, I can analyze the behavior of firms with different governance structures within a given market. Of particular interest is the behavior of three empirically described firm types:

- **The shareholder corporation** whose board only includes representatives

elected by shareholders.

- **The labor-run firm** whose board only includes representatives elected by employees.
- **The co-determined firm** whose board includes a mix of shareholder and employee representatives, usually with a shareholder majority.

All three structures are in effect nested within the concept of the co-determined firm, with the shareholder corporation and the labor-run firm being the limiting special cases where one group controls the entire board.

A. Board representatives and bargaining

The groups of stakeholders are represented by board members. The board is large and the share of board seats controlled by employees will be denoted η, so the outcome of the board bargaining problem corresponds to a solution to the Nash maximization problem:

$$\max_x \varepsilon \ln(u_e(x)) + \ln(u_s(x)),$$

where the employee bargaining power ε is the realization of:

$$\mathcal{E} \sim Loglogistic\left(\left(\frac{\eta}{1-\eta}\right)^{\frac{1}{b}},\ b\right).$$

Shareholder board representatives act in the interests of existing shareholders, who are risk-neutral, i.e., in the baseline model the utility of the shareholder board representatives is equal to the firm's profit function:

$$u_s(W, L) = \pi(W, L),$$

where $W \geq w$ is the wage paid to existing employees. $\pi(W, L)$ may be the result of an optimization problem, e.g., over capital acquisition or financing.

Employees on the other hand will have representatives whose goal is to maximize a weighted sum of the payments to existing and new labor:

$$u_e(W, L) = WL_0 + \lambda w(L - L_0),$$

where $\lambda \in [0, 1]$ is the weight the representative puts on payouts to new labor.

The intuition behind this utility function requires some explanation. First, the representatives are elected by existing employees, and it is in their interest that the representative should attempt to negotiate a higher wage. At the same time, increasing the effective amount of labor at the firm can also be in the representative's interest if, for example, the representative is paid for their service (e.g., the employees are represented by a union) and new employees bring additional fees. In other words, the parameter λ can be interpreted as a reduced form representation of the incentive structure of the employee representative.

Notably, while this incentive structure is exogenous for the purpose of the model, it can be of interest to, and affected by, policy. For instance, having strict requirements that the representative act in the interests of existing employees, similar to fiduciary duty, would likely reduce λ. As will be shown in later sections, there can be non-trivial social trade-offs between high and low values of λ.

B. Production

The firm's production decisions will be determined in the bargaining process.

Proposition 3. *Suppose that the profit function $\pi(W, L)$ is twice continuously differentiable and concave in labor L and there is a unique threshold value of L' such that $\pi_L(L') = -\lambda w$. Let $\underline{L}$ be the amount of labor optimally hired by a profit-maximizing firm and suppose that $L_0 < \underline{L}$, i.e., a profit-maximizing firm*

would seek to hire additional labor. Define ε' as:

$$\varepsilon' = \begin{cases} \frac{u_e(w,L')}{\pi(w,L')}, & \text{if } \pi(w,L') > 0; \\ \infty, & \text{otherwise.} \end{cases}$$

Then:

- *Equilibrium payoffs are strictly monotone in ε with $u_e^* \in [w\underline{L}, \pi(w,L')]$ and $u_s^* \in [0, \bar{\pi}]$.*
- *For $\varepsilon \leq \varepsilon'$ equilibrium labor is strictly increasing in ε and wages are constant at $W = w$.*
- *For $\varepsilon \geq \varepsilon'$, if such exist, equilibrium labor is constant at $L = L'$ and wages are strictly increasing.*

Specifically, equilibrium labor and wage follow:

$$L^*(\varepsilon) = \begin{cases} \hat{L}(\varepsilon), & \varepsilon \leq \varepsilon'; \\ L', & \varepsilon > \varepsilon'; \end{cases}$$

$$W^*(\varepsilon) = \begin{cases} w, & \varepsilon \leq \varepsilon'; \\ w + \frac{\pi(w,L')}{L_0} \cdot \frac{\varepsilon - \varepsilon'}{1+\varepsilon'}, & \varepsilon > \varepsilon', \end{cases}$$

where $\hat{L}(\varepsilon)$ solves:

$$-\frac{\pi_L(\hat{L})}{\lambda w} \cdot \frac{wL_0 + \lambda w(\hat{L} - L_0)}{\pi(w, \hat{L})} = \varepsilon.$$

The proof is presented in Appendix A.5. To better understand Proposition 3 first consider the following intermediate results.

Lemma 1. *If the profit function $\pi(W, L)$ is concave and there exists a unique value L' such that $\pi_L(L') = -\lambda w$, then in all equilibria where employee utility is below $u_e(w, L')$ there is no wage negotiation ($W = w$), and in all equilibria where utility is above $u_e(w, L')$ there is no further increase of labor ($L = L'$).*

The proof is presented in Appendix A.3.

In other words, the employee representatives will prioritize bargaining for an increase in labor over negotiating a higher wage.

For intuition consider a shareholder corporation operating as a monopoly in the product market. The firm will choose output to maximize its profits, which is generally below the output maximizing revenue. If the employee representative bargains for an increase in wages, then this increase will not affect production and revenue, and will directly reduce profits. If, on the other hand, they negotiates an increase in labor and production, then the cost of that increase will be partially offset by an increase in revenue and only have a second order effect on profits. As a result, the same increase in the employee representative's utility will come at a lower cost to shareholders and will be easier to reach an agreement on.

This result also has important implications for welfare. The increase in labor will simultaneously reduce deadweight loss from monopoly: by increasing labor and output compared to the shareholder optimum, the firm will approach the competitive equilibrium, at the cost of shareholder profits.

Lemma 2. *If the profit function $\pi(W, L)$ is concave in L, then the stakeholders' equilibrium utilities u_i^* are strictly monotone in ε, increasing for employees and decreasing for shareholders, with:*

$$u_s^* = \begin{cases} \bar{\pi}, & \varepsilon = 0; \\ 0, & \varepsilon \to \infty. \end{cases}$$

The proof is presented in Appendix A.4.

In other words, increasing employee board control, which on average results in higher employee bargaining power ε, strictly benefits them at the expense of the shareholders. In particular, full shareholder control results in profit maximization, while full employee control results in the profits being paid entirely to the employees (following Lemma 1, in the form of an increase of labor and potentially wages).

Importantly, the profits remain positive for any finite ε, i.e., in any scenario except the employee first best. However, as will be shown in Section VII, the amount paid out to shareholders at high levels of employee control may not be sufficient to attract investment.

V. Monopoly with single-factor linear production function

Consider a market with a monopolist operating following the timeline established in Section II.B and requiring no financing.

1) **Beginning of time:** The firm has some initial equity and initial effective labor L_0. The firm's board is large, and employees control a share η of the seats.

2) **Decision-making:** The board representatives of shareholders and employees bargain over the production decisions of the firm. The employees' wages are specified by a contract, while shareholders are the residual claimants.

3) **Labor:** The firm acquires labor in a competitive labor market with wage w, bringing its total labor to L.

4) **Production:** Production is realized according to a linear production function $Q(L) = AL$.

5) **Payoffs:** The firm sells the produced consumption goods at the product market with a downward-sloping demand function $P(Q) = c/(Q + d)$. The stakeholders receive their payoffs in accordance with their contracts.

Proposition 4. *The equilibrium choice of labor and wages by a co-determined monopoly with a single-factor linear production function follow:*

$$L^*(\varepsilon) = \begin{cases} \frac{(1+\varepsilon)\lambda\underline{L}-(1-\lambda)L_0}{(2+\varepsilon)\lambda} + \sqrt{\frac{\varepsilon}{2+\varepsilon}\underline{L}^2 + \left(\frac{\lambda\underline{L}+(1-\lambda)L_0}{(2+\varepsilon)\lambda}\right)^2}, & \varepsilon \leq \varepsilon'; \\ L', & \varepsilon > \varepsilon'; \end{cases}$$

$$W^*(\varepsilon) = \begin{cases} w, & \varepsilon \leq \varepsilon'; \\ w + \frac{1}{4dL_0}\left(\left(c - \frac{1}{A}w\right)^2 - \left(\frac{\lambda}{A}w\right)^2\right)\frac{\varepsilon - \varepsilon'}{1+\varepsilon}, & \varepsilon > \varepsilon', \end{cases}$$

where $\underline{L} = \frac{1}{2dA}\left(c - \frac{w}{A}\right)$ *is the amount of labor optimally hired by a profit-maximizing firm and*

$$L' = \frac{1}{2dA}\left(c - \frac{1-\lambda}{A}w\right);$$

$$\varepsilon' = \begin{cases} \frac{u_e(w,L')}{\pi(w,L')}, & \text{if } \pi(w, L') > 0; \\ \infty, & \text{otherwise} \end{cases}$$

are threshold values between labor and wage bargaining.

Proposition 4 follows from Proposition 3. The proof is presented in Appendix A.6.

It is worth noting that the bargaining threshold L' may be above the limit of the firm's profitability $\bar{L}$ such that profits at any $L \geq \bar{L}$ are weakly negative for any wage $W > w$. However, the structure of the bargaining problem ensures that such an amount of labor is never implemented. Indeed:

$$\lim_{\varepsilon \to \infty} \hat{L}(\varepsilon) = 2\underline{L} = \bar{L},$$

i.e., given the monotonicity of $\hat{L}$, $\forall \varepsilon, \hat{L}(\varepsilon) \leq \bar{L}$. In practical terms, the only effect of L' being above $\bar{L}$ is that equilibrium labor for any employee bargaining power ε is below the threshold of wage negotiation and hence wages are not increased above the market level no matter the degree of employee control.

Example V.1: I plot key variables as functions of the employee board control η under parameter values $c = d = 1$, $r = w = 0.5$, $A = 1.5$, $L_0 = 0.1$. For illustrative purposes, I use the median realization of the bargaining, i.e.:

$$\varepsilon = \left(\frac{\eta}{1-\eta}\right)^{\frac{1}{b}}.$$

The results are shown in Figure 4.

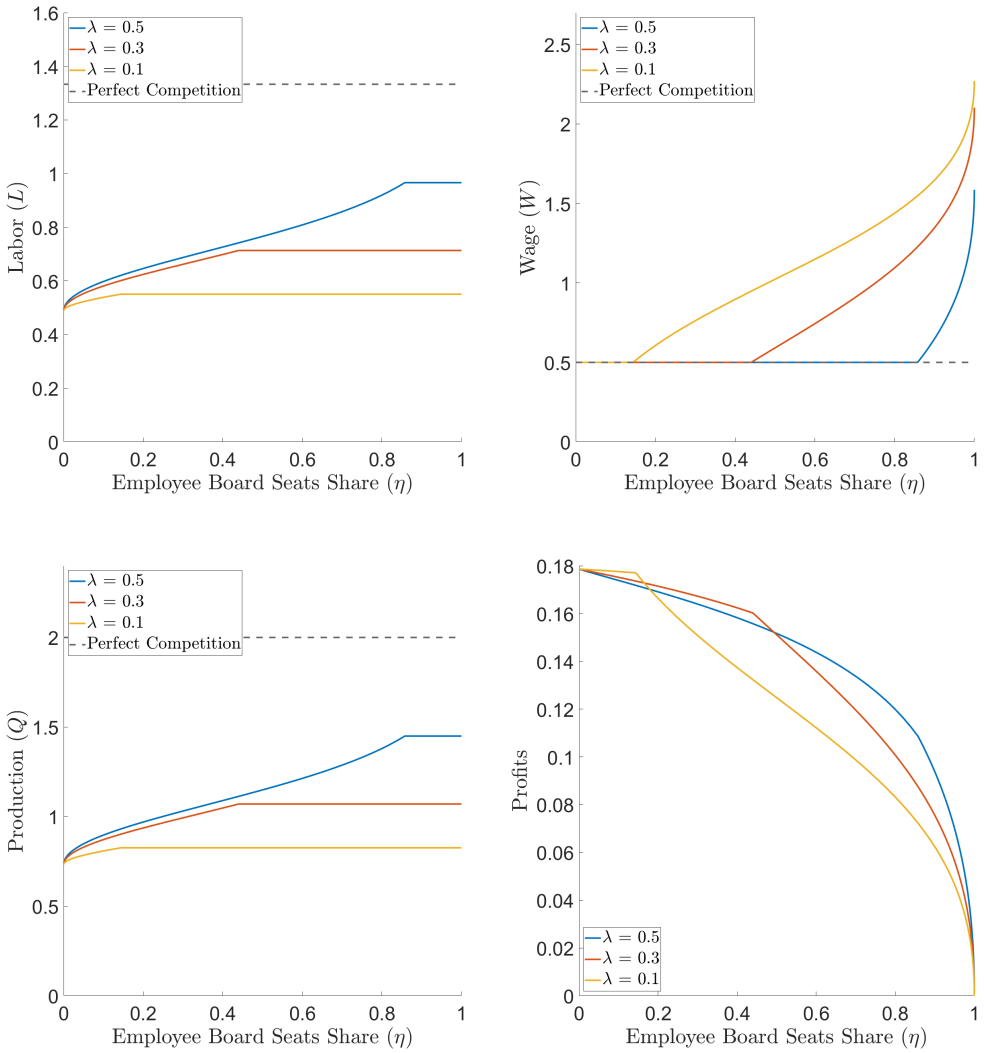


Figure 4. : Outcomes under monopoly with single factor production

VI. The effect of co-determination on capital accumulation

Consider now an extension allowing the firm to adjust the amount of its production capital at the same time as it acquires labor. Like labor, assume capital is purchased on a competitive market with rent r per unit of capital. Assume that the production function takes a Cobb-Douglas form:

