Essays on Moral Norms, Legal Unbundling and Franchise Systems

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Für meine Eltern und Großeltern...

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Introduction

Social and economic interactions always take place in some institutional framework that describes technological, legal or contractual constraints on possible actions and resulting material payoffs. The theory of games allows to describe such institutions in a mathematical way and to analyze how rational actors behave in a given institutional framework.

This thesis applies game theoretic methods to analyze consequences, emergence and design of institutions in three different contexts. The first chapter analyzes selection of norms and institutions in a world where some people are intrinsically motivated to follow non-enforceable social norms. The second and third chapters compare different unbundling requirements for natural monopolies that provide essential inputs to downstream firms. The fourth chapter studies issues in the design of franchise organizations and franchise contracts. Every chapter forms an independent and self-contained unit.

Chapter 1 is motivated by the observation that social interactions are not only guided by enforceable institutional rules, but typically also by non-enforceable social or moral norms that describe how people are supposed to act (see e.g. Elster 1989 for a survey). Compliance with such norms may not always be selfish rational and for social psychologists it has long been clear that a substantial fraction of people complies to norms because they feel guilty when breaking norms that they are expected to follow, see e.g. Heider (1946), Newcomb (1953), Festinger (1957) or Cialdini (1993). On the other hand, not all people care equally strong about norm compliance and some people seem not to feel guilty at all when breaking norms.

We examine the question how social interactions, norms and institutions are likely to be structured in a world where people with different intrinsic motivation to follow norms interact with each other. To formalize this question, we consider a simple model with only two types of players: 'compliers', who always comply with social or moral norms by intrinsic motivation, and types who act selfishly rational without feeling guilty if such behavior violates norms. We assume that types are private knowledge, i.e. no one can see from the outside whether another person is a complier or selfishly rational.

To study the question which norms and institutions could plausibly emerge in such a society, a voting-by-feet model is considered where the society consists of different communities that each have their own norms and institutions that govern social interactions. Inhabitants can freely migrate between communities and will join another community if that yields higher expected utility for themselves. While compliers feel morally obliged to follow the norms of the community they decided to join, selfish players feel not guilty when breaking those norms. Still, norms can indirectly influence selfish players' behavior, because selfish types take compliers' behavior strategically into account.

Voting-by-feet models have a long tradition in the literature of local provision of public goods initiated by Tiebout (1956). There is a notorious difficulty, however, in finding an appropriate equilibrium concept. Typically, a multiplicity of Nash equilibria exist (e.g. Westhoff, 1977) while the core is often empty (e.g. Greenberg and Weber, 1986). One way to deal with these problems is to consider equilibrium concepts that require stability only against coalitional deviations that remain beneficial if it is taken into account that the deviation can induce future deviations by others. Examples are the migration-proof Tiebout equilibrium by Conley and Konishi (2002), the theory of social situations by Greenberg (1990) or the largest consistent set by Chwe (1994).

These concepts all assume that types are perfect knowledge and do not account for possible problems of coalition formation under incomplete information. We therefore introduce the novel — but related — concept of 'migration-proof equilibrium'. It allows for public announcements that propose a joint migration to another community, but takes into account that it is not possible to exclude selfish players from such a migration because types are private information. Inhabitants participate in an announced migration only if it is still beneficial when one accounts for the fact that non-invited inhabitants may want to join.

We show that essentially all migration-proof equilibria lead to *complier optimal* norms and institutions. These are those norms and institutions that maximize the expected utility of compliant inhabitants given the fraction of compliers and selfish types in the total population.

To check the empirical relevance of this result, one ideally would like to analyze whether real-world institutions are complier optimal or whether in a given institutional framework observed non-selfish behavior is in line with complier optimal norms. Such an approach would be quite demanding, however, since precise information on selected and feasible actions, material payoffs or the set of technologically feasible institutions in the real world is almost impossible to obtain.

Economic experiments, however, provide plenty of observations about actual behavior in controlled institutional frameworks. We show that the stylized facts across popular economic experiments that study fairness and social preferences are indeed in line with a model where some players follow complier optimal norms and others act selfishly. Examples are the use of costly punishment, conditional cooperation, the fact that intentions matter, and concerns for social efficiency.

The voting-by-feet model and the experimental results are not the only motivation for complier optimal norms. Complier optimality can also be motivated as a sensible moral principle. We show that the basic idea is a variation of *rule-utilitarianism,* which has been strongly advocated as a rational form of moral behavior by John Harsanyi (e.g. 1985 or 1992). A substantial part of Chapter 1 is devoted to compare the differences and similarities in the moral justification and the implications of the two principles.

Chapters 2 and 3 deal with an interesting regulatory problem of important practical relevance. The declared goal of the European Union's liberalization policy for energy markets is to benefit consumers by encouraging competition among energy suppliers. Competition is a delicate issue, however, because the delivery of electricity or gas requires the use of transmission networks, which are classical examples of natural monopolies.

Although network access prices are typically regulated, preventing non-tariff discrimination by a network operator seems much more difficult in practice. Where network operators are vertically integrated with an incumbent energy supplier, regulators report of "sabotage" of downstream competitors in form of discriminatory information flows, undue delays in delivery of the service, overly complex contractual requirements, requiring unreasonably high bank guarantees and the like.[1]

An important regulatory question therefore is whether energy suppliers should be allowed to own or to control transmission networks. In its proposal for a new regulation of the energy sectors, the EU Commission strongly recommends complete ownership unbundling, i.e. energy suppliers and producers are not allowed to hold any shares in firms that operate the transmission networks. While most academic research compares ownership separation with unrestricted vertical integration, the actual standard

[1]See, e.g., European Commission, Energy Sector Inquiry (Jan. 10, 2007), Competition report on energy sector inquiry, part 1, para 169, or para 493, p. 163.

requirements for the energy industry in the EU prescribes a very interesting form of partial separation labeled as *legal unbundling*.[2]

Legal unbundling essentially means that the network must be operated by a legally independent upstream firm, but the upstream firm may be fully or partially owned by an incumbent firm active in the downstream market. The downstream incumbent is not allowed to directly interfere in the upstream operations, but its ownership share gives entitlement to the corresponding proportion of upstream profits.

In Chapter 2, we formalize legal unbundling as follows: The legally unbundled upstream firm maximizes only its own profits, while the downstream incumbent that owns the upstream firm maximizes the joint profits of the integrated firm.

The basic idea to model legal unbundling in the form that the unbundled firm independently maximizes its own profits has been introduced by Sibley and Weisman (1998) and Cremer, Crémer, and De Donder (2006), which to our knowledge are the only previous works that analyzes a theoretical model of legal unbundling.

One difference to our model is that they assume that the downstream operations are legally unbundled while the upstream firm maximizes joint profits (for comparison, we also examine their case, which we call "reverse" legal unbundling). A model where the upstream firm is legally unbundled is in our opinion, however, closer to legal practice where regulations prescribe that the network must be operated by a legally independent firm.

We compare the outcome under legal unbundling with the outcomes under vertical integration and ownership separation under the assumption that access prices are regulated (for the largest part of the analysis we consider a linear access price above marginal costs of network access) while non-tariff discrimination by the upstream firm cannot prevented.

Under fairly general assumptions on the form of downstream competition and on the possible effects of non-tariff discrimination, we find that legal unbundling leads to (weakly) higher total output than both vertical integration and ownership separation. In many cases this result implies that also consumer surplus is highest under legal unbundling.

The intuition why legal unbundling leads to higher total output than vertical integration is as follows. Due to the access price regulation, upstream profits are maximized when total output is maximal. Thus, if the upstream firm is legally unbundled, it

[2]For the electricity market see Directive 2003/54/EC, Articles 10 (1) and 15 (1), for the gas market see Directive 2003/55/EC, Articles 9 (1) and 13 (1). The regulations are required in all member states only since July, 2007.

wants to maximize total output and refrains from sabotage of downstream firms. In contrast, under vertical integration, upstream decisions also consider the incumbent's downstream profits, and to maximize joint profits it may be optimal to sabotage downstream competitors by making network access more difficult. We call this the *"sabotage effect"*.

When comparing legal unbundling to ownership separation, more complex forces are at work. First, since in both cases the upstream monopolist wants to maximize total output, typically neither under legal unbundling nor under vertical separation will the upstream monopolist sabotage downstream firms.

Second, while a vertically separated downstream incumbent is interested only in its own profits, under legal unbundling the downstream incumbent also has an interest in high upstream profits — and thereby in a high overall output. Under legal unbundling, the downstream incumbent will therefore select strategies that yield higher total output compared to ownership separation. We call this the *"downstream expansion effect"*.

Since one of the main policy concerns is about efficient network investments, we extend our analysis to different forms of investment decisions. Given our quantity results, it is quite intuitive that incentives for reducing the upstream firm's marginal costs are highest under legal unbundling. We also discuss capacity investments, which can discriminate between downstream firms, and incentives to invest in network reliability. For these two types of investments it is not generally clear that legal unbundling provides the highest investment incentives, although legal unbundling exhibits some desirable properties also for these sorts of investment decisions.

In Chapter 3, we allow for imperfections in legal unbundling in the form that the management of the upstream firm may not act completely independent but can be manipulated by the management of the downstream incumbent. We also allow for the case that the downstream incumbent has only partial ownership in the upstream firm.

We find that for any given ownership share, total output weakly increases if regulations become tougher in the sense that it is more costly for the downstream incumbent to manipulate the upstream firms' management. This is simply due to the fact that the sabotage effect becomes more severe when the upstream management is easily manipulated by the downstream management.

An increase incumbent's ownership share in the upstream firm on total output in general has ambiguous effects. On the one hand, the downstream expansion effect is stronger for larger ownership shares and therefore suggests higher total output. On

the other hand, larger ownership shares could make manipulation of the upstream firm easier and therefore increase the sabotage effect and reduce total output. While in the presence of imperfections we can thus no longer generally say whether legal unbundling is superior to ownership separation, the detailed analysis yields nevertheless important insights for regulatory policy.
One important insight is that the downstream expansion effect is more likely to dominate the sabotage effect under strict regulations that make manipulation of the upstream firm more difficult. This means that even if in cases of weak regulation ownership separation can lead to higher total output than legal unbundling, legal unbundling can become the better solution for consumers once regulation becomes stricter.
Furthermore, the analysis suggests that it could be beneficial for consumers to require that a minority stake of, say 10% or 20% in the network company is given to an outside investor, who receives substantial control rights over the network operator's management. The downstream incumbent is allowed to own the remaining shares of the upstream firm and receives the corresponding fraction profits, but is granted only very limited control rights. Since the downstream incumbent would still receive most of the upstream profits, the downstream expansion effect should remain of substantial size. At the same time, the outside investor has an interest to enforce that the network company maximizes only its own profits, which should make manipulation by the downstream incumbent much more difficult and therefore reduce the sabotage effect.

Chapter 4 analyzes organizational and contractual arrangements in franchise systems. A puzzling empirical regularity in franchising is the stable coexistence of franchised and company-owned stores within a chain. Following Bradach & Eccles (1989), we call this arrangement a *plural form.* In an extensive panel-data study Lafontaine and Shaw (2005) show that after some adjustment period the fraction of company-owned stores remains relatively stable over time and seems to be deliberately targeted in most franchise chains.
These observations contrast an early branch of literature (e.g. Oxenfeldt & Kelly, 1969), which considered franchising and the plural form to be transitory phenomena that facilitate access to initially scarce resources like capital (Caves & Murphy, 1976), managerial talent (Norton, 1988) or local information (Minkler, 1990). In the model of Gallini and Lutz (1992) the transition is reversed: chains start with company-ownership to signal profitable business to franchisees but once signalling is successful they can move towards a higher fraction of franchised stores.
To explain the long-run coexistence of company-owned and franchised stores, some

literature focus on differences between locations of individual stores. For example, Brickely and Dark (1987) find empirically that a smaller distance to chain headquarters or a lower proportion of repeat business makes a store more likely to be company-owned. Chakrabarty et. al. (2002) theoretically analyze how the plural form can arise if the chain has better information about the profitability of different store locations. Affuso (2002) adopts a different approach where the plural form can be optimal when managers are heterogeneous and self-select into franchise or company-employment contracts. She shows empirically that characteristics of store managers indeed significantly differ between franchise and company-owned stores.

Other papers focus on chain wide implications of the decision to have some company-owned stores. Scott (1995) and especially Lafontaine and Shaw (2005) have strong empirical arguments that company ownership is important to protect a chain's brand value. Bai and Tao (2000) provide a corresponding theoretical model for the plural form, where goodwill-effort of company-owned stores protects a chain's brand name, while franchise stores have higher sales efforts. Sorensen and Sorensen (2001) explain the plural form by focusing on the different roles of franchise and company-owned stores in exploration and organizational learning.

We have collected contract, interview and background data from the US fast-food industry to motivate a game-theoretic analysis that illustrates an additional reason for the plural form. The analysis is based on two stylized facts about franchise contracts, which hold in our sample and are more generally observed in franchising (see e.g. Bradach, 1998, or Blair & Lafontaine, 2005, for overviews): First, contracts typically give the chain strong power to decide upon certain activities, like introduction of new products or changes in building requirements. Once a chain selects such an activity, it must be implemented by franchisees. Second, franchisees have to pay royalties, which are fraction of sales-revenues, to the chain.

These two contractual features create a source of inefficiencies in decision making. Since royalties are based on revenues, and costs are born only by franchisees, the chain has incentives to choose inefficient activities that lead to high revenues but can be very costly for a store. A substantial fraction of company-stores can function as a commitment device for the chain to select more efficient activities, however. Such a commitment effect is present when the chain is obliged to uniform standards that require that the same activities must be selected for company-owned stores as for franchise stores. The reason is simply that for the fraction of the chain's total income that is contributed by company-owned stores, the cost of activities are fully internalized. Therefore, inefficient activities that lead to high revenues — but are very

costly — become less attractive as the fraction of company-owned stores increases.
We perform an game theoretic analysis of three different cases. In the first case, we assume that the chain is obliged to uniform standards between company-owned and franchise stores and chooses endogenously the optimal fraction of company-owned stores. We model the interaction between the chain and franchisees via a three stage game. In the first stage, the chain commits to a fraction of company-owned stores and offers a franchise contract that specifies the royalty. When franchisees accept the contract in Stage 2, nature draws a state of the world that determines revenues and costs, as well as the optimal chain-wide activities. In Stage 3, the chain observes the state of the world and selects a chain-wide activity. Finally revenues and costs are realized and split according to the franchise contract. We show that the chain may select a positive fraction of company-owned stores, even if company-owned stores are run less efficiently than franchise stores. Thus, the plural form endogenously results from our model.

In the second case, the chain selects not only the fraction of company-owned stores, but also decides whether to commit to uniform standards between franchise and company-owned stores. The analysis straightforwardly shows that in this case it is always optimal for the chain to contractually commit itself to such uniform standards.

Finally, we analyze the case where the optimal fraction of company-owned stores is determined by factors outside our model. We consider the extreme case where the fraction of company-owned stores is completely exogenous and analyze when it is optimal for the chain to have a contractual commitment to uniform standards. We show that for a sufficiently high fraction of company-owned stores, it is optimal to include such a commitment into the contract whereas for a sufficiently low fraction of company-owned stores, it is optimal not to have such a commitment.

This prediction is supported by our empirical analysis. We find a significant correlation between the fraction of company-owned stores and the strength of a contractual commitment to uniform standards in the data. We confirm in an ordered probit regression that this positive relation is robust to the inclusion of several control variables like a chain's size, age or its main product.

Chapter 1

Norms in a Partly Compliant Society

1.1 Introduction

The traditional economic postulate of a society inhabited only by selfish individuals has been severely challenged over the last decades by the insights of experimental economics. Although a substantial fraction of people shows behavior that is consistent with selfish behavior, a large fraction of people often acts in a reciprocal or altruistic way. For example, in one-shot interactions people cooperate in public good games or punish unfair behavior when punishment is costly (see e.g. Fehr and Gächter, 2000a). One reason for the observed behavior could be that people are guided by a set of implicit or explicit norms that describe how members of a community are supposed to interact (see Elster 1989 for a survey on social norms). Compliance with such norms may not always be selfish rational, and recent work like Charness and Dufwenberg (2005), Ellingsen and Johannesson (2004) or Gneezy (2005) explores the notion that compliance can arise because of intrinsic motivation, or feelings of guilt when one breaks norms that one has promised to keep or is expected to follow.[1]

To effectively incorporate norm-compliance into economic models, it is essential to have a tractable theory that predicts which concrete norms people follow in different situations. This paper proposes a simple, general principle that yields clear and empirically plausible predictions concerning such norms: *complier optimality*.

We consider a simple model with only two types of players: compliers, who are willing

[1]People's desire to avoid feelings of guilt together with a desire of consistency of words and actions has also long been analyzed in psycholgy, see e.g. Heider (1946), Newcomb (1953), Festinger (1957) or Cialdini (1993).

to follow norms by intrinsic motivation, and types who act selfishly rational and do not feel guilty when breaking a norm. Types are private knowledge, but the probability that a player is a complier (called complier's share) is commonly known. A *complier optimal norm* is a strategy-profile that maximizes the expected average utility of compliant types, given that it is common knowledge that compliers follow this norm. The principle of complier optimality is related to the philosophical concept of rule-utilitarianism, which has been strongly advocated as a rational form of moral behavior by John Harsanyi (see e.g. 1985 or 1992). The difference to complier optimal norms is that rule-utilitarian norms maximize the expected average of all players' utility — including utility of selfish types.

The main part of the paper analyses the predictions under complier optimal norms and rule-utilitarian norms for a series of games that have been widely analyzed in the experimental literature on fairness and social preferences.[2]

Already under the assumption that every player's material utility is linear in money, the model with complier optimal norms captures many of the experimental stylized facts. Examples are conditional cooperation, the use of costly punishment, the role of intentions, the observation that reciprocal subjects tend to trust more, or concerns for social efficiency.

For zero-sum games, complier optimal norms generally prescribe to act selfishly rational. Altruistic acts in games that are zero-sum in monetary payoffs, like giving in dictator games, can still be complier optimal, however, if preferences over material outcomes are extended for factors like risk-aversion, loss-aversion or envy.

Predicted behavior under rule-utilitarian norms is in some cases identical to, but often differs from, behavior under complier optimal norms. Roughly summarized, both types of norms have in common that they prescribe to punish non-cooperative behavior (or reward cooperative behavior), whenever common knowledge of such a norm can effectively induce selfish players to act more cooperatively. Rule-utilitarian and complier optimal norms usually differ, when no norm can effectively induce cooperative behavior by selfish types. This is for example the case when there is no or only a weak punishment option or norms cannot substantially change selfish players' incentives because the compliers' share is too small. In such cases, rule-utilitarian

[2]Although in recent years there has been a big interest in formalizing fairness and social preferences, we do not know of any work that analysis whether observations accross popular fairness experiments are in line with a model where some people follow rule-utilitarian norms. In general, there are surprisingly few applications or extensions of Harsanyi's game theoretic formulizations of rule-utilitarianism in the economic literature. One notable exception is the model by Feddersen and Sandroni (2006) who analyze voting-behaviour in a society with rule-utilitarian players.

norms essentially prescribe to act altruistic towards selfish players. An example is to cooperate as a second mover in a sequential prisoners' dilemma game even if the first-mover has defected — a prediction that is almost never observed in experiments. In contrast, complier optimal norms essentially prescribe in those cases to act selfishly towards selfish types; this means altruistic acts are only conducted if the probability that the other player is a complier is sufficiently large.

The range of experimental stylized facts matched by the model with complier optimal norms is quite large, compared to prominent models of social-preferences and reciprocity.[3] We compare the different concepts in Section 1.4.

Section 1.5 motivates complier optimal norms by showing that they arise endogenously in a voting-by-feet model. The basic idea is that a society consists of different communities that each have their own norm that prescribes how members of the community shall interact with each other. Players can freely migrate between communities and will join another community if that yields higher expected utility for themselves. In contrast to selfish players, a complier feels obliged to honestly follow the norm of the community she decided to join. We assume that no person can be prevented from migration — especially, compliers are not able to exclude selfish immigrants from their community. As is often the case in voting-by-feet models (see e.g. Conley and Konishi, 2002) traditional solution concepts do not yield satisfying results: in Nash equilibrium all norms can occur in populated communities; strong Nash equilibria typically do not exist. To make reasonable predictions, we introduce *migration-proof equilibrium* as a stability criterion. It requires stability against beneficial coalitional migrations. When evaluating the benefits of a coalitional migration, it is taken into account that uninvited players may join the migration.

We show first that — under some regularity conditions — a society constitutes a migration proof equilibrium if its entire population is located in a single community whose norm is complier optimal given the compliers' share of the total population. Second, in every migration-proof equilibrium, compliers' expected utility will be the same as in the society above. The voting-by-feet model can be easily extended by allowing communities also to differ in their institutions, which describe the enforceable rules that govern social interactions. We show that also complier optimal institutions arise.

The voting-by-feet approach differs from models that analyze development of pro-

[3]For example, Rabin (1993), Levine (1998), Fehr and Schmidt (1999), Bolton and Ockenfels (2000), Charness and Rabin (2002), Dufwenberg and Kirchsteiger (2004), Falk and Fischbacher (2006), Segal and Sobel (2007), or Cox et. al. (2007).

social behavior and culture from evolutionary perspectives (see Ostrom, 2000 or Bergstrom, 2002 for surveys). This is because in our model compliers, although voting-by-feet on norms and institutions, do not face evolutionary selection pressures when having lower payoffs than selfish players. We discuss the differences to evolutionary models in Section 1.6.2.

In Section 1.7, we present a moral justification for complier optimal norms. It is related to John Harsanyi's famous justification for rule-utilitarianism, which examines the moral code that people would rationally select in a fictitious 'original position' behind a veil of ignorance. Essential for the moral justification of complier optimal norms is the observation that even though selfish types receive no explicit welfare weight, they always have (weakly) higher expected utility than compliers. The reason is that, because types are private information, selfish types have the option to perfectly mimic compliant types.