$$Q(K, L) = AK^{\alpha}L^{1-\alpha}.$$

Proposition 5. *Suppose the co-determined firm faces a downward-sloping demand function, resulting in a marginal revenue function $MR(Q)$. The equilibrium choices of labor, capital, production and wages are then characterized by:*

$$L^*(\varepsilon) = \begin{cases} \frac{1}{A}MR^{-1}\left(\frac{r}{A}\kappa(\varepsilon)^{1-\alpha}\right)\kappa(\varepsilon)^{-\alpha}, & \varepsilon \leq \varepsilon'; \\ L', & \varepsilon > \varepsilon'; \end{cases}$$

$$K^*(\varepsilon) = L^*(\varepsilon) \cdot \kappa(\varepsilon);$$

$$Q^*(\varepsilon) = AK^*(\varepsilon)^{\alpha}L^*(\varepsilon)^{1-\alpha};$$

$$W^*(\varepsilon) = \begin{cases} w, & \varepsilon \leq \varepsilon'; \\ w + \frac{\pi(Q^*(\varepsilon'), w, L', K^*(\varepsilon'))}{L_0} \cdot \frac{\varepsilon - \varepsilon'}{1+\varepsilon'}, & \varepsilon > \varepsilon', \end{cases}$$

where κ denotes the amount of capital acquired by the firm per unit of labor:

$$\kappa(\varepsilon) = \frac{\alpha}{1-\alpha} \cdot \frac{w}{r} \cdot \left(1 - \varepsilon\lambda\frac{\pi(Q^*(\varepsilon), w, L^*(\varepsilon), K^*(\varepsilon))}{u_e(w, L^*(\varepsilon))}\right),$$

and the threshold values L' and ε' are:

$$L' = \frac{1}{A}MR^{-1}\left(\frac{1}{A}\left(\frac{r}{\alpha}\right)^{\alpha}\left(\frac{(1-\lambda)w}{1-\alpha}\right)^{1-\alpha}\right)\left(\frac{(1-\lambda)w}{r}\frac{\alpha}{1-\alpha}\right)^{-\alpha};$$

$$\varepsilon' = \begin{cases} \frac{u_e(w,L')}{\pi(Q^*(\varepsilon'),w,L',K^*(\varepsilon'))}, & \text{if } \pi(Q^*(\varepsilon'),w,L',K^*(\varepsilon')) > 0; \\ \infty, & \text{otherwise;} \end{cases}$$

The proof is presented in Appendix A.7.

This characterization differs from the problem of a standard profit-maximizating firm by the addition of a "shadow subsidy" on wages such that the effective wage is:

$$\tilde{w} = w \cdot \left(1 - \varepsilon\lambda \frac{\pi(Q,w,L,K)}{u_e(w,L)}\right) \leq w.$$

In particular, the shareholder optimum corresponds to that of a firm with no employee bargaining power, i.e., $\varepsilon = 0$:

$$\underline{L} = \frac{1}{A} MR^{-1} \left(\frac{1}{A}\left(\frac{r}{\alpha}\right)^{\alpha} \left(\frac{w}{1-\alpha}\right)^{1-\alpha}\right) \left(\frac{w}{r} \cdot \frac{\alpha}{1-\alpha}\right)^{-\alpha}.$$

Note that if the employee representatives do not value additional labor, i.e., when $\lambda = 0$, the firm hires the same amount of labor as a shareholder-controlled firm. Indeed, for such a firm bargaining between employees and shareholders is purely redistributive and affects only the wage, not the amount of labor or the firm's output.

A. Employee control and capital expenditures

Note that κ decreases in the size of the shadow subsidy, implying that giving employees greater control over firm decisions decreases the amount of capital per unit of labor that the firm acquires. However, this does not necessarily mean that firms with stronger employee control invest less than shareholder corporations.

Indeed, the behavior of total capital as a function of the shadow subsidy depends on the parameters of the demand function that the firm is facing:

$$\frac{dK}{d\tilde{w}} \propto \frac{dK}{d\left(\frac{r}{\alpha}\frac{\kappa^{1-\alpha}}{A}\right)} \propto \frac{P(Q) + P'(Q)Q}{2P'(Q) + P''(Q)Q} + Q.$$

For example, if $P(Q) = \frac{c}{Q+d}$, then

$$\frac{dK}{d\tilde{w}} \propto -\frac{(Q+d)^2 - 3(Q+d)Q + 2Q^2}{2d} = \frac{Q-d}{2}.$$

Similarly, if $P(Q) = c - dQ$, then

$$\frac{dK}{d\tilde{w}} \propto 2Q - \frac{c}{2d}.$$

In other words, if equilibrium output is low (and consequently marginal revenue is high), then increasing employee control will also result in an increase in capital accumulation, despite a decrease in per capita capital.

The intuition behind this result is in the dual relationship between capital and labor. From the point of view of production, capital and labor are complementary, so a co-determined firm has incentives to increase both labor and capital expenditures. On the other hand, from the point of view of budgeting (i.e., for a fixed amount of revenue), labor and capital are substitutes, so a co-determined firm has incentives to reallocate resources from capital to labor.

If revenue at the equilibrium output level is sufficiently sensitive to output, then the firm can afford to expand both labor and capital: capital gets a smaller piece of a larger pie. If, however, there is little revenue left on the table to expand production, then the reallocation effect dominates.

B. Monopoly

Consider a monpoly facing the same demand function as in Section V:

$$P(Q) = \frac{c}{Q+d}.$$

Example VI.1:

Following Proposition 5, I plot key variables as functions of the employee board

control η given parameter values $c = d = 1$, $r = w = 0.5$, $A = 1.5$, $\alpha = 0.5$, $L_0 = 0.1$. For illustrative purposes, I will use the median outcome of bargaining power, i.e.:

$$\varepsilon = \left(\frac{\eta}{1-\eta}\right)^{\frac{1}{b}}.$$

The results can be seen in Figure 5.

As expected, labor and production both increase with employee control, more so when the employee representatives value new labor ($\lambda \gg 0$), even approaching perfect competition when both employee control η and the value of new labor λ are high.

Under this parametrization, output is consistently below $d = 1$, so capital accumulation increases with employee control, albeit at a much lower rate than labor. Profits, on the other hand, consistently decrease with η.

It is worth noting the magnitude of the effects. For example, in the specifications above, giving employees a third of the board seats $\left(\eta = \frac{1}{3}\right)$ increases labor by 6-30%, capital by 3-13% and output by 5-22%. The lower bounds correspond more closely to the empirical estimates, but the model firm being a monopoly likely overstates the effect of employee control.

C. Oligopoly

Now consider a setup with N identical firms competing in the same product market as Cournot oligopolies. The production problem will be identical to that of a monopoly, with the exception that firms operate with residual demand functions rather than total market demand, with the market price depending on the combined output of all the firms. Let the inverse demand function be:

$$P(Q) = \frac{c}{Q+d},$$

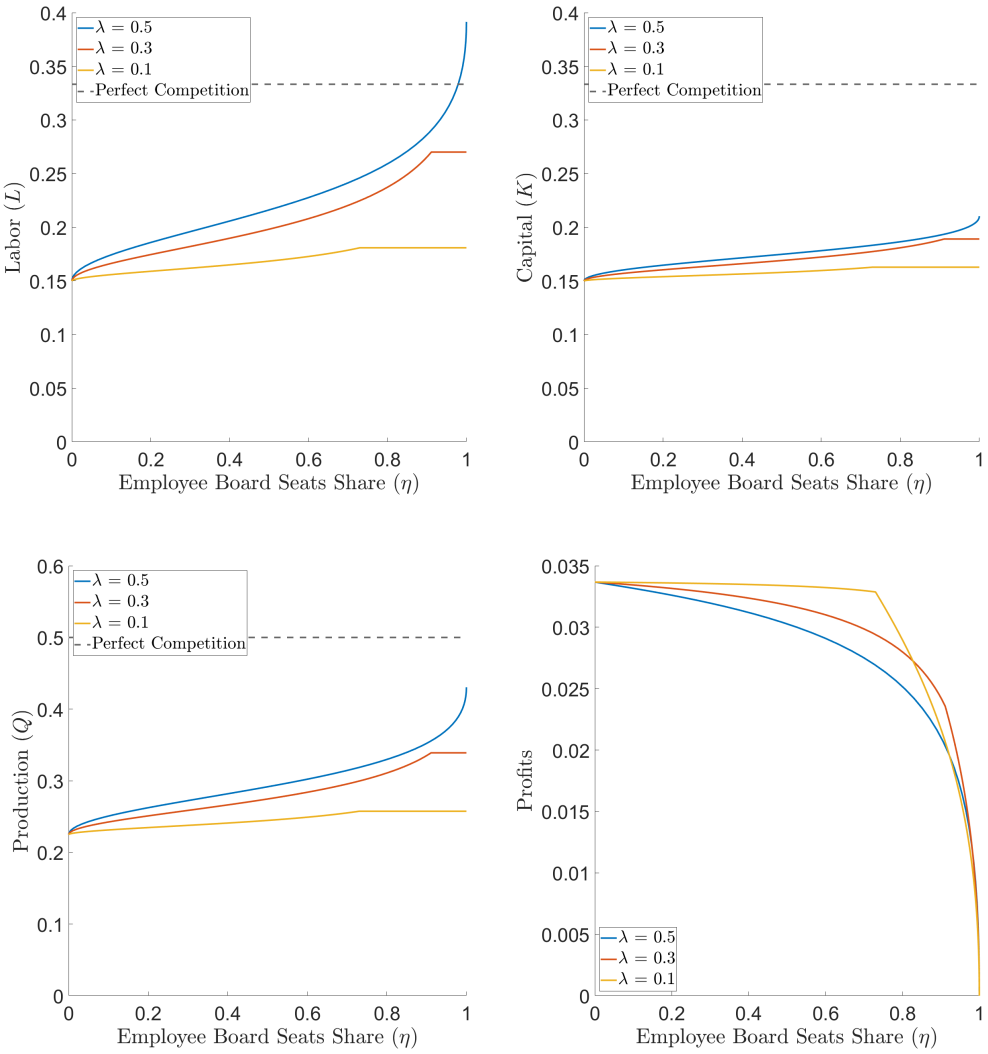


Figure 5. : Outcomes under monopoly

with each firm facing a residual demand function:

$$q_i = \frac{c}{P} - d - \sum q_{-i}.$$

Proposition 5 applies.

Example VI.2: For ease of illustration and comparison, I keep most of the parametric assumptions identical to Example VI.1.

Let $c = d = 1$, $r = w = 0.5$, $A = 1.5$, $\alpha = 0.5$, $\lambda = 0.3$, $L_0 = 0.1$, and the realization of the employee bargaining power be equal to the median of the distribution:

$$\varepsilon = \left(\frac{\eta}{1-\eta}\right)^{\frac{1}{b}}.$$

Consider a duopoly, i.e., $N = 2$. The results are presented in Figure 6. As mentioned in Example VI.1, the relative effects are greater in magnitude for a monopoly than for a duopoly, with the latter being closer to the magnitudes observed empirically (see Table 1).

At the same time, from the point of view of each individual firm its revenue is more sensitive to an increase in production, as the firms compete for market share. As a result, for the same value of new labor (λ) the employee representatives in a duopoly firm are less likely to resort to wage negotiation even at higher levels of employee control.

Table 1—: Changes in outcomes as a result of employees getting a third of the board seats.