The remaining paper is structured as follows. In Section 1.2, we present the basic model with compliers and selfish players, define complier optimal norms and rule-utilitarian norms and give existence results. In Section 1.3, we examine the model for prominent games analysed in the economic literature on fairness and compare predicted behavior with the experimental findings. In Section 1.4, we compare our approach with existing models of social preferences. Section 1.5 shows that complier optimal norms arise from a model of voting-by-feet. In Section 1.6, we discuss the voting-by-feet model and the differences to evolutionary approaches. Section 1.7 examines a moral justification for complier optimal norms. Section 1.8 concludes and illustrates a possible extension.

1.2 Basic Model

We first analyze the interaction between selfish players and compliers for any arbitrary norm. Resulting behavior is described by a *norm equilibrium*, for which we prove existence. Then we formally define rule-utilitarian and complier optimal norms.

1.2.1 Basic definitions

Social interaction in absence of compliers shall be described by a 'underlying game' with normal-form representation $G = (N, S, u)$. Note that G may be the normal-form representation of an extensive-form game. $N = \{1, ..., n\}$ describes the set of players; $S = S_1 \times ... \times S_n$ is the strategy space; $u : S \to R^n$ is the tuple of utility functions.

There are two types of players: compliers and selfish players. Types are private knowledge. Let $\theta = (\theta_1, ..., \theta_n)$ denote the actually drawn vector of players' types, where $\theta_i = 0$ means that player i is selfish and $\theta_i = 1$ means that player i is a complier. Types are independently drawn. The probability to draw a complier is κ and to draw a selfish player is $1 - \kappa$, with κ being common knowledge. We call κ the compliers' share in the population.

There is a norm $r = (r_1, ..., r_n) \in S$, which is simply a strategy-profile of the game G. Compliers always follow the norm, i.e. if player i is a complier she will play the strategy $r_i \in S_i$.

Selfish players take into account the behavior of compliers but do not feel guilty when violating the norm. Hence, for selfish players the presence of compliers transforms the original game G into a game of incomplete information. Let $s = (s_1, ..., s_n)$ denote the strategy profile played by selfish types in this game of incomplete information and define $s^{\theta}(s, r)$ by

$$s_i^{\theta}(s,r) := \begin{cases} s_i & \text{if } \theta_i = 0 \\ r_i & \text{if } \theta_i = 1 \end{cases} . \tag{1.1}$$

Thus, s^{θ} describes the strategies that are actually played, when the vector of selfish and compliant types θ is drawn. Let θ_{-i} and $s_{-i}^{\theta}(s, r)$ denote the types and played strategies of all players other than player i. For a given norm r and compliers' share κ, expected payoff of a *selfish player* i is then given by

$$u_i^{\kappa,r}(s) := \sum_{\theta_{-i}} \Pr(\theta_{-i}|\kappa) u_i(s_i, s_{-i}^{\theta}(s,r)) \tag{1.2}$$

where $\Pr(\theta_{-i}|\kappa) = \prod_{j \neq i} \kappa^{\theta_j} (1-\kappa)^{1-\theta_j}$. Since selfish players act individually rational, they must play a Nash equilibrium of the induced game with payoff function $u^{\kappa,r}(s)$. We denote this induced game by $G^{\kappa,r} = (N, S, u^{\kappa,r})$ and formally define

Definition 1.1 *A pair (r, s) of norm and selfish equilibrium strategy profile is a **norm equilibrium** for a compliers share κ and a game G if s is a Nash equilibrium of the induced game $G^{\kappa,r}$.*[4]

We will refer to the strategy profile s, which is played by selfish players in a norm equilibrium, as the *selfish (Nash) equilibrium.*

[4]Note that the norm r is *not* endogenously determined in a norm equilibrium. Endogenous in a norm equilibrium are only the selfish equilibrium strategies, which are induced by the given norm and compliers' share.

1.2.2 Existence of norm equilibria

We begin by establishing existence of norm-equilibria under relatively weak conditions.

Proposition 1.1 *If the underlying game $G = (N, S, u)$ fulfills the following three conditions*

1. *S_i is nonempty, compact and convex,*
2. *$u_i(s)$ is continuous in $(s_1, ..., s_n)$,*
3. *$u_i(s)$ is concave in s_i*

then for every $\kappa \in [0, 1]$ and every $r \in S$ a norm equilibrium exists.

Proof.
We need to show that for every $r \in S$ and every $\kappa \in [0, 1]$ the game $G^{\kappa,r}$ has a Nash equilibrium. We note that when G fulfills the three stated conditions, $G^{\kappa,r}$ also fulfills these conditions. For condition 1 this is clear, since $G^{\kappa,r}$ has the same strategy space as G. For Conditions 2 and 3 this holds true, because the payoff function of $G^{\kappa,r}$, i.e. $u^{\kappa,r}(s)$, is a linear combination of payoffs described by $u(s)$ and thus continuity / concavity of u implies continuity / concavity of $u^{\kappa,r}(s)$. The last step is to note that Conditions 1-3 are sufficient conditions for existence of a Nash equilibrium using the standard Nash-existence proof (see e.g. Mas-Colell et. al. 1995, p. 260-261). ■

In the usual Nash existence proof, only quasi-concavity of $u_i(s)$ in s_i instead of concavity is necessary. We need concavity because linear combinations of quasi-concave functions are not necessarily quasi-concave. The conditions stated in Proposition 1.1 are always fulfilled if G is a finite game, i.e. if every player's strategy space S_i is given by all mixed strategies over a finite set of pure strategies.

1.2.3 Equilibrium selection and refinements

In general, the game $G^{\kappa,r}$ may have multiple Nash equilibria, i.e. multiple norm equilibria may exist for a given norm and compliers' share. In those cases, we will define complier-optimal and rule-utilitarian norms conditional on a selfish equilibrium selection function $\psi : [0; 1] \times S \to S$, which selects for every compliers' share and norm a unique selfish Nash equilibrium of the game $G^{\kappa,r}$.[5] The selfish equilibrium selection

[5] A selection function technically facilitates the welfare analysis, since it guarantees a complete ordering of norms with respect to the expected average of compliers' or all players' utility. Robustness of the results can be checked by considering different equilibrium selection functions.

function can impose refinements on the class of selected equilibria. Especially, if the underlying game has sequential moves, selfish Nash equilibria that are not sequentially rational in the presence of compliers should be ruled out.[6] The selected selfish Nash equilibrium is denoted by $s(\kappa, r) := \psi(\kappa, r)$.

1.2.4 Selfish players' and compliers' expected utility

For a given selfish equilibrium selection function, we can write down the expected payoffs of a selfish player and a complier as a function of κ and r. For a selfish player i expected utility is given by

$$U_i(\kappa, r) := u_i^{\kappa,r}(s(\kappa, r)) = \sum_{\theta_{-i}} \Pr(\theta_{-i}|\kappa) u_i(s_i(\kappa, r), s_{-i}^{\theta}(s(\kappa, r), r)). \tag{1.3}$$

A compliant player i plays r_i and therefore her expected utility is given by

$$V_i(\kappa, r) := u_i^{\kappa,r}(r_i, s_{-i}(\kappa, r)) = \sum_{\theta_{-i}} \Pr(\theta_{-i}|\kappa) u_i(r_i, s_{-i}^{\theta}(s(\kappa, r), r)). \tag{1.4}$$

Since we assumed that each player has the same probability to be a complier, expected utility for selfish types is given by $U(\kappa, r) := \frac{1}{n}\sum_{i=1}^{n} U_i(\kappa, r)$ and for compliers by $V(\kappa, r) := \frac{1}{n}\sum_{i=1}^{n} V_i(\kappa, r)$.

Remark 1.1 *For every norm selfish players are weakly better off than compliers, i.e.*

$$V_i(\kappa, r) \leq U_i(\kappa, r) \ \forall i \text{ and } V(\kappa, r) \leq U(\kappa, r). \tag{1.5}$$

These inequalities must hold because types are private information and therefore a selfish player i can guarantee himself the expected payoff of a compliant player i by simply playing r_i himself.

1.2.5 Complier optimal and rule-utilitarian norms

Given a selfish equilibrium selection function ψ, we can now formally define complier optimal and rule-utilitarian norms. A norm r^o is complier optimal for a given share of compliers κ if it maximizes the expected average utility of compliant players, i.e.

$$r^o(\kappa) \in \arg\max_{r \in S} \{V(\kappa, r)\}. \tag{1.6}$$

[6] A sufficient condition for existence of a sequential equilibrium for every norm and compliers' share is that in every decision node of the underlying game there is only a finite set of possible actions. Examples 3.2, 3.3 and 3.5 illustrate games with sequential moves.

A rule-utilitarian norm r^u maximizes the expected average utility of all players (including selfish types), i.e.

$$r^u(\kappa) \in \arg\max_{r \in S} \{\kappa V(\kappa, r) + (1-\kappa) U(\kappa, r)\}. \tag{1.7}$$

We call a norm equilibrium with a complier optimal norm for a given κ, i.e. $(r^o(\kappa), s(\kappa, r^o(\kappa)))$, a *complier optimal norm equilibrium (CONE)*, and define similarly a *rule-utilitarian norm equilibria (RUNE)*.

Unfortunately, the sufficient conditions for existence of norm equilibria in Proposition 1.1 are not sufficient for the existence of complier optimal and rule-utilitarian norm equilibria. One can construct selfish equilibrium selection functions such that the objective functions on the right hand sides of equations (6) and (7) have no maximum, but only a supremum.[7] We can establish, however, a weaker existence result:

Proposition 1.2 *Assume G fulfills the conditions stated in Proposition 1.1. Then there exists a selfish equilibrium selection function ψ for which complier optimal norm equilibria (rule-utilitarian norm equilibria) exist for all κ.*

The proof is delegated to the appendix. It relies on an existence result for subgame-perfect equilibria in games with continuous strategy spaces by Börgers (1991).

1.3 Examples

In this section, we illustrate the models with complier optimal norms and rule-utilitarian norms for simple games that have been widely studied in the literature on fairness and compare the predictions with the experimental stylized facts.

We assume that selfish players act sequentially rational, and are 'weakly nice' in the sense that whenever they are indifferent between two actions, they choose that action that yields higher payoff for the other player. This guarantees existence of complier optimal and rule-utilitarian norm equilibria in all examples below.

1.3.1 A public goods game

Suppose social interaction is described by a simple public goods game with $n \geq 2$ players. Each player i chooses simultaneously an action $c_i \in \{0, 1\}$ where $c_i = 1$

[7] Consider, for example, a game where player 1 chooses a value $x \in [0, 1]$ and player 2 has no action. Player 1's payoff is always 0 and player 2's payoff is x. Consider a selfish equilibrium selection function where selfish player 1 chooses $x = 0$ if the norm says to choose 1, and $x = 1$ for every other norm. Then no complier optimal and no rule-utilitarian norm exist.

means she contributes one unit of money to a public good and $c_i = 0$ means she keeps the money for herself. We assume that every player has an identical linear utility function over monetary payoffs and that final payoffs are given by

$$u_i = \gamma \sum_{j=1}^{n} c_j - c_i \text{ with } \frac{1}{n} < \gamma < 1 \tag{1.8}$$

The parameter γ denotes the per capita return of contributing one unit to the public good. Since $\frac{1}{n} < \gamma < 1$, it is a strictly dominant strategy not to contribute, while the sum of payoffs is maximized if everyone contributes. Thus, selfish players will never contribute and it is straightforward to see that 'always contribute' is the unique rule-utilitarian norm for all feasible values of κ,[8] γ, and n. Complier optimal norms are characterized as follows:

Proposition 1.3 *For $\kappa > \frac{1-\gamma}{n\gamma-\gamma}$, the unique complier optimal norm is that all compliers contribute. For $\kappa < \frac{1-\gamma}{n\gamma-\gamma}$, the unique complier optimal norm is that no complier contributes. For $\kappa = \frac{1-\gamma}{n\gamma-\gamma}$, every norm is complier optimal.*

Proof.
Since non-contribution is strictly dominant, the norm has no influence on selfish players' behavior. Since, furthermore, the payoff is additive in each player's contribution, we can determine for each player i separately the complier optimal norm r_i. If a compliant player i contributes, her own payoff is reduced by $1-\gamma$, but the payoff of each of the other $n-1$ players increases by γ. A compliant player i knows for sure that she herself is a complier, but each other player is a complier only with probability κ. Therefore, contribution strictly increases compliers' expected utility if and only if $\kappa(n-1)\gamma > 1-\gamma$, which is equivalent to $\kappa > \frac{1-\gamma}{n\gamma-\gamma}$. The other two cases follow by similar reasoning. ■

The result is due to a trade-off between two factors. On the one hand, compliers should contribute, because other compliers can benefit from the positive externalities. On the other hand, contribution leads to a expected transfer of resources from compliers to selfish players (who themselves never contribute). Hence, in contrast to the rule-utilitarian norm, a complier optimal norm prescribes contribution only if the compliers' share κ is sufficiently high.

Furthermore, we find from the right hand side of the inequality $\kappa > \frac{1-\gamma}{n\gamma-\gamma}$ that compliers are rather willing to contribute if — ceteris paribus — the per capita return γ or

[8] To be precise, for $\kappa = 0$ every norm is a rule-utilitarian norm, which is true in all our examples. For briefness sake, we will not explicitly repeat this fact, but silently assume $\kappa > 0$ when we characterize rule-utilitarian norms.

the number of subjects n increase. That is because the expected positive externalities of contributions for other compliers become larger. This prediction is in line with the comparative statics from public goods experiments, see e.g. Isaac and Walker (1988), who show that — ceteris paribus — average contributions increase in the per capita return γ and group size n. In addition, Isaac and Walker find weak evidence that contributions fall in group size n when the total return of one contributed unit, i.e. $n\gamma$, is kept constant. This finding is also in line with predictions under complier optimal norms.[9]

1.3.2 A public goods game with a costly punishment technology

The experimental literature has established that contributions in public goods games can substantially increase if players have the opportunity to punish non-contributors, even if punishment is costly (see e.g. Fehr and Gaechter, 2000b). We show that these results are predicted by a models with complier optimal or rule-utilitarian norms.
Consider the two player version of the public goods game from Section 1.3.1 with a second stage where players can spend p units of money in order to reduce the other player's payoff by ηp. The parameter $\eta > 0$ describes the effectiveness of punishment. Thus, final payoffs after contributions (c_1, c_2) and punishment levels (p_1, p_2) are given by:

$$u_i = \gamma(c_1 + c_2) - c_i - p_i - \eta p_j \text{ for } j = 3 - i$$

The level of punishment p must be chosen from the interval $[0, \overline{p}]$, where $\overline{p}$ denotes an upper limit on the possible level of punishment.

Proposition 1.4 *If $\kappa\eta\overline{p} \geq 1 - \gamma$ then complier optimal and rule-utilitarian norms prescribe punishment of non-contributors with some (expected) level p that fulfills $p \geq \frac{1-\gamma}{\eta\kappa}$. In every resulting norm equilibrium all types contribute on the equilibrium path. If $\kappa\eta\overline{p} < 1 - \gamma$, no player will punish and outcomes are as in the public goods game without punishment.*

Proof.
Clearly, a sequential rational selfish player will never punish. Under a norm that prescribes punishment with an (expected) level of p after non-contribution and no punishment after

[9] Denote the total return by $\tau = n\gamma$. Compliers contribute whenever $\kappa > \frac{1-\frac{\tau}{n}}{\tau-\frac{\tau}{n}}$. Since $1 < \tau < n$, the right hand side is increasing in n. Thus, if τ is kept constant, compliers are less willing to contribute as n increases.

contribution, a selfish player will contribute if and only if $\kappa\eta p \geq 1-\gamma$ or $p \geq \frac{1-\gamma}{\eta\kappa}$. If also compliers contribute, this norm achieves the first best-outcome that everyone contributes and there is no punishment on the equilibrium path. Since this norm yields the first-best outcome, it is clearly rule-utilitarian. Since, additionally, compliers have the same expected utility than selfish types, the norm must also be complier optimal (recall that compliers can never have higher expected payoffs than selfish types).

For $\kappa\eta\overline{p} < 1-\gamma$, it is always rational for selfish players not to contribute, even when they will be maximally punished. Thus, punishment cannot change selfish players' behavior and therefore it cannot be complier optimal (or a rule-utilitarian norm) to spend any resources on costly punishment. Since there is no punishment, selfish players do not contribute and complier optimal and rule-utilitarian contribution decisions are the same as in the public goods game without punishment technology. ■

Thus, under a sufficiently strong punishment technology (i.e. $\kappa\eta\overline{p} > 1-\gamma$), it is a complier optimal and rule-utilitarian norm to punish non-contributors in order to induce selfish players to contribute.

Our model predicts that on the equilibrium path punishment must never be carried out by compliers. Punishment can occur with positive probability, however, if one relaxes the assumptions that the norm and compliers' share are common knowledge or that all selfish players act perfectly rational.[10]

1.3.3 A sequential prisoners' dilemma or simple trust game

We illustrate now a sequential prisoners' dilemma game, which can also be interpreted as a simple trust game. Assume payoffs are given as in the public goods game in Section 1.3.1, but there are only two players who sequentially decide whether to contribute or not. To simplify the exposition, we assume that the game is in pure strategies only. Since there are only 8 different pure strategy-profiles, the following intuitive results are straightforward to verify and we omit the formal proofs.[11]

Obviously, a sequential rational selfish player 2 will never contribute. A selfish player 1 may strictly prefer to contribute, however, if a compliant player 2 follows the norm of conditional cooperation: 'Contribute if and only if player 1 has contributed'. Expected

[10] For example, assume that a percentage q of selfish players errorneously believes that there are no compliers and therefore does not contribute. It is then complier optimal to contribute and to punish non-contributors with level $p^* = \frac{1-\gamma}{\eta\kappa}$ whenever $(\kappa + (1-q)(1-\kappa))\,\gamma - (1-\gamma) - q(1-\kappa)p^* \geq \max\{\kappa\gamma - (1-\gamma), 0\}$.

[11] Equilibrium outcomes remain the same, if we allow for mixed strategies and no interesting additional insights are gained.

payoff for a selfish player 1 from contributing is then given by $\kappa\gamma + \gamma - 1$. Since his payoff from not contributing is zero, he strictly prefers to contribute whenever $\kappa\gamma + \gamma - 1 > 0$, which is equivalent to $\kappa > \frac{1-\gamma}{\gamma}$. If this condition holds, the unique complier optimal norm and rule-utilitarian norm are identical and prescribe conditional cooperation for player 2 and contribution for player 1.

If the compliers' share is below the threshold $\frac{1-\gamma}{\gamma}$, a selfish player 1 cannot be influenced by any norm and will never contribute. Complier optimal and rule-utilitarian norms differ in this case.

The unique rule-utilitarian norm then prescribes contribution for player 1 and unconditional contribution by player 2. This means that, in order to increase total welfare, a player 2 shall contribute, even if he observes that player 1 has not contributed.

In contrast, conditional cooperation by player 2 and contribution by player 1 remains the unique complier optimal norm in the range $\frac{1-\gamma}{3\gamma-1} < \kappa \leq \frac{1-\gamma}{\gamma}$. Given that a compliant player 1 contributes and therefore perfectly separates from a selfish player 1, it is clear that conditional cooperation by player 2 must be complier optimal. Note, however, that a compliant player 1 has a negative expected payoff from contributing in this range. The reason that contributing is still complier optimal is that it creates a positive externality for a compliant player 2. A general interpretation of this result is that it can be complier optimal to trust other people to a larger extend than is individually rational. For $\kappa < \frac{1-\gamma}{3\gamma-1}$, contribution becomes too costly for a compliant player 1, however, and in no complier optimal norm equilibrium there will be contribution on the equilibrium path.

That player 2 either conditionally cooperates or does never cooperate is in line with experimental studies of sequential Prisoners' Dilemma games (see Bolle and Ockenfels, 1990, and Clark and Sefton, 2001, or Berg et. al., 1995, for trust games), where unconditional cooperation by player 2 is almost never observed. Thus, the predictions under complier optimal norms seem more plausible than under rule-utilitarian norms. The prediction that, as second movers, compliers act reciprocal while, as first movers, they trust more than selfish players is in line with recent experimental results by Altmann et. al. (forthcoming), who find that reciprocal subjects trust significantly more than selfish subjects.

1.3.4 Two player zero-sum games

Consider a two player zero-sum game $G = (\{1,2\}, S, u)$, with $u_1(s) + u_2(s) = 0$ for all $s \in S$. A general zero-sum theorem states that s^* is a Nash equilibrium of G if and only if for both players s_i^* is a maxmin strategy, i.e. $s_i^* \in \arg\max_{s_i \in S_i} \min_{s_j \in S_j} u_i(s_i, s_j)$.

Further, all Nash equilibria give the same expected payoff for player i, denoted by u_i^{maxmin}. We show that also in every complier optimal norm equilibrium expected payoff for both a compliant and selfish player i is given by u_i^{maxmin}.

Proposition 1.5 *Assume $\kappa < 1$. A norm r^o is complier optimal in a two player zero-sum game G if and only if $V_i(\kappa, r^o) = U_i(\kappa, r^o) = u_i^{maxmin}$ $\forall i$.*[12]

Proof.
Define $\Delta_i := U_i(\kappa, r) - V_i(\kappa, r)$ and note that $\Delta_i \geq 0$ (see Remark 1.1). Expected utility in a zero-sum game is 0, i.e. $\kappa V(\kappa, r) + (1-\kappa)U(\kappa, r) = 0$. This can be written as $\kappa V(\kappa, r) + (1-\kappa)\left[V(\kappa, r) + \frac{1}{2}\sum \Delta_i\right] = 0$, yielding $V(\kappa, r) = -(1-\kappa)\frac{1}{2}\sum \Delta_i$. If for some complier $V_j(\kappa, r) \neq u_j^{\text{maxmin}}$ at least one complier i gets lower expected utility than u_i^{maxmin}. Since a selfish player i can guarantee himself expected payoff of at least u_i^{maxmin}, by playing a maxmin strategy, this leads to $\Delta_i > 0$, implying $V(\kappa, r) < 0$. This cannot be complier optimal, since compliers' expected utility is 0 when the norm equals a profile of maxmin strategies. ■

Thus, complier optimal norms essentially prescribe to act selfishly in the zero-sum game. In contrast, *every* strategy-profile is a rule-utilitarian norm in a zero-sum game, since the sum of utilities does not depend on the played strategies.