	% change	
	Monopoly	Duopoly
Labor (L)	23%	12%
Capital (K)	9%	5%
Production (Q)	16%	8%

VII. Financing and risk

Recall the monopolistic firm. Suppose it needs to raise a fixed minimum amount of financing I before beginning production, i.e., it cannot use market proceeds on

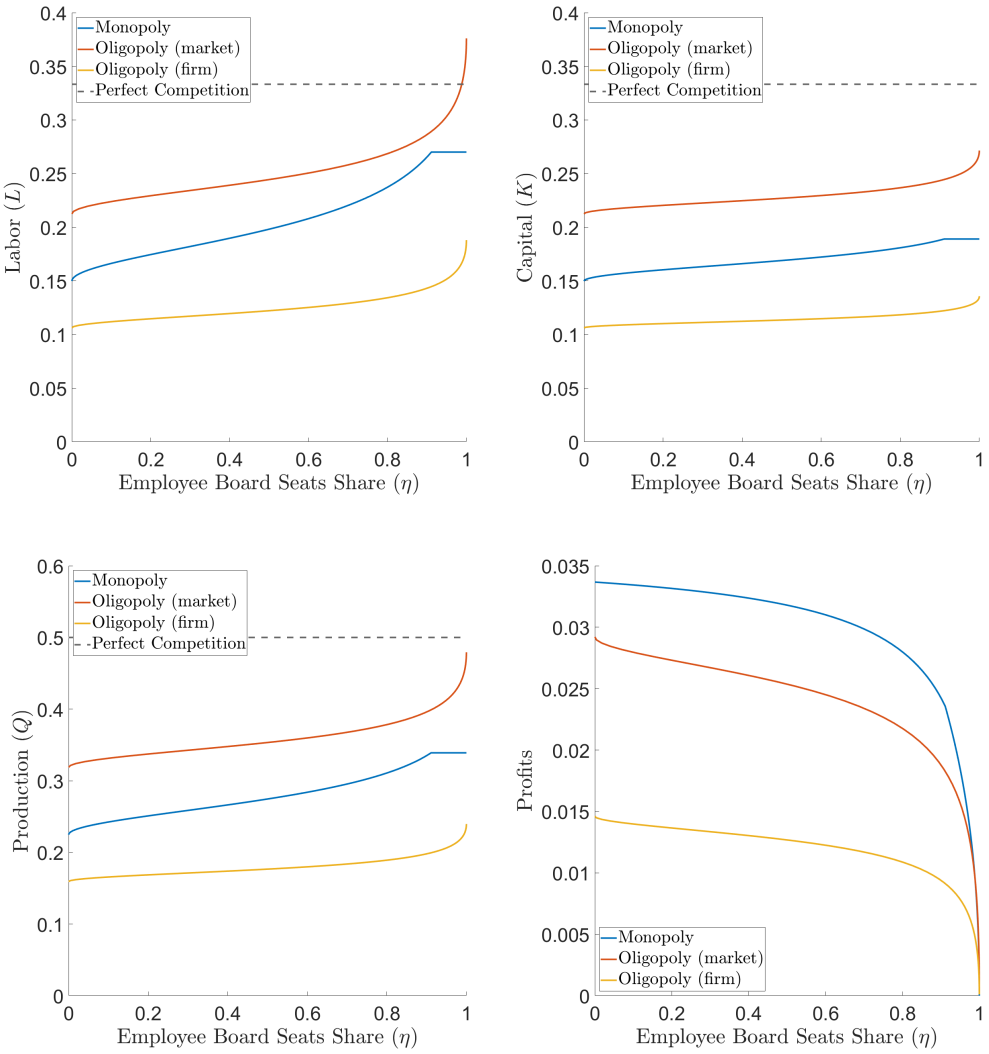


Figure 6. : Outcomes under duopoly

capital expenditures. It can raise financing by issuing either debt with face value V and market value D or equity with market value E, so that $D + E \geq I$. Any financing not spent on capital accumulation can be saved at the risk-free rate R_f.

In addition, suppose that the firm is no longer operating in a riskless environment. Specifically, it is faced with a linear demand function with a multiplicative demand

shock Z with realization ζ so that $Q(P,\zeta) = \zeta(c - P)$. Let $F(\zeta)$ and $f(\zeta)$ be respectively the cdf and pdf that characterize the distribution and assume that the realization ζ is not known at the time of financing but is known at the time of labor acquisition and production.

If at the payoff stage the firm is unable to pay all of its obligations, i.e., repay its debt and pay wages to all of its employees, then the firm defaults. Assume that there is a bankruptcy cost B, so that $B\%$ of the firm's cash flows are lost in bankruptcy, and that in bankruptcy shareholders are wiped out while employees are junior to debt, so that the total amount paid to employees is:

$$\max\left((1-B)\left(P(Q)Q + R_f(D+E-I)\right) - V, 0\right) \leq wL.$$

distributed equally among all employees. I will assume that in bankruptcy the firm chooses an amount of labor that maximizes profits and cannot offer wages above the market, reflecting its best attempt to avoid default.

Finally, assume that the firm is subject to taxation in the form of a corporate tax with rate τ. If the firm's profits π are positive, it must pay taxes $\tau\pi$, leaving $(1-\tau)\pi$ to the shareholders.

If board representatives have commitment power, the board can make all decisions ex-ante, at the financing stage. However, if commitment is not perfect, then either side can initiate a (potentially costly) renegotiation after the demand shock is realized.

The timeline is therefore:

1) **Beginning of time:** The firm enters the period with some initial equity and initial labor L_0.

2) **Decision-making:** The board representatives of shareholders and employees bargain over the financing, labor and production decisions of the firm. The board is large, and employees control a share η of the seats. The employees' wages are specified by a contract, while shareholders are the

residual claimants.

3) **Financing:** The firm raises the necessary funding I by issuing debt and equity in a competitive financial market with risk-neutral investors.

4) **Demand shock:** The value ζ of the demand shock Z is realized.

5) **Renegotiation:** If commitment is not perfect, the representatives of shareholders or employees can initiate a renegotiation of the labor and production decisions.

6) **Labor:** The firm hires labor l, bringing its total labor to L.

7) **Production:** Production is realized according to a production function $F(L)$.

8) **Payoffs:** The firm sells the produced consumption goods at the product market. Payoffs to stakeholders are realized according to their contracts. If the firm's revenue and savings are not sufficient to cover its obligations, the firm defaults.

Before solving the model for different levels of commitment it is worth establishing some simplifying facts.

Observation 1: *In equilibrium, a co-determined firm will choose to default if and only if the same firm would default under full shareholder control, i.e.,* $\bar{\pi} < 0$.

Observation 1 follows immediately from Proposition 3. If $u_s^* \in [0, \bar{\pi}]$ and payoffs are strictly monotone, then u_s^* must be positive for any finite ε as long as $\bar{\pi} > 0$. At $\bar{\pi} = 0$ the firm will not default, but it is nonetheless a special case that will be discussed in further details below. In any case, it is an event of measure zero.

Observation 2: *In equilibrium, a firm will raise just enough funding to cover its capital expenditures, i.e.,* $D + E = I$.

The intuition behind this Observation is as follows. Issuing debt increases default risk, so if $D > 0$ and $D + E > I$, then the firm can reduce its debt issuance and hence its risk of default without impacting its production – this would be a Pareto-improvement for the shareholders and employees. At the same time, as will be established in more detail later, a firm will never choose pure equity financing, i.e., $D = 0$ and $E > 0$. Therefore, $D + E = I$.

A. Perfect commitment

Consider first the situation when commitment is perfect, i.e., renegotiation is impossible (infinitely costly). Then the following result holds.

Proposition 6 ***The Modigliani-Miller Theorem for a co-determined firm.*** *The choice between issuing equity and debt (i.e., capital structure) is ex-ante irrelevant if:*

- *there are no taxes* ($\tau = 0$)*;*
- *there is no cost to default* ($B = 0$)*;*
- *employee representatives do not value new labor* ($\lambda = 0$)*;*
- *commitment is perfect.*

The proof can be found in Appendix A.8.

Corollary 6.1. *If there are no taxes, commitment is perfect and employee representatives do not value new labor, but the cost of default B is positive, then the firm will only issue equity.*

Indeed, if in the absence of cost of default and taxes, the firm is indifferent between equity and debt, then with a positive cost of default and no tax advantage debt is strictly inferior to equity from the point of view of both shareholders and employees. The firm will therefore issue no debt no matter the governance structure.

B. No commitment

Consider instead a board whose members have no commitment power, i.e., renegotiation is costless.

Labor and production

Proposition 7. *For each realization ζ of the demand shock equilibrium labor and wages follow:*

$$L^*(\zeta,\varepsilon,V)=\begin{cases}\hat{L}(\zeta,\varepsilon,V), & \varepsilon\leq\varepsilon'(\zeta,V);\\ L'(\zeta), & \varepsilon>\varepsilon'(\zeta,V);\end{cases}$$

$$W^*(\zeta,\varepsilon,V)=\begin{cases}w, & \varepsilon\leq\varepsilon'(\zeta,V);\\ w+\frac{\pi(w,L'(\zeta),\zeta,V)}{L_0}\cdot\frac{\varepsilon-\varepsilon'}{1+\varepsilon'}, & \varepsilon>\varepsilon'(\zeta,V);\end{cases}$$

where

$$\hat{L}(\zeta,\varepsilon,V)\ =\frac{(1+\varepsilon)\lambda\ \underline{L}(\zeta)-(1-\lambda)L_0}{(2+\varepsilon)\lambda}+\sqrt{\frac{\varepsilon}{2+\varepsilon}\left(\underline{L}(\zeta)^2-\zeta\frac{V}{A^2}\right)+\left(\frac{\lambda\underline{L}(\zeta)+(1-\lambda)L_0}{(2+\varepsilon)\lambda}\right)^2};$$

$$L'(\zeta)=\frac{\zeta}{2A}\left(c-(1-\lambda)\frac{w}{A}\right).$$

$$\varepsilon'(\zeta,V)=\begin{cases}\frac{u_e(w,L')}{\pi(w,L'(\zeta),\zeta,V)}, & \textit{if } \pi(w,L')>0;\\ \infty, & \textit{otherwise.}\end{cases}$$

The proof can be found in Appendix A.9.

There are two separate mechanisms through which capital structure affects the bargaining outcome over labor and wages.

First, increasing the proportion of debt financing increases the likelihood of default and therefore the interest rate V/D. Keeping the size of the initial investment fixed, this reduces profits for every value of L.

At the same time, increasing the proportion of debt reduces payouts to equity, which further reduces profits for every value of L. Note that this latter effect is,

in principle, purely mechanical – e.g., in the absence of bankruptcy costs and given the competitiveness and risk-neutrality of the investors, both new equity and new debt get an average return equal to the risk-free rate, so the choice between debt and equity does not affect the firm's financial outcomes. However, even if the return on both securities is the same, equity is voting, so after financing the shareholder representatives represent both new and old equity, which affects the bargaining process. In other words, whether cashflows are "classified" as debt or as equity has an effect on the distribution of surplus.

Notably, issuing more equity effectively reduces the shareholders' bargaining power relative to issuing debt. The greater the proportion of cashflows that are considered profits, i.e., payouts to equity, the greater are the hold-up costs of the board negotiations. As a result, all other things equal, increasing the proportion of equity financing would result in a higher employee payoff, a higher, but not proportionately higher, total payout to equity and a lower payout to old shareholders, until the bargaining equilibrium condition is satisfied.

Debt and equity

Proposition 8. *At the time of bargaining over capital structure, the ex-ante expected payoffs of the representatives are monotonic in the amount of debt issued:*

- *Expected shareholder payoff is non-decreasing in the amount of debt issued.*
- *Expected employee payoff is non-increasing in the amount of debt issued.*

In equilibrium, both the shareholder- and employee-controlled firms use only debt financing and issue no equity.

The proof can be found in Appendix A.10.

Notably, the expected payoff of existing shareholders increases monotonically in the amount of debt issued. Not only do they get the benefits of tax shields, but issuing debt also increases their bargaining power in the renegotiation. Given that the costs of default do not directly affect payments to shareholders, the increase

in default risk from debt issuance has no effect on their expected payoff compared to issuing equity, since the reduced downside is, given the competitiveness of the financial market, exactly offset by an increased upside.

The expected employee payoff on the other hand strictly decreases in the amount of debt issued, since all tax shield benefits are captured by shareholders, while costs of default are suffered by the employees.