Consider a dictator game where player 1 splits 1 unit of money between him and player 2. Assume both players have identical linear utility in own monetary payoff (using $u_i(\pi_i) = \pi_i - 0.5$ this yields a zero-sum game). By our result, the unique complier optimal norm is that player 1 keeps all money for himself. For intuition, note that with probability $(1-\kappa)$ transferred money would be given to a selfish player, which would reduce expected monetary payoff of compliers.

1.3.5 Dictator and ultimatum games and envy

Considering the previous example, note that a game which is zero-sum in monetary payoffs is not necessarily a zero-sum game according to players preferences, for example when players are risk-averse or feel envious. In this example, we illustrate the interplay between complier optimal norms and envy using the following utility

[12] Usually, this means that r^o must be profile of maxmin strategies itself. For a counterexample, however, consider a matching pennies game with $u(H, H) = u(T, T) = (1, -1)$ and $u(H, T) = u(T, H) = (-1, 1)$. The only maxmin strategy is an equal mix between H and T. For $\kappa = 0.5$, there exists, however, a complier optimal norm equilibrium with norm (H, H) and selfish equilibrium strategies (T, T), i.e. randomization takes place via a player's type.

function over monetary payoffs

$$u_i(\pi_i, \pi_j) = \pi_i - \alpha \max\{\pi_j - \pi_i, 0\} \text{ with } \alpha > 0.$$

Here, a player feels envy when he has a lower monetary payoff than the other player. The degree of envy α is assumed to be equal for all players, irrespective of whether a player is selfish or a complier. This utility function is a simplified version of inequity aversion by Fehr and Schmidt (1999) — simplified, because we do not incorporate a term that explicitly models "guilt", felt by a player who has a higher payoff than the other.

Dictator game

In a dictator game player 1 splits an amount of money between him and player 2. Let the total amount of money be normalized to 1 and let x denote the share offered to player 2. Clearly, a selfish player 1 will give nothing to player 2. When a compliant player 1 gives an amount $x^o \leq 0.5$ to player 2, compliers' expected utility is given by $\frac{1}{2}((1-x^o) + \kappa(x^o - \alpha(1 - x^o - x^o))$. Maximization of this term implies that it is complier optimal to offer

$$x^o \in \begin{cases} 0 & \text{if } \kappa < \frac{1}{1+2\alpha} \\ [0, 0.5] & \text{if } \kappa = \frac{1}{1+2\alpha} \\ 0.5 & \text{if } \kappa > \frac{1}{1+2\alpha} \end{cases}.$$

The condition $\kappa \lesseqgtr \frac{1}{1+2\alpha}$ illustrates two factors that determine how much a compliant player 1 should give to player 2. On the one hand, an equal split is beneficial because it reduces envy of a compliant player 2. On the other hand, transferring money has a negative effect because with probability $1-\kappa$ it is given to a selfish player 2. For $\kappa = \frac{1}{1+2\alpha}$ both effects balance out. For example, if $\alpha = \frac{1}{3}$ an equal split would be complier optimal in a dictator game whenever $\kappa \geq 0.6$.

Andreoni and Miller (2002) performed dictator experiments where transfers were multiplied by an efficiency factor f, i.e. monetary payoffs are given by $(1-x, fx)$. They show that for higher efficiency factors, dictators are more willing to make an equal split or even allow the responder to have a higher payoff. As is intuitively clear, our model matches this stylized fact.[13]

[13] In the set-up of Andreoni and Miller, a compliant dictator should give nothing if $\kappa < \frac{1}{f+(1+f)\alpha}$, equalize final payoffs if $\frac{1}{f+(1+f)\alpha} < \kappa < \frac{1+(1+f)\alpha}{f}$ and give everything if $\kappa > \frac{1+(1+f)\alpha}{f}$.

Ultimatum game

An ultimatum game extends a dictator game by giving player 2 (called responder) the opportunity to reject the offer x by player 1 (called proposer), in which case both get paid zero. It is straightforward to show that an envious selfish responder accepts only offers that are weakly higher than $x^* := \frac{\alpha}{1+2\alpha}$. Furthermore, we find:

Proposition 1.6 *In every complier optimal norm equilibrium all proposers offer $x^o := \min\{0.5, \kappa + (1-\kappa)x^*\}$ and all offers are accepted on the equilibrium path. Outcomes of rule-utilitarian norm equilibria are the same with the one exception that compliant proposers always offer $x = 0.5$.*

The formal proof is relegated to the appendix, but we give the basic intuition here. If compliant responders follow a norm where they reject all offers below a level $x^o > x^*$ and accept an offer of x^o, a selfish proposer, who trades-off the probability of a rejection and the gains from offering only x^*, is willing to offer x^o as long as $x^o \leq \kappa + (1-\kappa)x^*$. It can never be complier optimal (or a rule-utilitarian norm) that a compliant proposer offers less than a selfish proposer.[14] It is therefore optimal to induce selfish proposers to make offers that are as near as possible to an equal split in order to reduce total envy , i.e. to select $x^o := \min\{0.5, \kappa + (1-\kappa)x^*\}$. That under a complier optimal norm a compliant proposer offers never more than x^o, becomes intuitively clear from the following observation: whenever κ and α are sufficiently high such that an equal split in the dictator game is complier optimal, we also have $x^o = 0.5$.
In contrast to the dictator game, in the ultimatum game an arbitrary small amount of envy already suffices to find substantial offers in complier optimal norm equilibria, since

$$\lim_{\alpha \to 0} x^o = \min\{\kappa, 0.5\}.^{15}$$

The stylized facts from ultimatum experiments (see for example the overviews by Güth, 1995, Camerer and Thaler, 1995 or Roth, 1995), can be summarized as follows: The vast majority of offers lie between 0.4 and 0.5, virtually no offer exceeds 0.5 and offers below 0.2 are very rare. Offers near 0.5 are practically never rejected, whereas the rejection rate for offers below 0.2 is very high. In our model we find, that all offers

[14] Intuitively, this is simply a consequence of the general fact that a compliant proposer can never have higher expected payoff than a selfish proposer.

[15] The same result holds if players are infinitesimal loss-averse with reference level 0.5 or risk averse under equal initial wealth. When players are monetary payoff maximizers, offers between 0 and κ can be found in different complier optimal norm equilibria.

below 0.2 are rejected if $x^* = 0.2$, which corresponds to $\alpha = \frac{1}{3}$. For this level of α we find $x^o = \min\{0.2 + 0.8\kappa, 0.5\}$. This means that already for $\kappa \geq \frac{1}{4}$ observed offers x^o should lie between 0.4 and 0.5.

Ultimatum game with non-intentional offers

Blount (1995) performed an experimental treatment where the offer was not selected by the proposer but randomly chosen by a computer. She showed that minimal acceptance levels are significantly lower when the offer was randomly selected, but that some offers still were rejected. Blount's finding can be explained by our model. It is straightforward to check that for $\alpha < \kappa$, complier optimality prescribes that a compliant responder accepts all offers (for rule-utilitarian norms the condition is $\alpha < 1$; if envy is larger, very unequal offers may be rejected under both norms, however). A compliant responder still feels envy, but weighs the monetary payoff of a compliant proposer higher than her envy. The difference to the intentional treatment arises because for random offers a norm has no strategic impact on proposers' behavior. An envious selfish responder, however, still rejects every offer below x^*, since it does not matter for him how the offers were selected.
Our model similarly also captures the role of intentions in other experiments, like behavior in best-shot games (see Harrison and Hirshleifer 1989, Prasnikar and Roth 1992) or the mini-ultimatum games analyzed in Falk et. al. (2003).

1.4 Comparison with models of social preferences

In the examples of Section 1.3, we illustrated that our behavioral model based on complier optimal norms is in line with important stylized facts from experiments, like conditional cooperation, costly punishment of non-cooperators, the role of intentions, as well as concerns for social efficiency. In this section we briefly review some prominent models of social preferences (see Sobel, 2005 for a detailed survey), and discuss an important conceptual difference to our model.

Overview of existing models

In inequity aversion theories, as Fehr and Schmidt (1999) or Bolton and Ockenfels (2000), players do not like inequalities in monetary outcomes, which can explain costly punishment like rejection of low offers. Since utility depends only on outcomes, these models have the advantage to be analytically convenient, but also the drawback that they cannot account for the role of intentions.

In Levine (1998) and in the generalization by Gul and Pesendorfer (2005) types are to a different degree altruistic or spiteful and there is a reciprocal element in the form that players like high payoffs for altruistic types but dislike high payoffs for spiteful types. In their model intentions can matter because selected actions can signal a players' type.

Another set of social-preference models, including Rabin's (1993) fairness theory for normal form games, builds on psychological game theory (Geanakoplos et. al., 1989) where players can get utility from beliefs. The reciprocity models by Dufwenberg and Kirchsteiger (2004) or Falk and Fischbacher (2006) extend the framework to extensive form games. In these models, another player's action is classified as 'unkind' if he also could have chosen another action that would lead to a higher payoff on the equilibrium path for oneself (Falk and Fischbacher also include equity concerns). Players get emotional satisfaction from punishing 'unkind' actions and rewarding 'kind' actions.

Charness and Rabin (2002) consider a welfare criterion that is a mixture of the sum and minimum of all players' payoffs. Reciprocal players dislike other players whose strategies show that they do not put sufficient weight on the welfare criterion. Their exact solution concept is implicitly based on psychological games and quite complex.[16]

López-Pérez (2006) proposes a 'norm-based' approach that uses the same welfare-criterion as Charness and Rabin. He assumes that there are some morally motivated people who follow that strategy-profile that would maximize the criterion if *everyone* complied to this strategy-profile. While those strategy-profiles do not prescribe punishment, he assumes that players feel not obliged to follow the norm once another player deviated and get emotional satisfaction from punishing the deviator.

A different rationale for costly punishment

The presented models describe the use of costly punishment as a consequence of negative emotions like envy, dislike, or anger towards non-cooperative people that one is currently interacting with. In contrast, a prescription by complier optimal norms and rule-utilitarian norms to punish non-cooperators is based on a positive concern for the broad group of all compliers or all people, respectively.

For example, the reasoning of a complier who observed non-cooperative behavior in a situation where costly punishment is complier optimal could be as follows: "I do not like to punish this selfish guy, since it is costly for me and I do not care about his payoff. If every complier, however, thought this way and decided not to punish then selfish players would not take the threat of punishment seriously and the welfare of

[16] For alternative reciprocity models, see also Cox et. al. (2007) or Segal and Sobel (2007).

every complier would be reduced in the long run. Therefore, I will punish him — for the sake of all compliers."

In most situations it is difficult to distinguish whether a decision to punish is triggered by negative emotions or because people think it is a social duty to punish non-cooperators. Indeed, in our opinion both factors are likely to play a role, and to increase the realism of our model negative emotions should be included, as we illustrated for the case of envy.