Example VII.1: Let $c = 100$, $w = 7.5$, $A = 0.15$, $\lambda = 0.3$, $L_0 = 1$, $B = 0.1$, $\tau = 0.25$, and the realization of employee bargaining power be equal to the median of the distribution:

$$\varepsilon = \left(\frac{\eta}{1-\eta}\right)^{\frac{1}{b}}.$$

The shock Z is assumed to be lognormal with parameters $\mu_Z = -5$ and $\sigma_Z = 1.5$, resulting in an average demand function $P(Q) \approx 100 - 50Q$. The results are presented in Figure 7.

The dependence of debt issuance on employee control in the presence of both costly default and taxes is non-monotonic. For low levels of employee control, shareholders choose the amount of debt to maximize the tax benefits of debt net of the costs of default. As labor representation increases, employee representatives negotiate lower amounts of debt, since the tax shields only benefit shareholders, while default costs disproportionately affect labor. Shareholders can afford to reduce debt since expropriation is not a significant risk when shareholders control most of the board and debt's commitment value is low.

However, at higher levels of employee control, shareholders push the firm to issue more debt to avoid a significant loss in bargaining power in the future: while debt payments are fixed contractually, payments to shareholders are not, and the existing shareholders' bargaining power can be diluted by the arrival of new shareholders. In other words, debt acts as a commitment device for the firm to repay existing equity.

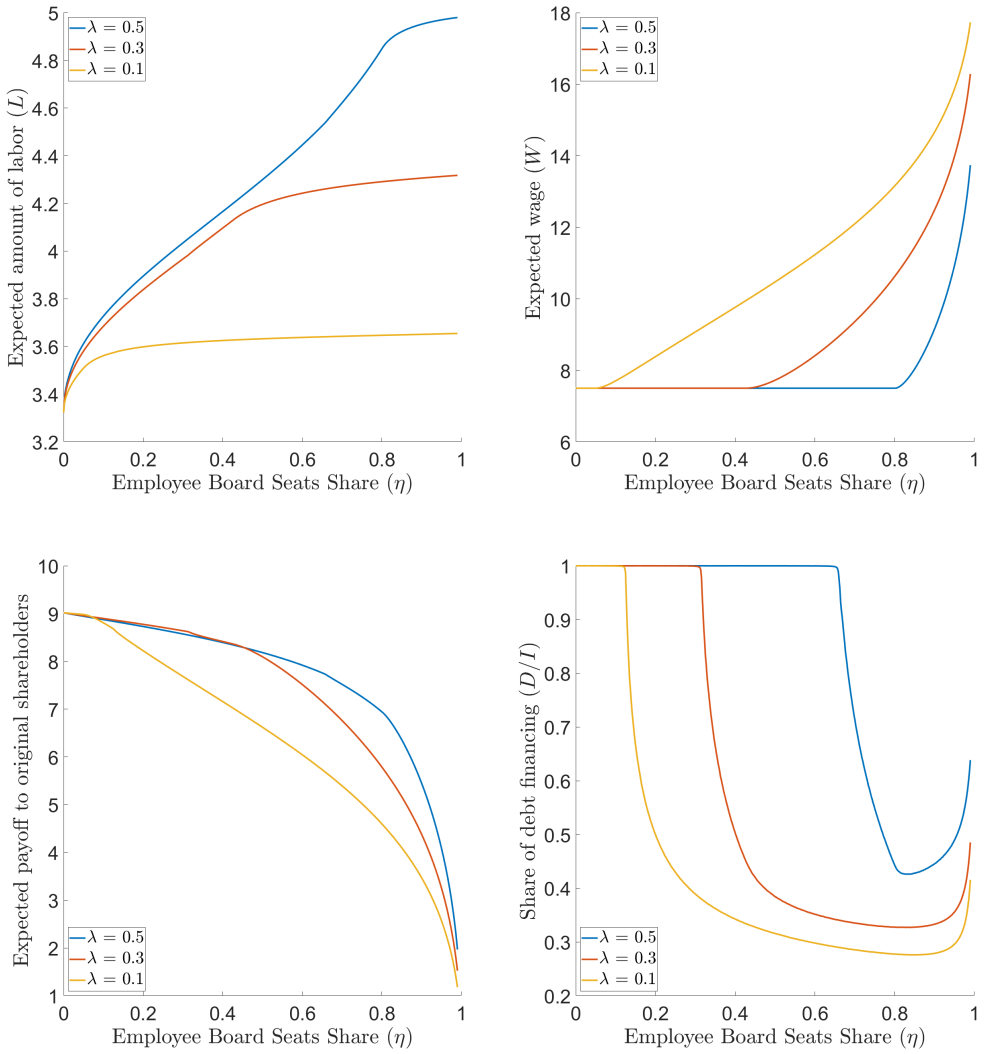


Figure 7. : Outcomes under monopoly with risk and financing

This aligns with some commonly raised concerns about co-determined and labor-controlled firms. Indeed, since payments to equity are not fixed in contractual form, shareholders can be comparatively vulnerable to expropriation. This can reduce the ability of the firm to raise equity.

Similar to some models of investor expropriation by entrepreneurs, the effect is

a result of the conflict between old and new investors and the change in bargaining power that comes with issuing new equity without allocating corresponding board control.

VIII. Conclusion

In the debate on optimal corporate governance, there has been remarkably little attention to modeling the behavior of organizational structures besides the shareholder corporation.

Given the recent rise in empirical research on the topic of co-determination (Jäger, Schoefer, and Heining 2020; Harju, Jäger, and Schoefer 2021), a strong theoretical base is necessary to interpret the findings and guide further empirical research and policy.

The model presented in this paper provides some framework to interpret the empirical results. In particular, it demonstrates a compelling explanation for the absence of higher wages at co-determined firms, as well as the mild positive effect of co-determination on capital accumulation.

In addition, I also address concerns common in the literature related to potential expropriation of equity by employees and the inability of a labor-controlled firm to issue equity. I demonstrate that the effect of employee control on the choice between debt and equity is non-monotonic. For low levels of employee control, increasing labor bargaining power reduces the amount of debt issued, since the tax benefits of debt primarily benefit shareholders while the costs of default disproportionately affect employees. At the same time, at firms with high levels of employee control and without other commitment mechanisms, shareholders will push for a higher debt-to-equity ratio.

The model therefore establishes a trade-off of labor control. On one hand, increasing employee control can reduce dead weight loss from market power and even reduce socially inefficient debt accumulation caused by the tax advantages of debt. On the other hand, at higher levels of employee control, giving additional

bargaining power to employees has no positive effect on labor and production and only creates incentives to redistribute profits and accumulate risky debt.

Given the understanding that shareholder welfare maximization would yield the best results in competitive markets, policy discussions have historically focused on enforcing market competition. Yet most observed markets are not perfectly competitive, whether because it is too costly to enforce, or due to a lack of political will to do so. The examples presented in this paper show that under some conditions increasing labor control can reduce monopoly dead weight loss in a way that is complementary to antitrust policy.

At the same time, using employee control as a mechanism to internalize market failures not directly tied to employee welfare may not be the most effective approach. Indeed, depending on the degree of control and incentive structure of the representatives, increasing employee control could have purely redistributive effects or lead to an excessive preference for using labor over production capital that would be inefficient when considering the economy as a whole.

A potentially more fruitful approach would be to provide greater control rights to affected stakeholders. Following Coase, well-defined property rights should allow bargaining parties to internalize externalities. However, financial markets have split property rights and control rights – indeed, none of the shareholders *own* the firm in a conventional sense. Further separating control from cash flows by allocating control rights to non-shareholder stakeholders could facilitate socially efficient bargaining. The model presented in this paper can be easily extended and generalized for such a control structure.

Appendix

1. *Proof of Proposition 1 (Bargaining equilibrium with variable surplus)*

Proposition 1. *Consider a Rubinstein bargaining game with player utilities $u_i(x)$ and a variable surplus determined by a feasibility constraint $C(x) \leq 0$.*

Let $\hat{u}_i(u_j)$ describe the Pareto frontier available to the players, in other words:

$$\hat{u}_i(u_j) = \max_x u_i(x),$$

subject to

$$u_j(x) \geq u_j;$$

$$C(x) \leq 0.$$

Let u_i^j be the equilibrium utility that player i gets in equilibrium if player j is the proposer and assume that when indifferent, a proposer offers a Pareto-optimal allocation over a suboptimal one.

The bargaining game then has a unique SPNE. The equilibrium proposer payoffs can be found from the following system of equations:

$$\forall i,\ u_i^i = \hat{u}_i(\beta_{-i} u_{-i}^{-i}).$$

The payoff of player j under proposer i corresponds to a point on the Pareto-frontier:

$$u_j^i = \hat{u}_j(u_i^i).$$

It is worth noting that the strategy space in this game is defined over final payoffs u rather than parameter values x: each player chooses whether to agree to a proposed payoff, no matter how that payoff is achieved. This is important for the purpose of establishing uniqueness, since a strategy uniquely defined over payoffs, e.g., "Accept all agreements with payoff greater than 5", may be non-uniquely defined over parameter values if the same payoff can be achieved with multiple values of the parameters x.

For a simple example, consider a game with two players with the same discount

factor β, and utilities defined as functions of three parameters:

$$u_1(x) = x_1;$$

$$u_2(x) = x_2 + x_3,$$

subject to

$$x_1 + x_2 + x_3 = 1.$$

This game is obviously equivalent to a standard Rubinstein bargaining game, so the equilibrium strategy for both players is to accept any offer that yields them a payoff of at least:

$$u^{np} = \frac{\beta}{1+\beta}$$

whenever they are not the proposer and to offer the other player exactly u^{np} whenever they are, thus receiving:

$$u^{p} = \frac{1}{1+\beta}$$

These strategies form a unique SPNE. However, the same payoffs can be achieved by a continuum of different combinations of x_2 and x_3 that yield the same equilibrium allocation u_2. With this in mind, let us move on to the proof.

Proof. First note that in the presence of discounting and given that we are only interested in subgame perfect Nash equilibria, it is sufficient to consider one-time deviations from equilibrium strategies, i.e., equilibrium strategies and payoffs in other periods can be taken as given. Conjecture that the equilibrium strategies in any round of bargaining are for proposing player i to offer player j payoff u_j^i and for player j to accept the offer if and only if the offered payoff is at least $\beta_j u_j^j$,

where the values u_j^i are determined by the following equilibrium conditions:

$$\forall i \neq j, \begin{cases} u_i^i = \hat{u}_i \left(\beta_j u_j^j \right); \\ u_j^i = \hat{u}_j \left(u_i^i \right). \end{cases}$$

We can now consider each player's one-time deviation from those equilibrium strategies.

First consider the first period strategy of player 2: accept an offer x iff the payoff $u_2(x)$ is at least $\beta_2 u_2^2$. Accepting an offer x' with a payoff $u_2\left(x'\right)$ lower than $\beta_2 u_2^2$ is not a profitable deviation, since they can always refuse it and get their equilibrium proposer payoff in the next period:

$$\beta_2 u_2^2 > u_2\left(x'\right).$$

Conversely, rejecting an offer x'' with a payoff higher $u_2\left(x''\right)$ higher than $\beta_2 u_2^2$ is not a profitable deviation either since their payoff from waiting will be:

$$\beta_2 u_2^2 < u_2\left(x''\right).$$

Therefore, player 2 has no profitable one-time deviations when player 1 is the proposer. Player 1 can offer an agreement x' that maximizes player 1's own payoff:

$$\max_x u_1(x),$$

subject to:

$$u_2(x) \geq \beta_2 u_2^2;$$

$$C(x) \leq 0.$$

Player 1 will then achieve a payoff of:

$$u_1^1 = \hat{u}_1 \left(\beta_2 u_2^2 \right).$$

and offer player 2 the corresponding Pareto-efficient payoff:

$$u_2^1 = \hat{u}_2\left(u_1^1\right).$$

By construction, u_2^1 satisfies player 2's bargaining condition: $u_2^1 \geq \beta_2 u_2^2$. Indeed, if the constraint on player j's utility is binding, i.e., player 1 is constrained by player 2's bargaining demands in achieving u_1^1, then the corresponding Pareto-efficient payoff for player 2 is $\hat{u}_2\left(u_1^1\right) = \beta_2 u_2^2$. If the constraint is not binding, then that means player 1 chooses optimally to offer player 2 a payoff higher than $\beta_2 u_2^2$.

Therefore, the agreement x' will be accepted by player 2. Given that it maximizes player 1's utility among all agreements that player 2 is willing to accept, no deviation will be profitable.