The hypothesis that compliance to social norms plays at least some role in a decision to punish non-cooperative behavior is supported by a neuro-economic study by Knoch et. al. (2006). They considered the question whether subjects that are confronted with a low offer in an ultimatum game have either an immediate emotional impulse to reject the low offer that can be overwritten by rational concerns to take the money, or whether there is an immediate selfish impulse to take the money that can be overwritten by concerns for social or moral norms to reject the low offer. They show that disruption of the dorsolateral prefrontal cortex (DLPFC), a part of the brain that is widely thought as a control instance that can inhibit immediate motivational impulses, leads to substantially higher acceptance rates in ultimatum games. They interpret this result as indication that subjects have an immediate selfish impulse to accept low offers, but that a non-disrupted DLPFC can inhibit such an selfish impulse if it contradicts social or moral norms.

1.5 Competition of norms and institutions via voting by feet

1.5.1 Overview

In this section we show that complier optimal norms arise from a model of voting-by-feet. The basic idea is that a society consists of different communities with different norms. Social interactions take place only within a community, but inhabitants can freely migrate between communities. While compliers always accept and follow the norms of the community they decided to join, selfish players do not feel guilty when breaking those norms. It is straightforward to allow communities not only to differ in their norms, but also in their institutions that describe the enforceable rules and technological constraints of social interactions.

We do not claim that selection of norms and institutions in real world does mainly occur via voting-by-feet. Instead this selection seems to be the outcome of a rather

complex process, influenced by historical events, opinion leaders, election outcomes and many more factors. Nevertheless, although being a rough simplification, we think that our voting-by-feet model is able to capture important elements of this selection process, like the idea that the success of new norms or institutions depends on which types of inhabitants are primarily attracted by these new norms and institutions.
To simplify the exposition, we first introduce our voting-by-feet model by analyzing competition of norms only. We start with a formal definition of a society and define a *Nash-stable equilibrium* as a society where no individual inhabitant wants to migrate to another community. Then we introduce the concept of a *migration-proof equilibrium*, where we additionally require stability against coalitional migrations that are successful even if non-invited players join. We then discuss five conditions that are needed for the main results, which follow. Afterwards, we extend the model such that the voting-by-feet process jointly determines institutions and norms. In Section 1.6, we discuss the relation of our stability criterion to existing concepts.

1.5.2 Formal definition of a society

A society is populated by a continuum of compliant and selfish inhabitants of measures $\hat{\mu}_c$ and $\hat{\mu}_s$, respectively. The compliers' share in the society's total population is denoted by $\widehat{\kappa} := \frac{\hat{\mu}_c}{\hat{\mu}_c+\hat{\mu}_s}$. A society is described by a finite set of communities $\{C^j\}_{j\in J}$ (indexed by a set J) over which the total population is distributed. Each community is characterized by a tuple $C^j = (\mu_s^j, \mu_c^j, r^j)$, where μ_s^j and μ_c^j are the measures of selfish and compliant inhabitants and r^j the community's norm. We assume that every community has a positive measure of inhabitants and let κ^j denote the compliers' share in community C^j. A community's inhabitants randomly meet in small groups and play a game G that describes the institutional rules of social interaction. Until Section 1.5.8 we consider the game G, and the selfish equilibrium selection function ψ to be exogenously given and to be the same in all communities. We assume that each position in the game is equally likely for each inhabitant. Thus, expected utility of a compliant inhabitant of community C^j is given by $V(\kappa^j, r^j)$ and of a selfish inhabitant by $U(\kappa^j, r^j)$.

1.5.3 Nash-stable equilibrium

Our first requirement for a stable society is that there are no two communities where inhabitants of the same type get different expected utility. We say a single selfish / compliant inhabitant *prefers to move* from his origin community C^o to a populated destination community C^d if selfish / compliant inhabitants' expected utility in C^d is *strictly* higher than in C^o. We formally define:

Definition 1.2 *A society $\{C^j\}_{j\in J}$ constitutes a* ***Nash-stable equilibrium*** *if no inhabitant prefers to move to another existing community.*

Since we do not allow a single inhabitant to create a new community, every society consisting of a single community is Nash-stable, i.e. every norm can occur in some Nash-stable society.

1.5.4 Motivating migration-proof equilibrium

In the concept of migration-proof equilibrium —introduced below— we allow for the possibility that inhabitants can jointly migrate to a new or existing community. The concept takes seriously the limits of coalition formation due to private information of types and our assumption that no one can be prevented from migration.

We want to motivate the basic ideas with a simple example: Let the game G be a public goods game and consider a society with initially only one community C^0, which has as norm that nobody contributes. Consider now the possibility of public announcements like the following: "To all compliers in community C^0, let us migrate jointly to a new community C^1, where will all follow the norm to contribute to the public good! You will all be better off there!". Our solution concept will be based on the idea that the addressees of such announcements are willing to migrate if and only if migration is strictly beneficial even in the case where other, non-invited, inhabitants, who prefer to follow to the new community, join the migration.

In our example, also all selfish players prefer to migrate from C^0 to C^1, once compliers follow the announcement and move to C^1. Since types are private knowledge, we assume that compliers are not able to exclude the selfish inhabitants from their new community C^1. If all selfish inhabitants follow to C^1, resulting compliers' share in C^1 will be again $\widehat{\kappa}$. Thus, in this example, the joint migration will be beneficial in the long run for the originally addressed compliers only if contribution in a population with compliers' share $\widehat{\kappa}$ leads to higher compliers' expected utility than following a norm of no contribution.

1.5.5 Formalizing migration-proof equilibrium

Let a collection $M = (\{m_c^j, m_s^j\}_{j=1}^J, C^d)$, describe a simultaneous migration to a community C^d. An entry $\{m_c^j, m_s^j\}$ means that from community C^j compliers of measure

m_c^j and selfish inhabitants of measure m_s^j participate in the migration M. As one building stone of our definition, we need to introduce the notion of uncoordinated migration:

Definition 1.3 *We say a migration M can occur uncoordinatedly if the destination community C^d already exists and every participant of M prefers to move from her origin community to the destination community (evaluating expected utilities as given before the migration).*

Obviously, uncoordinated migration can occur only in societies that are not Nash-stable. In the spirit of the example above, we also want to allow for announced migrations, where a set of inhabitants is invited to jointly migrate to some new or existing community C^d. If people follow the announcement and the coordinated migration takes place, the society may not be Nash-stable anymore and other inhabitants may follow to C^d via uncoordinated migration. We assume that individuals are skeptical about announcements and only want to participate in the announced migration, if this is strictly beneficial, no matter who follows to C^d via uncoordinated migration. Formally:

Definition 1.4 *An **announced migration** M to a destination community C^d is **successful** if and only if for every sequence of uncoordinated migrations to C^d that may occur afterwards, the participants of M are strictly better off in C^d than they were initially.*

This leads to the definition of a migration-proof equilibrium:

Definition 1.5 *A society constitutes a **migration-proof equilibrium** if it is Nash-stable and no successful announced migration exists.*

1.5.6 Conditions

We will now present joint conditions on the game and selfish equilibrium selection function, that are required for our results.

Condition 1 (C1) *A complier optimal norm $r^o(\kappa)$ exists for all κ.*[17]

All our examples fulfill this condition.

[17]Condition C1 can be relaxed such that a complier optimal norm has to exist just for $\widehat{\kappa}$. This requires, however, a more complicated formulation of conditions C3, C4.

Condition 2 (C2) *There are at least some compliers in the society, i.e.* $\widehat{\kappa} > 0$.

Condition 2 is relevant because we can obviously say nothing interesting about norms when it is common knowledge that there are no compliers at all.
For the next condition, let us define the highest payoff that selfish inhabitants can achieve, under the given selfish equilibrium selection function, when no compliers are present by

$$U_{\kappa=0} := \max_{r \in S} U(0, r). \tag{1.9}$$

Condition 3 (C3) *For every* κ *compliers can be least as well off as inhabitants of a purely selfish community, i.e.* $V(\kappa, r^o(\kappa)) \geq U_{\kappa=0}\ \forall \kappa$.

Condition 4 (C4) *The highest expected utility that compliers can achieve in a community with the societies' share of compliers* $\widehat{\kappa}$ *is as least as high as the expected utility compliers can achieve in a community with a smaller compliers' share, i.e.* $V(\kappa, r^o(\kappa)) \leq V(\widehat{\kappa}, r^o(\widehat{\kappa}))$ *for all* $\kappa < \widehat{\kappa}$.

Conditions C3 and C4 could only be violated when there are multiple selfish Nash equilibria, and even then only for certain ill-behaved selfish equilibrium selection functions. To illustrate a violation consider a game G with payoff-matrix

	A	B
A	1,1	0,1
B	1,0	0,0

The unique complier optimal norm is (A,A), but every strategy-profile is a selfish Nash equilibrium. Problems arise, for example, with a selfish equilibrium selection function that selects (B,B) when in a community $\kappa \geq \widehat{\kappa}$ and (A,A) when $\kappa < \widehat{\kappa}$. Then conditions C3 and C4 are violated and one can easily show that no migration-proof equilibrium exists where a community has complier share $\widehat{\kappa}$, i.e. Proposition 1.8 (below) could not hold. For 'regular' selfish equilibrium selection functions conditions C3 and C4 are, however, always fulfilled. The following proposition exemplifies a sufficient condition, on the selfish equilibrium selection function.

Proposition 1.7 *Conditions C3 and C4 are fulfilled if always a selfish Nash equilibrium* $s(\kappa, r)$ *is selected that maximizes compliers' expected utility.*

Proof.
C3: Let $s_{\kappa=0}$ be a Nash equilibrium where players in a completely selfish community get utility of $U_{\kappa=0}$.Under the norm $r := s_{\kappa=0}$, for every compliers' share the strategy profile

$s_{\kappa=0}$ is a selfish Nash equilibrium, i.e. compliers get expected payoff of at least $U_{\kappa=0}$ if the complier optimal selfish Nash equilibrium is chosen.
C4: We find a moral norm r' that guarantees compliers a payoff of at least $V(\kappa, r^o(\kappa))$ for any $\kappa' > \kappa$. For all i, let r'_i be a mixed strategy where with probability $\frac{\kappa}{\kappa'}$ the original moral norm $r_i^o(\kappa)$ is played and with probability $(1 - \frac{\kappa}{\kappa'})$ the selfish Nash strategy $s_i(\kappa, r^o(\kappa))$ is played. When complier apply r' in a community with complier share κ', clearly $s(\kappa, r^o(\kappa))$ will be a selfish equilibrium. When $s(\kappa, r^o(\kappa))$ is selected complier' expected utility is given by $\frac{\kappa}{\kappa'}V(\kappa, r^o(\kappa))+(1 - \frac{\kappa}{\kappa'})U(\kappa, r^o(\kappa)) \geq V(\kappa, r^o(\kappa))$. ■
Conditions C1-C4 are fulfilled in all examples in Section 1.3 and are sufficient for our existence result (Proposition 1.8 below). For the uniqueness result (Proposition 1.9 below), we additionally need the following condition:

Condition 5 (C5) *There exists a complier optimal norm $r^o(\widehat{\kappa})$ such that for all $\kappa > \widehat{\kappa}$ one has $V(\kappa, r^o(\widehat{\kappa})) \geq V(\widehat{\kappa}, r^o(\widehat{\kappa}))$.*

Condition C5 says that at least for some complier optimal norm $r^o(\widehat{\kappa})$, compliers' are not worse off when the fraction of compliers is higher than $\widehat{\kappa}$, i.e. selfish players are not needed to obtain a compliers' expected utility of at least $V(\widehat{\kappa}, r^o(\widehat{\kappa}))$. The condition is fulfilled for all examples in Section 1.3.