If $\hat{u}_2\left(u_1^1\right) > \beta_2 u_2^2$, then there may exist agreements x'' that would yield a lower payoff to player 2 and thus still be accepted, while yielding the same equilibrium payoff to player 1. However, bargaining over such equilibria is not economically meaningful, and neither side benefits from implementing a suboptimal allocation. I therefore assume that when indifferent players choose Pareto-optimal allocations over suboptimal ones, which rules out such equilibria.

Symmetrically, the payoffs under player 2's proposal must be:

$$u_1^2 = \hat{u}_1\left(u_2^2\right);$$
$$u_2^2 = \hat{u}_2\left(\beta_1 u_1^1\right).$$

which confirms the conjecture.

QED

2. Proof of Proposition 2 (Asymptotic bargaining equilibrium)

Proposition 2. *Consider a coalitional Rubinstein bargaining game with a variable surplus, i.i.d. Beta-distributed discount factors and constant coalition proportions* η_j.

In such a game, for any number of players, there is a unique SPNE for each realization of discount factors. For a large number of players, each equilibrium corresponds to the maximum of a weighted sum of the logs of the utilities:

$$\max_x \varepsilon \ln\left(u_1(x)\right) + \ln\left(u_2(x)\right),$$

subject to

$$C(x) \leq 0,$$

where the weight on the payoff of the second coalition is normalized to 1 without loss of generality. The weight ε, which I will refer to as bargaining power, is determined by the realization of discount factors and is the realization of an approximately log-logistically distributed random variable $\mathcal{E}$:

$$\mathcal{E} \sim \textit{Loglogistic}\left(\left(\frac{\eta_1}{\eta_2}\right)^{\frac{1}{b}},\ b\right),$$

where b denotes the second parameter of the Beta distribution of discount factors.

Proof. Recall the equilibrium condition of the bargaining game with variable surplus and apply the coalitional structure to it:

$$\forall i,\ j \neq i, \begin{cases} u_i^j = \ \hat{u}_i\left(u_{-i}^j\right) \\ u_i^i = \hat{u}_i\left(\bar{\beta}_{-i} u_{-i}^{-i}\right) \end{cases}$$

where $\bar{\beta}_i = \max_{p \in C_i}\{\beta_p\}$ is the patience of coalition i.

Consider a sequence of games $\{1,\ 2, \ldots k, \ldots\}$ with an increasing number of players N_k, keeping the relative sizes η_i of the coalitions fixed:

$$N_1 < N_2 < \ldots < N_k < \ldots$$

such that $\lim_{k\to\infty} N_k = \infty$ and the number of players in coalition i in game k is therefore $\eta_i N_k$

The additional surplus coalition 1 gets from being the proposer compared to when coalition 2 is the proposer is:

$$u_1^1 - u_1^2 = u_1^1 - \hat{u}_1\left(u_{-1}^2\right).$$

Similarly, the proposer surplus of coalition 2 is:

$$u_2^2 - u_2^1 = u_2^2 - \hat{u}_2\left(u_{-2}^1\right).$$

We can find the limit of the ratio of proposer benefits as:

$$\lim_{N\to\infty} \frac{u_1^1 - u_1^2}{u_2^2 - u_2^1} = \lim_{N\to\infty} \frac{u_1^1 - \hat{u}_1\left(u_{-1}^2\right)}{u_2^2 - \hat{u}_2\left(u_{-2}^1\right)}.$$

Note that, in equilibrium:

$$\forall i, j, \quad u_i^j \geq \bar{\beta}_i u_i^i$$

$$\Downarrow$$

$$\forall i, j, \; u_i^i = \hat{u}_i\left(\bar{\beta}_{-i} u_{-i}^{-i}\right) \geq \hat{u}_i\left(u_{-i}^j\right).$$

At the same time, as $N \to \infty$,

$$\bar{\beta}_i = \max_{i \in C_i} \beta_i \xrightarrow{P} 1$$

$$\Downarrow$$

$$u_i^j = \hat{u}_i\left(u_{-i}^j\right) \xrightarrow{P} \bar{\beta}_i u_i^i \xrightarrow{P} u_i^i,$$

Which implies:

$$\lim_{N\to\infty} \frac{u_1^1 - u_1^2}{u_2^2 - u_2^1} = \lim_{N\to\infty} \frac{\left(1 - \bar{\beta}_1\right) u_1^1}{\left(1 - \bar{\beta}_2\right) u_2^2}.$$

Equivalently,

$$\lim_{N\to\infty} \left(\frac{u_2^2}{u_1^1} \cdot \frac{u_1^1 - u_1^2}{u_2^2 - u_2^1} \right) = \lim_{N\to\infty} \frac{1 - \bar{\beta}_1}{1 - \bar{\beta}_2}. \tag{A1}$$

Using the result that $u_i^j \xrightarrow{P} u_i^i$ and defining u_i as that limit, the left-hand side can be written as:

$$\lim_{N\to\infty}\left(\frac{u_2^2}{u_1^1}\cdot\frac{u_1^1-u_1^2}{u_2^2-u_2^1}\right)=\frac{\partial\hat{u}_1\left(u_2\right)}{\partial u_2}\cdot\frac{u_2}{\hat{u}_1\left(u_2\right)}$$

for some equilibrium values of u_2.

We can also find the limiting distribution of the right-hand side. First, observe that the limiting distribution only depends on the second parameter of the Beta distribution of discount factors.

Indeed, the cdf can be found as:

$$P\left(\lim_{N\to\infty}\frac{1-\bar{\beta}_1}{1-\bar{\beta}_2}<\rho\right)=\lim_{N\to\infty}\int_0^1\int_0^1 1\left[\frac{1-\beta_1}{1-\beta_2}<\rho\right]f_{N,1}\left(\beta_1\right)f_{N,2}\left(\beta_2\right)d\beta_1 d\beta_2,$$

where $f_{N,i}(\beta)$ is the pdf of $\bar{\beta}_i$ in a game with N players.

Using a change of variables, this probability becomes:

$$P\left(\lim_{N\to\infty}\frac{1-\bar{\beta}_1}{1-\bar{\beta}_2}<\rho\right)=\lim_{N\to\infty}\int_0^1\int_0^1 1\left[\frac{1-F_{N,1}^{-1}\left(p_1\right)}{1-F_{N,2}^{-1}\left(p_2\right)}<\rho\right]dp_1dp_2=$$

$$=\int_0^1\int_0^1 1\left[\lim_{N\to\infty}\frac{1-F_{N,1}^{-1}\left(p_1\right)}{1-F_{N,2}^{-1}\left(p_2\right)}<\rho\right]dp_1dp_2.$$

The limit can be estimated using L'Hôpital's rule:

$$\lim_{N\to\infty}\frac{1-F_{N,1}^{-1}\left(p_1\right)}{1-F_{N,2}^{-1}\left(p_2\right)}=\lim_{N\to\infty}\frac{f_{N,2}\left(F_{N,2}^{-1}\left(p_2\right)\right)}{f_{N,1}\left(F_{N,1}^{-1}\left(p_1\right)\right)}.$$

Using β_i to denote $F_{N,i}^{-1}\left(p_i\right)$:

$$\lim_{N\to\infty}\frac{1-\beta_1}{1-\beta_2}=\lim_{N\to\infty}\frac{\eta_2 NF\left(\beta_2\right)^{\eta_2 N-1}f\left(\beta_2\right)}{\eta_1 NF\left(\beta_1\right)^{\eta_1 N-1}f\left(\beta_1\right)}=\lim_{N\to\infty}\frac{\eta_2 p_2^{\frac{\eta_2 N-1}{\eta_2 N}}f\left(\beta_2\right)}{\eta_1 p_1^{\frac{\eta_1 N-1}{\eta_1 N}}f\left(\beta_1\right)}=$$

$$=\lim_{N\to\infty}\frac{\eta_2 p_2\beta_2^{a-1}\left(1-\beta_2\right)^{b-1}}{\eta_1 p_1\beta_1^{a-1}\left(1-\beta_1\right)^{b-1}}=\lim_{N\to\infty}\frac{\eta_2 p_2\left(1-\beta_2\right)^{b-1}}{\eta_1 p_1\left(1-\beta_1\right)^{b-1}}$$

$$\Downarrow$$

$$\lim_{N\to\infty}\frac{1-\beta_1}{1-\beta_2}=\left(\frac{\eta_2 p_2}{\eta_1 p_1}\right)^{\frac{1}{b}}.$$

Crucially, the limit is the same for any value of a. It is therefore wlog to estimate the limiting distribution for $a=1$:

$$P\left(\frac{1-\bar{\beta}_1}{1-\bar{\beta}_2}<\rho\right)=1-P\left(\bar{\beta}_1<1-\rho\left(1-\bar{\beta}_2\right)\right)=$$

$$=1-\int_0^1 F\left(1-\rho(1-x)\right)^{\eta_1 N}\eta_2 N F(x)^{\eta_2 N-1}f(x)dx=$$

$$=1-\eta_2 N\int_0^1\left(1-\rho^b(1-x)^b\right)^{\eta_1 N}\left(1-(1-x)^b\right)^{\eta_2 N-1}b(1-x)^{b-1}dx.$$

Changing variables:

$$\left\{\begin{array}{c} y=(1-x)^b \\ dy=-b(1-x)^{b-1}\end{array}\right\}$$

$$P\left(\frac{1-\bar{\beta}_1}{1-\bar{\beta}_2}<\rho\right)=1-\eta_2 N\int_0^1\left(1-\rho^b y\right)^{\eta_1 N}(1-y)^{\eta_2 N-1}dy.$$

The second term is an expression for the hypergeometric function:

$$P\left(\frac{1-\bar{\beta}_1}{1-\bar{\beta}_2}<\rho\right)=1-\eta_2 N B\left(1,\eta_2 N\right){}_2F_1\left(-\eta_1 N,1,\eta_2 N+1,\rho^b\right),$$

where $B(a,b)$ is the complete Beta function and ${}_2F_1(a,b,c;z)$ is the hypergeometric function. Using $B(1,b)=b^{-1}$:

$$P\left(\frac{1-\bar{\beta}_1}{1-\bar{\beta}_2}<\rho\right)=1-{}_2F_1\left(-\eta_1 N,1,\eta_2 N+1,\rho^b\right).$$

The hypergeometric function can be expressed as an infinite sum:

$${}_2F_1\left(-\eta_1 N,1,\eta_2 N+1,\rho^b\right)=\sum_{i=0}^{\infty}\frac{\left(-\eta_1 N\right)_i\left(1\right)_i}{\left(\eta_2 N+1\right)_i\, i!}q^{bi},$$

where:

$$(x)_i = \begin{cases} 1, & i = 0; \\ x(x+1)\dots(x+i-1), & i > 0. \end{cases}$$

Then:

$$P\left(\frac{1-\bar{\beta}_1}{1-\bar{\beta}_2} < \rho\right) = 1 - \sum_{i=0}^{\infty} \frac{(-\eta_1 N)_i}{(\eta_2 N + 1)_i} \rho^{bi} =$$

$$= 1 - \sum_{i=0}^{\infty} \frac{(-\eta_1 N)\,(-\eta_1 N + 1)\dots(-\eta_1 N + i - 1)}{(\eta_2 N + 1)\,(\eta_2 N + 2)\dots(\eta_2 N + i)} \rho^{bi}.$$

Taking the limit as $N \to \infty$,

$$\lim_{N\to\infty} P\left(\frac{1-\bar{\beta}_1}{1-\bar{\beta}_2} < \rho\right) = 1 - \sum_{i=0}^{\infty} \left(-\frac{\eta_1}{\eta_2}\rho^b\right)^i = \frac{1}{1 + \frac{\eta_1}{\eta_2}\rho^{-b}}.$$

Combining the left-hand and right-hand sides of eq. (A1) results in:

$$P\left(\frac{\partial \hat{u}_1(u_2)}{\partial u_2} \cdot \frac{u_2}{\hat{u}_1(u_2)} < \varepsilon\right) = \frac{1}{1 + \frac{\eta_1}{\eta_2}\varepsilon^{-b}}.$$

In other words, the equilibrium bargaining power ε follows a log-logistic distribution with parameters $\left(\frac{\eta_1}{\eta_2}\right)^{\frac{1}{b}}$ and b, which concludes the proof.

QED

3. Proof of Lemma 1 (Priority of labor over wages in bargaining)

Lemma 1. *If the profit function $\pi(W, L)$ is concave and there exists a unique value L' such that $\pi_L(L') = -\lambda w$, then in all equilibria where employee utility is below $u_e(w, L')$ there is no wage negotiation ($W = w$), and in all equilibria where utility is above $u_e(w, L')$ there is no further increase of labor ($L = L'$).*

Proof. Let $\underline{L}$ be the amount of labor chosen by the shareholder corporation ($\varepsilon = 0$), and for now assume that $L_0 \leq \underline{L}$. Note that the shareholder corporation simply maximizes profits, so it will set $W = w$ and pick $L = \underline{L}$ that satisfies the FOC:

$$\pi_L(w, L) = 0,$$

which will result in the global maximum of profits $\bar{\pi} > 0$ and a global minimum of employee utility $w\underline{L}$.

Now consider a co-determined firm, i.e., a firm with $\eta > 0$. Let η be such that $u_e > w\underline{L}$. In order to increase their payoff from $w\underline{L}$, the employee representatives can either negotiate a higher W or hire more labor. Suppose the firm increases the amount of labor by a small amount ΔL. The gain in utility from this increase will be equal to $\lambda w \Delta L$ and the loss of profits will be approximately equal to:

$$\pi_L(\underline{L})\,\Delta L = 0.$$

On the other hand, achieving the same utility gain through wage negotiation would require a one-to-one profit decrease of $\lambda w \Delta L > 0$. It follows that for the same fixed value of profits $\pi < \bar{\pi}$ the employee representatives can achieve a higher payoff by increasing labor than by negotiating higher wages.

However, this is only true in a neighborhood of $\underline{L}$. Indeed, if

$$\pi_L(L) < -\lambda w,$$

then a marginal increase in utility achieved by increasing labor will have a greater negative impact on profits than if it had been achieved through wage negotiations.

QED

4. Proof of Lemma 2 (Co-determined firm profitability)

Lemma 2. *If the profit function $\pi(W, L)$ is concave in L, then the stakeholders' equilibrium utilities u_i^* are strictly monotone in ε, increasing for employees and decreasing for shareholders, with:*

$$u_s^* = \begin{cases} \bar{\pi}, & \varepsilon = 0; \\ 0, & \varepsilon \to \infty. \end{cases}$$

Proof. For all η such that equilibrium employee utility u_e^* is above the threshold value $u_e(w, L')$ Proposition 2 and Lemma 1 imply:

$$\frac{u_e(W, L')}{\pi(W, L')} = \frac{u_e(w, L') + (W - w)L_0}{\pi(w, L') - (W - w)L_0} = \varepsilon \Rightarrow W = w + \frac{\pi(w, L')}{L_0} \cdot \frac{\varepsilon - \varepsilon'}{1 + \varepsilon}$$

which is strictly increasing in ε.

Whereas for all ε such that equilibrium employee utility u_e^* is below the threshold value $u_e(w, L')$ Proposition 2 and Lemma 1 similarly imply:

$$-\frac{\pi_L(L)}{\lambda w} \cdot \frac{u_e(w, L)}{\pi(w, L)} = \varepsilon.$$

If the profit function is concave, then the left-hand side is strictly increasing in L, and, combined with the fact that the right-hand side is strictly increasing in ε, this once again results in u_e^* strictly increasing with ε.

We have established that equilibrium payoffs must lie on the Pareto-frontier. This implies that if u_e^* is strictly increasing in ε, then u_s^* must me strictly decreasing to avoid violating Pareto-optimality.

Finally, $\varepsilon = 0$ corresponds to a profit-maximizing shareholder corporation which picks $L = \underline{L}$, resulting in $u_e^* = w\underline{L},\ u_s^* = \bar{\pi}$. At the same time, $\varepsilon \to \infty$ corresponds to the employee-run firm: it maximizes employee payoff subject to the zero-profit constraint, which results in $u_s^* = 0$.

QED

5. Proof of Proposition 3 (Equilibrium choice of labor and wages)

Proposition 3. *Suppose that the profit function $\pi(W, L)$ is twice continuously differentiable and concave in labor L and there is a unique threshold value of L' such that $\pi_L(L') = -\lambda w$. Let $\underline{L}$ be the amount of labor optimally hired by a profit-maximizing firm and suppose that $L_0 < \underline{L}$, i.e., a profit-maximizing firm*

would seek to hire additional labor. Define ε' *as:*

$$\varepsilon' = \begin{cases} \frac{u_e(w,L')}{\pi(w,L')}, & \text{if } \pi(w,L') > 0; \\ \infty, & \text{otherwise.} \end{cases}$$

Then:

- *Equilibrium payoffs are strictly monotone in* ε *with* $u_e^* \in [w\underline{L}, \pi(w,L')]$ *and* $u_s^* \in [0, \bar{\pi}]$.
- *For* $\varepsilon \leq \varepsilon'$ *equilibrium labor is strictly increasing in* ε *and wages are constant at* $W = w$.
- *For* $\varepsilon \geq \varepsilon'$*, if such exist, equilibrium labor is constant at* $L = L'$ *and wages are strictly increasing.*

Specifically, equilibrium labor and wage follow:

$$L^*(\varepsilon) = \begin{cases} \hat{L}(\varepsilon), & \varepsilon \leq \varepsilon'; \\ L', & \varepsilon > \varepsilon'; \end{cases}$$

$$W^*(\varepsilon) = \begin{cases} w, & \varepsilon \leq \varepsilon'; \\ w + \frac{\pi(w,L')}{L_0} \cdot \frac{\varepsilon - \varepsilon'}{1+\varepsilon'}, & \varepsilon > \varepsilon', \end{cases}$$

where $\hat{L}(\varepsilon)$ *solves:*

$$-\frac{\pi_L(\hat{L})}{\lambda w} \cdot \frac{wL_0 + \lambda w(\hat{L} - L_0)}{\pi(w,\hat{L})} = \varepsilon.$$

Proof. The first result follows immediately from Lemma 2.

For the second and third results we now need to consider two cases. Let L' be the value of labor such that $\pi_L(L') = -\lambda w$.

Case 1: $\pi(w,L') > 0$

We can define ε' to be the realization of bargaining power that corresponds to L':

$$\varepsilon' = -\frac{\pi_L(L')}{\lambda w} \cdot \frac{u_e(w, L')}{\pi(w, L')} = \frac{u_e(w, L')}{\pi(w, L')}.$$

From Lemma 2, we know that employee payoff is increasing in ε. Therefore, for $\varepsilon < \varepsilon'$, $u_e(W, L) < u_e(w, L')$. Following Lemma 1, this implies that for $\varepsilon < \varepsilon'$ $W = w$ and, according to Proposition 2, $L = \hat{L}$ that must solve:

$$\varepsilon = -\frac{\pi_L\left(\hat{L}\right)}{\lambda w} \cdot \frac{wL_0 + \lambda w\left(\hat{L} - L_0\right)}{\pi\left(w, \hat{L}\right)}.$$

Similarly, for $\varepsilon \geq \varepsilon'$, $u_e(W, L) \geq u_e(w, L')$, $L = L'$ and $W = \hat{W}$ that must solve:

$$\varepsilon = -\frac{\hat{W}L_0 + \lambda w(L' - L_0)}{\pi(w, L')} \Rightarrow \hat{W} = w + \frac{\pi(w, L')}{L_0}\frac{\varepsilon - \varepsilon'}{1 + \varepsilon}.$$

Case 2: $\pi(w, L') \leq 0$

In this case, according to Lemma 2, all values of ε must correspond to $L \leq L'$ and $u_e(W, L) \leq u_e(w, L')$. Therefore, following Lemma 1, $W = w$ while $L = \hat{L}$ can be found from Proposition 2:

$$\varepsilon = -\frac{\pi_L\left(\hat{L}\right)}{\lambda w} \cdot \frac{wL_0 + \lambda w\left(\hat{L} - L_0\right)}{\pi\left(w, \hat{L}\right)}.$$

Combining the outcomes for the two cases yields the second and third results, thus completing the proof.

QED

6. Proof of Proposition 4 (Equilibrium with single-factor linear production function)

Proposition 4. *The equilibrium choice of labor and wages by a co-determined monopoly with a single-factor linear production function follow:*

$$L^*(\varepsilon) = \begin{cases} \frac{(1+\varepsilon)\lambda\underline{L}-(1-\lambda)L_0}{(2+\varepsilon)\lambda} + \sqrt{\frac{\varepsilon}{2+\varepsilon}\underline{L}^2 + \left(\frac{\lambda\underline{L}+(1-\lambda)L_0}{(2+\varepsilon)\lambda}\right)^2}, & \varepsilon \leq \varepsilon'; \\ L', & \varepsilon > \varepsilon'; \end{cases}$$

$$W^*(\varepsilon) = \begin{cases} w, & \varepsilon \leq \varepsilon'; \\ w + \frac{1}{4dL_0}\left(\left(c - \frac{1}{A}w\right)^2 - \left(\frac{\lambda}{A}w\right)^2\right)\frac{\varepsilon-\varepsilon'}{1+\varepsilon}, & \varepsilon > \varepsilon', \end{cases}$$

where $\underline{L} = \frac{1}{2dA}\left(c - \frac{w}{A}\right)$ *is the amount of labor optimally hired by a profit-maximizing firm and*

$$L' = \frac{1}{2dA}\left(c - \frac{1-\lambda}{A}w\right);$$

$$\varepsilon' = \begin{cases} \frac{u_e(w,L')}{\pi(w,L')}, & \text{if } \pi(w,L') > 0; \\ \infty, & \text{otherwise} \end{cases}$$

are threshold values between labor and wage bargaining.

Proof. The firm's profit function is:

$$\pi(W,L) = Q(L)\cdot P(Q(L)) - WL_0 - w(L-L_0)$$

$$= AL(c - dAL) - WL_0 - w(L-L_0).$$

The threshold value L' can be found from:

$$\pi_L(L') = -\lambda w,$$

$$L' = \frac{1}{2dA}\left(c - \frac{1-\lambda}{A}w\right),$$

corresponding to:

$$\varepsilon' = \begin{cases} \frac{u_e(w,L')}{\pi(w,L')}, & \text{if } \pi(w,L') > 0; \\ \infty, & \text{otherwise.} \end{cases}$$

Note that:

$$\underline{L} = \frac{1}{2dA}\left(c - \frac{w}{A}\right) \leq L'$$

$$\bar{L} = \frac{1}{dA}\left(c - \frac{w}{A}\right)$$

For $L \in [\underline{L}, L']$, the equilibrium amount of labor follows from Proposition 3:

$$-\frac{\pi_L(L)}{\lambda w} \cdot \frac{u_e(w,L)}{\pi(w,L)} = \varepsilon,$$

$$\hat{L}(\varepsilon) = \frac{(1+\varepsilon)\lambda\underline{L} - (1-\lambda)L_0}{(2+\varepsilon)\lambda} + \sqrt{\frac{\varepsilon}{2+\varepsilon}\underline{L}^2 + \left(\frac{\lambda\underline{L} + (1-\lambda)L_0}{(2+\varepsilon)\lambda}\right)^2}.$$

Note that:

$$\hat{L}(0) = \underline{L},$$

$$\lim_{\varepsilon\to\infty} \hat{L}(\varepsilon) = 2\underline{L} = \bar{L},$$

i.e., $\forall\varepsilon, \hat{L}(\varepsilon) \in [\underline{L}, \bar{L}]$, even if $L' > \bar{L}$. Otherwise, for ε such that $\hat{L}(\varepsilon) > L'$, the equilibrium wage can be found from:

$$\frac{u_e(W,L')}{\pi(W,L')} = \varepsilon,$$

$$W = w + \frac{1}{4dL_0}\left(\left(c - \frac{1}{A}w\right)^2 - \left(\frac{\lambda}{A}w\right)^2\right)\frac{\varepsilon - \varepsilon'}{1+\varepsilon}.$$

QED

7. Proof of Proposition 5 (Equilibrium with two-factor Cobb-Douglas production function)

Proposition 5. *Suppose the co-determined firm faces a downward-sloping demand function, resulting in a marginal revenue function $MR(Q)$. The equilibrium choices of labor, capital, production and wages are then characterized by:*

$$L^*(\varepsilon) = \begin{cases} \frac{1}{A} MR^{-1}\left(\frac{r}{A}\kappa(\varepsilon)^{1-\alpha}\right)\kappa(\varepsilon)^{-\alpha}, & \varepsilon \leq \varepsilon'; \\ L', & \varepsilon > \varepsilon'; \end{cases}$$

$$K^*(\varepsilon) = L^*(\varepsilon) \cdot \kappa(\varepsilon);$$

$$Q^*(\varepsilon) = AK^*(\varepsilon)^{\alpha} L^*(\varepsilon)^{1-\alpha};$$

$$W^*(\varepsilon) = \begin{cases} w, & \varepsilon \leq \varepsilon'; \\ w + \frac{\pi(Q^*(\varepsilon'), w, L', K^*(\varepsilon'))}{L_0} \cdot \frac{\varepsilon - \varepsilon'}{1+\varepsilon'}, & \varepsilon > \varepsilon', \end{cases}$$

where κ denotes the amount of capital acquired by the firm per unit of labor:

$$\kappa(\varepsilon) = \frac{\alpha}{1-\alpha} \cdot \frac{w}{r} \cdot \left(1 - \varepsilon\lambda \frac{\pi(Q^*(\varepsilon), w, L^*(\varepsilon), K^*(\varepsilon))}{u_e(w, L^*(\varepsilon))}\right),$$

and the threshold values L' and ε' are:

$$L' = \frac{1}{A} MR^{-1}\left(\frac{1}{A}\left(\frac{r}{\alpha}\right)^{\alpha}\left(\frac{(1-\lambda)w}{1-\alpha}\right)^{1-\alpha}\right)\left(\frac{(1-\lambda)w}{r}\frac{\alpha}{1-\alpha}\right)^{-\alpha};$$

$$\varepsilon' = \begin{cases} \frac{u_e(w, L')}{\pi(Q^*(\varepsilon'), w, L', K^*(\varepsilon'))}, & \text{if } \pi(Q^*(\varepsilon'), w, L', K^*(\varepsilon')) > 0; \\ \infty, & \text{otherwise;} \end{cases}$$

Proof. Recall from Lemma 1 that for low values of employee bargaining power ε, the board will set the wage at the market level w and bargain over labor and, conversely, for high levels of employee bargaining power the board will hire labor corresponding to the threshold value L' and bargain over wages. This allows me to separate the optimization problem between labor and wages.