1.5.7 Main results

The following propositions characterize all migration-proof equilibria, and show that norms arise that are complier optimal for the society's share of compliers $\widehat{\kappa}$.

Proposition 1.8 *Assume conditions C1-C4 hold. A society consisting of a single community that applies a complier optimal norm $r^o(\widehat{\kappa})$ constitutes a migration-proof equilibrium.*

Proposition 1.9 *Assume conditions C1-C5 hold. In every migration-proof equilibrium compliers' expected utility equals $V(\widehat{\kappa}, r^o(\widehat{\kappa}))$ in all communities.*

The basic intuition behind these results is simply that selfish players want to be where compliers are and compliers (who cannot get rid of selfish players) want to be in a place with a complier optimal norm. The robustness of these results and the relation to different solution concepts are discussed in Section 1.6.

1.5.8 Simultaneous competition of institutions and norms

It is straightforward to extend the voting-by-feet model, by allowing communities also to differ in the game that describes the enforceable rules of social interaction (this game is labeled as an 'institution') and in the way how selfish Nash equilibria are selected.

Assume social interactions can be structured in different ways that are characterized by a set of possible games Γ.[18] Let $N(G), u(G), S(G)$ denote the set of players, payoff functions, and strategy profiles of a game $G \in \Gamma$. For each game G there is a set of possible selfish equilibrium selection functions $\Psi(G)$. As described in Section 1.2.3, a selfish equilibrium selection function $\psi \in \Psi(G)$ selects for every norm and compliers' share a Nash equilibrium of the induced game $G^{\kappa,r}$, which is played by selfish players. The set of selfish equilibrium selection functions $\Psi(G)$ should include only those selection functions that obey sensible equilibrium refinements, like sequential equilibrium.

A community shall be characterized by its population as well as a triple of game, norm and selfish equilibrium selection functions $\lambda = (G, r, \psi)$ with $r \in S(G)$ and $\psi \in \Psi(G)$. We call λ a *norm-institution* and denote by Λ the set of all possible norm-institutions. Expected utility of compliers and selfish inhabitants within a given community are denoted by $V(\kappa, \lambda)$ and $U(\kappa, \lambda)$ and are defined as in Section 1.2.4. A norm-institution that is complier optimal for complier share κ is defined by

$$\lambda^o(\kappa) \in \Lambda^o(\kappa) := \arg\max_{\lambda \in \Lambda} V(\kappa, \lambda). \tag{1.10}$$

It turns out that the same definitions, which we used to model competition of norms, can be used to model competition of norm-institutions and that we get equivalent results. To derive this model, we simply have to replace every norm that appears in conditions C1-C5 and in Propositions 1.8 and 1.9 and their proofs by the corresponding norm-institution. The proofs of Propositions 1.8 and 1.9 carry over, because they only make use of conditions C1-C5 (especially the monotonicity conditions C3-C5) and of the fact that in no community selfish players can be worse off than compliers, which is also true when communities are described by norm-institutions.

To sum up, this implies, first that there is always a migration-proof equilibrium with the entire population in a community C^o that has a complier optimal norm-institution $\lambda^o(\widehat{\kappa})$, and second that in all migration-proof equilibria compliers' utility is given by

[18] Except for requiring that the modified versions of conditions C1-C5 (see in the text below) hold, we need no additional restriction on the set of games.

$V(\widehat{\kappa}, \lambda^o(\widehat{\kappa}))$. In other words: A complier optimal combination of institution, norm, and selfish equilibrium strategies arises.

Gürerk et. al. (2006) conducted an economic experiment where subjects could vote-by-feet between two different institutions: a public goods game with a costly punishment option and one without (Section 1.3.2 illustrates that having a punishment option is indeed always weakly better for compliers). In their experiment, virtually the whole population migrates to the community with the institution that allows for costly punishment, which is in line with our theoretical prediction. There over 40% of subjects punish non-contributors and high levels of contribution can be stabilized.

1.6 Discussion of the voting-by-feet model

1.6.1 Migration-proof equilibrium compared to existing concepts

Voting-by-feet is much analyzed in a branch of literature emerging from Tiebout (1956), who analyzed local provision of public goods. In voting-by-feet models there is a notorious difficulty in finding an appropriate solution concept. One faces a problem of too many equilibria when using a Nash concept (e.g. Westhoff, 1977) or of non-existence when requiring stability against all immediately beneficial coalitional deviations (see e.g. Greenberg and Weber, 1986). Conley and Konishi (2002) discuss these problems and resolve some of them for a special Tiebout model by defining a "migration-proof Tiebout equilibrium", which requires stability only against those coalitional deviations that can be successful when accounting for possibly induced future migration. More generally applicable are the theory of social situations by Greenberg (1990) or the largest consistent set by Chwe (1994), which are based on related ideas.

These concepts, however, are defined only for a finite number of inhabitants. Also, they consider a full information environment where types of all players are known and there are no informational problems in coalition formation. Thus, we cannot directly use these concepts but define migration-proof equilibria to extend the basic ideas to our set-up.

Since the results of voting-by-feet models depend on the solution concept, we want to sketch which aspects of migration-proof equilibrium are crucial for our results.

Under concepts that require stability against all immediately beneficial coalitional deviations (like strong Nash equilibrium or the core), equilibria in our set-up would generally not exist. For example, suppose the institution is given by the public goods game described in Section 1.3.1. If a society has a community inhabited only by compliers with contribution as norm, a coalition of selfish inhabitants benefits by migrating to this community. In all other societies, a coalition of compliers benefits by creating such a community. Therefore, no society would be stable against all immediately beneficial coalitional deviations.

We already noted that in a Nash stable society all norms can arise in societies consisting only of a single community, because a single player cannot create a new community. We also would not get our general results in a model with myopic migration dynamics where new communities arise by chance with some random initial population — a setup resembling models of competition of conventions in coordination games, like Ely (2002) or Oechssler (1997). In such a model, stability would strongly depend on the exact specification of the underlying migration dynamics — especially it would hinge on the factors determining whether compliers or selfish inhabitants migrate more quickly to a newly emerged community. To get some intuition why, note that a community with high compliers' share and a reasonable norm will be an attractive destination for both compliant and selfish migrants. If compliers initially migrate more quickly, the compliers' share in such a new community will remain high and the compliers' share in the existing communities will fall. This makes further migration more attractive, and the new community can grow and thereby substantially destabilize the society. If, on the other hand, initially many selfish inhabitants migrate to the new community, its complier share will drop, making further migration unattractive and may even induce the few initial compliers to leave. The new community may therefore quickly cease existence, i.e. it would not destabilize society.

In summary, to get our general results it is important that new communities are created by coalitional migrations and it is also important that members of a coalition take into account that other non-invited inhabitants may follow the migration. One will find, however, that our results are robust to several variations of the equilibrium concept that do not violate these key assumptions. For example, it is not crucial that members of the coalition only worry about uncoordinated migration by uninvited inhabitants: Even if one defined an announced migration M to be successful when participants of M are strictly better off by migration no matter which subset of uninvited inhabitants joins the migration, the results in Propositions 1.8 and 1.9 would still hold.

1.6.2 Relation to evolutionary models

It is reasonable to assume that over a long period of human history, reproductive success was strongly linked to material wealth, while at the same time most people stayed for their whole life within the same local communities, where neighbors usually were well informed about of each others' behavior. A series of papers (see Ostrom, 2000 or Bergstrom, 2002 for excellent surveys) have shown how under such conditions pro-social behavior, like conditional cooperation, or preferences that can lead to such behavior, like an aversion to break norms, can survive biological evolution.

Our voting-by-feet model considers a quite different world where guilt-averse and selfish players interact, but reproductive success is not linked to material wealth, interactions can take place anonymously, and people can freely choose between different communities where they perform social interactions. We argue that these assumptions indeed capture important aspects of the modern world.

First, in modern welfare-states it seems clearly no longer the case that only rich people are able to get many offsprings. Also, cross-country correlations yield no evidence for a positive correlation between material income and population growth in the modern world. Using the Penn World Table (Heston et. al. 2006), one finds that in every year since 1984 a country's population growth rate is even *negatively* correlated to its previous year's GDP per head.[19]

Second, many people in the modern world are mobile and have substantial freedom in choosing their communities in which different forms of social interactions take place, like the firm they work in, the clubs and organizations in which they spend their free time, or the online communities where they sell and buy used products.

Third, with modern information technology it is feasible and often inexpensive to create institutions in which social and economic interactions take place anonymously. If in the modern world still many interactions take place within institutions that try to avoid anonymity and make a person's past behavior transparent (like, for example, the reputation mechanism used by Ebay), this may simply be due to the fact that such institutions are selected because they are complier optimal.

Often evolutionary models do not intend to model biological evolution, but interpret the evolutionary process as a learning model where players imitate other successful players. Thinking of such models, one could ask why we assume that compliers do not *learn* to be selfish. A simple answer is that a guilt averse player may not *want* to imitate selfish persons who break their communities' norms, since she would feel bad

[19]For the whole data set, starting in 1950, we find such negative cross-country correlations in more than 75% of all years.

when doing so.
In summary, our analysis is not targeted to substitute evolutionary or learning models but aimed to complement their insights by analyzing competition of norms and institutions under different assumptions that form a somewhat opposite but nevertheless sensible approximation of the modern world. Since the behavioral predictions of the two approaches are quite similar, i.e. reciprocity and conditional cooperation typically emerge in both settings, our findings add therefore to the robustness of the general insights from evolutionary models.

1.7 A moral justification for complier optimal norms

This section describes an alternative justification — a moral justification — for complier optimal norms, which is based on a variation of the tale that John Harsanyi (e.g. 1985 or 1992) used to motivate rule-utilitarianism. Harsanyi, similar to John Rawls (1973), considered a fictitious original position where all people of a society gather to decide upon a moral code. This gathering takes place behind a veil of ignorance, where no one knows what will be his position later in real life. Harsanyi shows that in such an original position everyone wants to choose rule-utilitarian norms, i.e. norms that maximize every person's identical expected utility behind this veil of ignorance. In our model with selfish and compliant types, rule-utilitarian norms would be preferred by every person in the original position if there is complete ignorance about one's type later in life, i.e. if no one knows whether she will be compliant or selfish.
In our variation of this tale, the gathering in the original position consists of two steps. In the first step, every person is free to make a commitment to comply —later in life— to the moral code that will be selected in the second step, i.e. every person decides whether she wants to be a complier or not. In the second step, those and only those people that declared compliance will gather and decide upon the moral code. Since only compliers are present in the second gathering, everyone prefers those norms that maximize expected utility of compliers, i.e. complier optimal norms.
How is the procedure in our tale that only compliers decide over the moral code morally justified? An initial decision to be a complier can be considered as a gift to the other members of the society. That is because everyone in the society is weakly better off if some people decide to be compliant than if everyone were selfish. Furthermore, this gift is costly for compliers in so far that selfish people are always weakly better off than compliers. We find it indeed morally well justified that a poorer person

(complier) making a costly gift to richer persons (selfish types), who do not make a gift themselves, can at least freely decide how much she wants to give. This means it is acceptable to choose complier optimal norms and thereby make a smaller, less costly gift to selfish players than if rule-utilitarian norms were selected.