For low values of ε, the firm's objective function is:

$$\max_{Q,K,L} \varepsilon \ln u_e(w,L) + \ln \pi(Q,w,L,K),$$

subject to

$$Q \leq AK^{\alpha}L^{1-\alpha}.$$

The KKT problem is then:

$$\mathcal{L}(Q,L,K) = \varepsilon \ln\left(wL + \lambda w(L-L_0)\right) + \ln\left(Q\cdot P(Q) - rK - wL\right) - \mu\left(Q - AK^{\alpha}L^{1-\alpha}\right);$$

$$\frac{\partial \mathcal{L}}{\partial Q} = \frac{MR(Q)}{\pi(Q,w,L,K)} - \mu = 0;$$

$$\frac{\partial \mathcal{L}}{\partial K} = -\frac{r}{\pi(Q,w,L,K)} + \mu\alpha A\left(\frac{K}{L}\right)^{\alpha-1} = 0;$$

$$\frac{\partial \mathcal{L}}{\partial L} = \varepsilon\frac{\lambda w}{u_e(w,L)} - \frac{w}{\pi(Q,w,L,K)} + \mu(1-\alpha)A\left(\frac{K}{L}\right)^{\alpha} = 0,$$

where $MR(Q) = P(Q) + P'(Q)Q$ is the firm's marginal revenue.

Per capita capital is then characterized by the following equation:

$$\kappa \triangleq \frac{K}{L} = \frac{\alpha}{1-\alpha}\cdot\frac{w}{r}\cdot\left(1 - \varepsilon\lambda\frac{\pi(Q,w,L,K)}{u_e(w,L)}\right),$$

and production, labor and capital by:

$$Q = MR^{-1}\left(\frac{1}{A}\left(\frac{r}{\alpha}\right)^{\alpha}\left(\frac{w}{1-\alpha}\right)^{1-\alpha}\left(1 - \varepsilon\lambda\frac{\pi(Q,w,L,K)}{u_e(w,L)}\right)^{1-\alpha}\right);$$

$$L = \frac{Q}{A}\kappa^{-\alpha};$$

$$K = \frac{Q}{A}\kappa^{1-\alpha}.$$

Recall from Proposition 3 that the threshold value L' corresponds to employee bargaining power ε' such that, given corresponding optimal production Q' and

capital K':

$$\varepsilon' = \frac{u_e(w, L')}{\pi(Q', w, L', K')}.$$

It follows that:

$$L' = \frac{1}{A} M R^{-1} \left(\frac{1}{A} \left(\frac{r}{\alpha} \right)^{\alpha} \left(\frac{(1-\lambda)w}{1-\alpha} \right)^{1-\alpha} \right) \left(\frac{(1-\lambda)w}{r} \frac{\alpha}{1-\alpha} \right)^{-\alpha}$$

It is possible that this value for L' results in negative profits. This means that the zero-profit condition is reached before (i.e., at a lower L) the employee representatives turn to wage negotiation. In this case, following Lemma 2, for any value of employee bargaining power the board will only bargain over labor and wages will remain fixed at the market level w. By definition, ε' is then set to be infinitely large.

Combining, the optimal choices of labor, capital and production are characterized by:

$$L^*(\varepsilon) = \begin{cases} \frac{1}{A} M R^{-1} \left(\frac{r}{A} \kappa(\varepsilon)^{1-\alpha} \right) \kappa(\varepsilon)^{-\alpha}, & \varepsilon \leq \varepsilon'; \\ L', & \varepsilon > \varepsilon'; \end{cases}$$

$$K^*(\varepsilon) = L^*(\varepsilon) \cdot \kappa(\varepsilon),$$

$$Q^*(\varepsilon) = A K^*(\varepsilon)^{\alpha} L^*(\varepsilon)^{1-\alpha},$$

where

$$\kappa(\varepsilon) = \frac{\alpha}{1-\alpha} \cdot \frac{w}{r} \cdot \left(1 - \varepsilon \lambda \frac{\pi(Q^*, w, L^*, K^*)}{u_e(w, L^*)} \right).$$

The optimal wage W for follows from Proposition 3:

$$W^*(\varepsilon) = \begin{cases} w, & \varepsilon \leq \varepsilon'; \\ w + \frac{\pi(Q^*(\varepsilon'), w, L', K^*(\varepsilon'))}{L_0} \cdot \frac{\varepsilon - \varepsilon'}{1 + \varepsilon'}, & \varepsilon > \varepsilon'; \end{cases}$$

QED

8. Proof of Proposition 6 (Modigliani-Miller Theorem for a co-determined firm)

Proposition 6 ***The Modigliani-Miller Theorem for a co-determined firm.*** *The choice between issuing equity and debt (i.e., capital structure) is ex-ante irrelevant if:*

- *there are no taxes* ($\tau = 0$)*;*
- *there is no cost to default* ($B = 0$)*;*
- *employee representatives do not value new labor* ($\lambda = 0$)*;*
- *commitment is perfect.*

Proof. This result is straightforward and follows the same logic as the Modigliani-Miller theorem.

If commitment is perfect, then the board can commit to state-by-state production decisions at the same time as it makes decisions about the choice of financing. The ex-ante bargaining will be conducted over expected utilities $U_s = E[u_s]$ and $U_e = E[u_e]$.

In the absence of taxes and cost of default the expected shareholder payoff is equal to expected revenue less expected payments to labor, debt and new equity. Given competitive financial markets, the expected return of new investors must be equal to the risk-free rate, i.e., their combined expected payoff must be equal to $R_f I$. Under $\lambda = 0$, the expected employee payoff is equal to the expected payments to labor, so shareholder payoff can be written as:

$$E[u_s] = E[P(Q) \cdot Q] - R_f I - E[u_e].$$

Recall that when $\lambda = 0$, employees and shareholders agree on production decisions and choose $L = \underline{L}$ to maximize revenue less the market cost of labor. In other words, expected revenue is independent of expected employee payoff and of the choice between debt and equity. As a result, the equilibrium condition from Proposition 2 will take the form:

$$\varepsilon = -\frac{dE\left[u_e\right]}{dE\left[u_s\right]} \cdot \frac{E\left[u_s\right]}{E\left[u_e\right]} = \frac{E\left[u_s\right]}{E\left[u_e\right]} = \frac{E\left[P(Q)\cdot Q\right] - R_f I - E\left[u_e\right]}{E\left[u_e\right]}.$$

The outcome of the bargaining will therefore not be affected by the choice between debt and equity, and neither will the expected payoffs of shareholders and employees. In other words, both groups are ex-ante indifferent between issuing debt and equity.

QED

9. Proof of Proposition 7 (Labor and wages under financing without commitment)

Proposition 7. *For each realization ζ of the demand shock equilibrium labor and wages follow:*

$$L^*(\zeta,\varepsilon,V) = \begin{cases} \hat{L}(\zeta,\varepsilon,V), & \varepsilon \leq \varepsilon'(\zeta,V); \\ L'(\zeta), & \varepsilon > \varepsilon'(\zeta,V); \end{cases}$$

$$W^*(\zeta,\varepsilon,V) = \begin{cases} w, & \varepsilon \leq \varepsilon'(\zeta,V); \\ w + \frac{\pi(w,L'(\zeta),\zeta,V)}{L_0} \cdot \frac{\varepsilon-\varepsilon'}{1+\varepsilon'}, & \varepsilon > \varepsilon'(\zeta,V); \end{cases}$$

where

$$\hat{L}(\zeta,\varepsilon,V) \;= \frac{(1+\varepsilon)\lambda\, \underline{L}(\zeta) - (1-\lambda)L_0}{(2+\varepsilon)\lambda} + \sqrt{\frac{\varepsilon}{2+\varepsilon}\left(\underline{L}(\zeta)^2 - \zeta\frac{V}{A^2}\right) + \left(\frac{\lambda\underline{L}(\zeta) + (1-\lambda)L_0}{(2+\varepsilon)\lambda}\right)^2};$$

$$L'(\zeta) = \frac{\zeta}{2A}\left(c - (1-\lambda)\frac{w}{A}\right).$$

$$\varepsilon'(\zeta,V) = \begin{cases} \frac{u_e(w,L')}{\pi(w,L'(\zeta),\zeta,V)}, & \textit{if } \pi(w,L') > 0; \\ \infty, & \textit{otherwise.} \end{cases}$$

Proof. The firm's problem can be solved by backwards induction, starting from the labor and production decision.

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At the time of production debt V is fixed, and the realization ζ of Z is known. The profit function and its labor derivative for every realization of Z are:

$$\pi(W, L, \zeta, V) = (1-\tau)\left(AL\left(c - \frac{1}{\zeta}AL\right) - WL_0 - w\left(L - L_0\right) - V\right);$$

$$\pi_L(L, \zeta) = (1-\tau)\left(A\left(c - \frac{2}{\zeta}AL\right) - w\right).$$

The threshold value L' is determined as:

$$\frac{\pi_L\left(L', \zeta\right)}{1-\tau} = -\lambda w;$$

$$L'(\zeta) = \frac{\zeta}{2A}\left(c - (1-\lambda)\frac{w}{A}\right).$$

The shareholder optimum $\underline{L}$ is:

$$\underline{L}(\zeta) = \frac{\zeta}{2A}\left(c - \frac{w}{A}\right).$$

The optimal choices of labor and wages follow from Proposition 3:

$$\hat{L}(\zeta, \varepsilon, V) = \frac{(1+\varepsilon)\lambda\, \underline{L}(\zeta) - (1-\lambda)L_0}{(2+\varepsilon)\lambda} + \sqrt{\frac{\varepsilon}{2+\varepsilon}\left(\underline{L}(\zeta)^2 - \zeta\frac{V}{A^2}\right) + \left(\frac{\lambda\underline{L}(\zeta) + (1-\lambda)L_0}{(2+\varepsilon)\lambda}\right)^2};$$

$$\hat{W}(\zeta, \varepsilon, V) = w + \frac{\pi\left(w, L'(\zeta), \zeta, V\right)\varepsilon - u_e\left(w, L'(\zeta)\right)}{(1+\varepsilon)L_0}.$$

QED

10. Proof of Proposition 8 (Capital structure under financing without commitment)

Proposition 8. *At the time of bargaining over capital structure, the ex-ante expected payoffs of the representatives are monotonic in the amount of debt issued:*

- *Expected shareholder payoff is non-decreasing in the amount of debt issued.*

- *Expected employee payoff is non-increasing in the amount of debt issued.*

In equilibrium, both the shareholder- and employee-controlled firms use only debt financing and issue no equity.

Proof. In order to find the expected payoffs of the parties for each value of debt and determine the equilibrium amount of debt issued, we must first establish the conditions under which the firms defaults.

Default thresholds

Let $\bar{\zeta}$ be such that the firm defaults under $\zeta < \bar{\zeta}$ and $\underline{\zeta}$ be such that for $\zeta < \underline{\zeta}$ debt cannot be repaid in full, i.e., employees, who are junior to debt, are not paid at all.

I will assume that in bankruptcy the firm hires labor $\underline{L}$, reflecting its best attempt to reach positive profits. While the employee representatives' incentives and power under default have not been specified, it is reasonable to assume that they cannot increase wages above the market rate – a firm in bankruptcy cannot distribute bonuses to some employees at the expense of its stakeholders, including other employees.

For $\zeta < \bar{\zeta}$, $L = \underline{L}(\zeta)$ and:

$$P\left(Q\left(\underline{L}(\zeta)\right), \zeta\right) = \frac{1}{2}\left(c + \frac{w}{A}\right) \triangleq \underline{P}.$$

$\bar{\zeta}$ is then determined from the zero-profit condition:

$$\underline{P}Q\left(\underline{L}(\zeta)\right) - w\underline{L}(\zeta) - V = 0 \Rightarrow \bar{\zeta}(V) = \frac{V}{\frac{1}{4}\left(c - \frac{w}{A}\right)^2}.$$

Similarly, $\underline{\zeta}$ satisfies:

$$(1-B)\underline{P}Q\left(\underline{L}\right) - V = 0 \Rightarrow \underline{\zeta}(V) = \frac{V}{\frac{1}{4}(1-B)\left(c^2 - \frac{w^2}{A^2}\right)}.$$

I will assume that default costs are small enough for a firm to be able to repay senior debt for some $\zeta \leq \bar{\zeta}$, i.e.:

$$\underline{\zeta} < \bar{\zeta} \Leftrightarrow B < 2\frac{w}{Ac + w}.$$

Employee payoff

First note that:

$$\hat{L}\left(\bar{\zeta}(V), \varepsilon, V\right) = \underline{L} < L',$$

$$\lim_{\zeta \to +\infty} \hat{L}(\zeta, \varepsilon, V) = +\infty.$$

By continuity of $\hat{L}(\zeta, \varepsilon, V)$ with respect to ζ, there exists some $\zeta'(\varepsilon, V) > \bar{\zeta}(V)$ such that $\hat{L}\left(\zeta'(\varepsilon, V), \varepsilon, V\right) = L'$. Given additionally the monotonicity of $\hat{L}$, $\zeta'(\varepsilon, V)$ is unique for every pair ε, V. Expected employee payoff is then:

$$E_Z\left[u_e(\varepsilon, V)\right] =$$

$$= \int_{\underline{\zeta}(V)}^{\bar{\zeta}(V)} \frac{(1-B)\underline{P}A\underline{L}(\zeta) - V}{\underline{L}(\zeta)} \left(L_0 + \lambda\left(\hat{L}(\zeta, \varepsilon, V) - L_0\right)\right) f(\zeta)d\zeta +$$

$$+ w \int_{\bar{\zeta}(V)}^{\zeta'(\varepsilon,V)} \left(L_0 + \lambda\left(\hat{L}(\zeta, \varepsilon, V) - L_0\right)\right) f(\zeta)d\zeta +$$

$$+ \int_{\zeta'(\varepsilon,V)}^{\infty} \left(\hat{W}(\zeta, \varepsilon, V)L_0 + \lambda w\left(L'(\zeta) - L_0\right)\right) f(\zeta)d\zeta$$

The integrand as a function of ζ is discontinuous at $\bar{\zeta}$. However, separating the cost of default results in an expression of utility as a difference between two integrals of continuous piecewise differentiable functions:

$$E_Z\left[u_e(\zeta, \varepsilon, V)\right] = \int_0^{\infty} g(\zeta, \varepsilon, V)f(\zeta)d\zeta - \int_0^{\bar{\zeta}(V)} B\underline{P}A\left(L_0 + \lambda\left(\underline{L}(\zeta) - L_0\right)\right) f(\zeta)d\zeta$$

where:

$$g(\zeta,\varepsilon,V)=\begin{cases} B\underline{P}A\left(L_0+\lambda\left(\underline{L}(\zeta)-L_0\right)\right), & \zeta<\underline{\zeta}(V);\\ \frac{\underline{P}A\underline{L}(\zeta)-V}{\underline{L}(\zeta)}\left(L_0+\lambda\left(\underline{L}(\zeta)-L_0\right)\right), & \underline{\zeta}(V)\le\zeta<\bar{\zeta}(V);\\ wL_0+\lambda w(\hat{L}(\zeta,\varepsilon,V)-L_0), & \bar{\zeta}(V)\le\zeta<\zeta'(\varepsilon,V);\\ \hat{W}(\zeta,\varepsilon,V)L_0+\lambda w\left(L'(\zeta)-L_0\right), & \zeta\ge\zeta'(V). \end{cases}$$

The derivative of expected employee payoff with respect to the face value of debt is then:

$$\frac{\partial E_Z\left[u_e(\zeta,\varepsilon,V)\right]}{\partial V}=$$

$$=\int_0^{\infty}\frac{\partial g(\zeta,\varepsilon,\ V)}{\partial V}d\zeta-B\underline{P}A\left(\lambda\underline{L}\left(\bar{\zeta}(V)\right)+(1-\lambda)L_0\right)f\left(\bar{\zeta}(V)\right)\frac{d\bar{\zeta}}{dV}=$$

$$=-\lambda\left(F\left(\bar{\zeta}(V)\right)-F\left(\underline{\zeta}(V)\right)\right)-(1-\lambda)L_0\frac{2A}{c-\frac{w}{A}}\int_{\underline{\zeta}(V)}^{\bar{\zeta}(V)}\frac{1}{\zeta}f(\zeta)d\zeta+$$

$$+\lambda w\int_{\bar{\zeta}(V)}^{\zeta'(V)}\frac{\partial\hat{L}(\zeta,\varepsilon,V)}{\partial V}f(\zeta)d\zeta-\frac{\varepsilon}{1+\varepsilon}\left(1-F\left(\zeta'(\varepsilon,V)\right)\right)-$$

$$-\frac{B\underline{P}A\left(\lambda\underline{L}\left(\bar{\zeta}(V)\right)+(1-\lambda)L_0\right)f\left(\bar{\zeta}(V)\right)}{\frac{1}{4}\left(c-\frac{w}{A}\right)^2},$$

where:

$$\frac{\partial\hat{L}(\zeta,\varepsilon,V)}{\partial V}=-\frac{\varepsilon}{2+\varepsilon}\frac{\zeta}{A^2}\frac{1}{2}\left(\frac{\varepsilon}{2+\varepsilon}\left(\underline{L}^2-\zeta\frac{V}{A^2}\right)+\left(\frac{\lambda\underline{L}+(1-\lambda)L_0}{(2+\varepsilon)\lambda}\right)^2\right)^{-\frac{1}{2}}\le 0$$

and, if $\zeta\ \sim\ \text{LogNormal}\left(\mu_Z,\sigma_Z\right)$:

$$\int_{\underline{\zeta}(V)}^{\bar{\zeta}(V)}\frac{1}{\zeta}f(\zeta)d\zeta=e^{-\mu_\zeta+\frac{\sigma_\zeta^2}{2}}\left(\Phi\left(\frac{\ln\bar{\zeta}(V)-\mu_\zeta}{\sigma_\zeta}+\sigma_\zeta\right)-\Phi\left(\frac{\ln\underline{\zeta}(V)-\mu_\zeta}{\sigma_\zeta}+\sigma_\zeta\right)\right)\ge 0.$$

Expected employee payoff is therefore non-increasing in borrowing.

Shareholder payoff

The expected payoff of the original shareholders is equal to the expected revenue less the expected costs of default and the expected payments to other stakeholders, i.e., employees, debtholders, new shareholders, and the government (taxes). Investor competition and risk-neutrality imply that the expected return to debtholders and new shareholders must be equal to the risk-free return. The expected payoff to existing shareholders is then, suppressing the dependence of L and W on ζ, ε and V:

$$E_Z\left[u_s(\zeta,\varepsilon,V)\right] = E_Z\left[P\left(\zeta,\ Q(L)\right)Q(L)\right] - E\left[WL_0 + w\left(L-L_0\right)\right] -$$

$$-E\left[\tau\left[P\left(\zeta,\ Q(L)\right)Q(L) - WL_0 + w\left(L-L_0\right) - V\right]_+\right] -$$

$$-\int_0^{\bar{\zeta}(V)} B\underline{P}A\underline{L}(\zeta)f(\zeta)d\zeta - R_f I = \int_0^{\infty} h(\zeta,\varepsilon,V)f(\zeta)d\zeta - R_f I,$$

where:

$$h(\zeta,\varepsilon,V) =$$

$$\begin{cases} (1-B)\underline{P}A\underline{L}(\zeta), & \zeta < \underline{\zeta}(V) \\ V, & \underline{\zeta}(V) \le \zeta < \bar{\zeta}(V) \\ (1-\tau)\left(P\left(A\hat{L}(\zeta,\varepsilon,V),\zeta\right)A\hat{L}(\zeta,\varepsilon,V) - w\hat{L}(\zeta,\varepsilon,V)\right) + \tau V, & \bar{\zeta}(V) \le \zeta < \zeta'(\varepsilon,V) \\ (1-\tau)\left(P\left(AL'(\zeta),\zeta\right)AL'(\zeta) - \hat{W}(\zeta,\varepsilon,V)L_0 - w\left(L'(\zeta)-L_0\right)\right) + \tau V, & \zeta \ge \zeta'(\varepsilon,V) \end{cases}$$

is continuous, and differentiable within every interval.

Therefore, the derivative of the expected payoff with respect to the face value of debt is:

$$\frac{\partial E_Z\left[u_s(\zeta,\varepsilon,V)\right]}{\partial V} = \int_0^{\infty}\frac{\partial h(\zeta,\varepsilon,V)}{\partial V}f(\zeta)d\zeta \ = F\left(\bar{\zeta}(V)\right) - F\left(\underline{\zeta}(V)\right) +$$

$$+\int_{\bar{\zeta}(V)}^{\zeta'(\varepsilon,V)}\left[(1-\tau)2A^2\left(\frac{1}{2A}\left(c-\frac{w}{A}\right) - \frac{1}{\zeta}\hat{L}(\zeta,\varepsilon,V)\right)\frac{\partial\hat{L}(\zeta,\varepsilon,V)}{\partial V} + \tau\right]f(\zeta)d\zeta +$$

$$+\left((1-\tau)\frac{\varepsilon}{1+\varepsilon}+\tau\right)\left(1-F\left(\zeta'(\varepsilon,V)\right)\right)$$

Note that:

$$\frac{\partial\hat{L}(\zeta,\varepsilon,V)}{\partial V}<0$$

$$\hat{L}(\zeta,\varepsilon,V)\geq\frac{\zeta}{2A}\left(c-\frac{w}{A}\right)=\underline{L}(\zeta)$$

The original shareholders' expected payoff is non-decreasing in the face value of debt.

Equilibrium condition for choice of capital structure

Following Proposition 2, the equilibrium choice of debt for each value of employee bargaining power ε corresponds to the result of the following maximization problem:

$$\max_{V}\varepsilon\ln E_Z\left[u_e\left(\zeta,\varepsilon,V\right)\right]+\ln E_Z\left[u_s\left(\zeta,\varepsilon,V\right)\right],$$

subject to $D(V)\leq I$, which results in the equilibrium condition:

$$-\frac{\frac{\partial E_Z[u_s(\zeta,\varepsilon,V)]}{\partial V}}{\frac{\partial E_Z[u_e(\zeta,\varepsilon,V)]}{\partial V}}\cdot\frac{E_Z\left[u_e(\zeta,\varepsilon,V)\right]}{E_Z\left[u_s(\zeta,\varepsilon,V)\right]}=\varepsilon.$$

The equilibrium for the shareholder-controlled firm follows immediately from this condition. Indeed, since shareholder payoff is non-decreasing in the amount of debt issued, a shareholder-controlled firm will only issue debt financing, borrowing $D=I$.

The employee-controlled firm, on the other hand, would prefer to only raise equity financing. Recall, however, the results of the second period labor and wage bargaining, as seen in Proposition 7 and Lemma 2. At high levels of employee bargaining power ε, the firm's profits approach 0 for any realization ζ of the demand shock, which constrains the firm in the amount of equity it can commit to issue. Indeed, since the employee-controlled firm cannot commit to repay any of the profits to shareholders, whether new or old, the firm has no choice but to

issue debt, payments for which are guaranteed under penalty of bankruptcy, and senior to employee wages. As a result, a labor-controlled firm will borrow $D = I$.

QED

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