In our variation of the tale, we assumed that the decision to be a complier or selfish is a deliberate decision of every person, while in the first version types are something that nature chooses when it determines the positions in real life. Asking whether the one or the other version seems more reasonable leads to deep philosophical questions about whether all our preferences and acts are predetermined or whether we indeed have a free will and a free choice to act morally or not and can be held responsible for our choice. Since a thorough discussion is far beyond the scope of this paper, we only note that many authors in the philosophical and ethical literature share the view that there is free choice and personal accountability for a decision to act morally or not (see e.g. Eshleman, 2004, and, O'Connor, 2006, for good introductionary surveys on the topics).

Finally, we want to stress that the given moral justification for complier optimal norms is based on the assumption that selfish types are never worse off than compliers, which is the case in our model because selfish types act rationally, types are private knowledge and both types have identical abilities and preferences over material payoffs. It is beyond the scope of this paper to evaluate moral implications in situations where selfish players may also be worse off than compliers, like cases where selfish types are bounded rational.

1.8 Concluding remarks

Like existing models of social preferences and reciprocity this paper has been motivated by the large amount of experimental evidence showing that many people deviate in systematic ways from selfish behavior. The common approach of social preference models is to directly augment preferences by concerns for other players' payoffs (these concerns can depend on types, observed actions or beliefs) such that resulting equilibrium behavior matches empirical stylized facts. This paper has contributed to the development of an alternative approach: First, assume some players are willing to follow strategies that correspond to certain social or moral norms; then find a general and tractable principle that describes for any given game the precise form of these norms and makes predictions that are in line with empirical stylized facts.

We have proposed complier optimality as such a general principle. It has some appealing properties. First, although we consider a very simple model with only two types, predictions are in line with many important stylized facts across experiments. Second, like rule-utilitarianism, it can be justified as a moral principle that describes a form of collectively rational behavior. Third, complier optimal norms arise from a model of voting-by-feet.

Despite these appealing properties, it is also clear that the presented model with only two types is neither able nor intended to match in detail the large heterogeneity in individual behavior that is typically observed in experiments. In principle the idea of complier optimal norms could be extended to more complex models with several types, who, for example, differ in their degree of norm compliance. While allowing for more realism, such extensions are likely to reduce the tractability of the model, however.

Some analytically simple modification of the model can be achieved by letting complier optimal norms maximize some transformed version $\widetilde{V}(\kappa, r)$ of compliers' expected utility. For example, compliers may dislike when selfish players are in expectation much better off. A quadratic formulation of such *exploitation aversion* is incorporated by setting $\widetilde{V}(\kappa, r) := V(\kappa, r) - \gamma(U(\kappa, r) - V(\kappa, r))^2$ with $\gamma > 0$.

Chapter 2

Legal Unbundling can be a Golden Mean between Vertical Integration and Ownership Separation

2.1 Introduction

In many industries vertically integrated firms are not only active in the final product market, but they also supply essential inputs to potential downstream competitors. Prominent examples are network industries, like energy, rail, or telecommunications where access to a transmission or a railway network is an essential input. Another example is the software industry where, e.g., Microsoft offers "compatibility" to Windows and at the same time competes in the applications market. An important and heavily researched policy question is: should vertical integration be allowed? Standard arguments in favor of integration are that integration at least partially overcomes the double marginalization problem and that it might provide better investment incentives for the upstream operations. The main motivation to vertically separate an integrated firm is that integration can lead to discriminatory behavior against downstream competitors.

We analyze a third alternative: legal unbundling. Legal unbundling means that the essential input must be controlled by a legally independent entity with an autonomous management, but a firm that is active in the downstream market is still allowed to own this entity. Ownership under legal unbundling entitles the downstream firm to receive the entity's profits, but interferences in the entity's operations are forbidden. Forms of legal unbundling are commonly observed in network industries. Legal unbundling is the current standard requirement for the energy industry in Europe, and the related concept of "Independent System Operators" is also an option in the proposals for a new EU regulation.[1] In the US, forms of legal unbundling exist for natural gas pipelines and in large parts of the electricity transmission systems that are operated by Regional Transmission Organizations or Independent System Operators.[2] Similar forms of "partial separation" are also common in the telecommunications industry in Europe and the US.[3]

Irrespective of how the industry is vertically structured, the price for the essential input is usually regulated. Typically, regulators use linear tariffs above the marginal cost, e.g., in order to allow for the coverage of fixed costs. While non-discrimination with respect to the access tariff is relatively easy to impose,[4] non-tariff discrimination remains an important problem in practice. Regulators and competitors report of such "sabotage" in form of discriminatory information flows, undue delays in delivery of the service, overly complex contractual requirements, requiring unreasonably high bank guarantees and the like.[5] Our research question therefore is: How does legal unbundling compare to the outcomes of vertical integration and vertical separation if access prices are regulated while non-tariff discrimination cannot be prevented?

To answer this, we propose a fairly general setup. There is one upstream monopolist (F_0), a potentially integrated affiliated downstream firm (F_1), the "incumbent", and

[1] For the electricity market, see Directive 2003/54/EC, Articles 10 (1) and 15 (1), for the gas market, see Directive 2003/55/EC, Articles 9 (1) and 13 (1) and the proposal to amend this Directive issued 2007-09-19.

[2] See Federal Energy Regulatory Commission, Order 636 (issued 1992-04-18) for natural gas and Order 2000 (issued 1999-12-20) for electricity transmission.

[3] For the US see Section 272 of the Telecommunications Act of 1996; for the European Union see Directive 2002/21/EC, Article 13 (1b).

[4] Although this also can be an issue, e.g., if non-linear tariffs are used. They might be tailored such that only the subsidiary of the integrated company can realize low prices. Exactly for this reason, regulators are skeptical about such tariffs. See, e.g., European Commission, Energy Sector Inquiry, Competition report on energy sector inquiry (Jan. 10, 2007), part 1, para 155, p. 58. One example was the access to the Deutsche Telekom network required to offer narrowband internet access (a product called T-Online-Connect-Interconnect), where Deutsche Telekom offered quantity rebates which were only realized by its own subsidiary "T-Online". The regulatory authority ruled this to be discriminatory. See the German regulator's annual report "Tätigkeitsbericht 1998/99", p. 67.

[5] See, e.g., European Commission, Energy Sector Inquiry (Jan. 10, 2007), Competition report on energy sector inquiry, part 1, para 169, or para 493, p. 163: For the Telecommunications sector, see for instance a submission of the VATM (Association of competitors to Deutsche Telekom) to the European Commission, "Markteintrittsbarrieren im deutschen Telekommunikationsmarkt", September 2001.

$n - 1$ potential downstream competitors. The upstream firm produces an essential input at constant marginal cost c_0, which the downstream firms need in a fixed proportion to produce the final output. We impose no other restriction on the downstream firms' technologies, in particular, some or all competitors might be more or less efficient than the incumbent F_1. In the downstream market, the incumbent moves first; no other restrictions are imposed on the downstream competition. Strategies could, for example, affect quantities, (non-linear) prices, investments or entry decisions. That the incumbent moves first is mainly a simplifying assumption; we exemplify with Cournot competition that the main results also apply with simultaneous moves in the downstream market.

The upstream firm F_0 sells the input to all downstream firms at a regulated linear access price a above marginal costs (we also extend this setup to more general forms of price regulation). Although price discrimination is not possible, F_0 can "sabotage" the downstream firms, i.e., it can influence the cost and demand situation of each downstream firm.

Four different vertical structures are compared: integration of F_0 and F_1; separation (i.e., all firms are independent); legal unbundling (F_0 is legally independent and maximizes its own profits but is owned by F_1); additionally, we discuss also "reverse unbundling" where the downstream firm is legally unbundled — although this seems to be of less relevance in practice.

Our main result is that legal unbundling leads to (weakly) higher levels of output than all the other vertical structures. In many cases, higher output will translate into (weakly) higher consumer surplus under legal unbundling. The intuition for why legal unbundling leads to higher quantities than vertical integration is as follows. Due to the access price regulation, upstream profits of F_0 are maximized when total output is maximal. Thus, if F_0 is legally unbundled, it wants to maximize total output and refrains from sabotage of the downstream firms. In contrast, with vertical integration, F_0 also takes into account downstream profits of F_1 and may engage in sabotage of downstream competitors in order to increase downstream profits. We call this the *"sabotage effect"*.

When comparing legal unbundling to vertical separation, more complex forces are at work. First, since in both cases the upstream firm wants to maximize total output, neither under legal unbundling nor under vertical separation will the upstream (usually) sabotage downstream firms, i.e., there is essentially no sabotage effect.

Second, while a vertically separated downstream firm F_1 is interested only in its own profits, under legal unbundling F_1 also has an interest in high upstream profits — and thereby in a high overall output. Under legal unbundling, the downstream firm F_1 will therefore select strategies that yield higher total output compared to separation. We call this the *"downstream expansion effect"*.

Part of the downstream expansion effect is explained by the well-known intuition from the double marginalization problem: Under legal unbundling the incumbent calculates with the true input costs c_0 and not — as under separation — with the higher access price a and is therefore willing to expand output. In addition, the incumbent takes into account that he can induce an output change by downstream competitors. We call this the *"induced output effect"*. For instance, in the case of legal unbundling and price competition, the incumbent sets a lower price than under separation, in order to increase the output of entrants, who respond to the more aggressive pricing by lowering their own prices. That the induced output effect is indeed additional to the effect from double marginalization becomes apparent when one considers more sophisticated regulatory schemes that solve the double marginalization problem. Even under those schemes, the induced output effect can lead to output expansion under legal unbundling, as discussed in Section 2.5.1.

Since one of the main policy concerns is about efficient network investments, we extend our analysis to different forms of investment decisions. Given our quantity results, it is quite intuitive that incentives for reducing the upstream firm's marginal costs are highest under legal unbundling. We also discuss capacity investments, which can discriminate between downstream firms, and incentives to invest in network reliability. For these two types of investments it is not generally clear that legal unbundling provides the highest investment incentives. Nevertheless, legal unbundling exhibits some desirable properties also for these sorts of investment decisions.

Despite its great policy relevance in the European Union, there is little literature on legal unbundling. Two important exceptions are Sibley and Weisman (1998) and Cremer, Crémer, and De Donder (2006). They have introduced the idea that the unbundled firm independently maximizes its own profits, while being a fully-owned subsidiary. Both analyse, however, only the case that we label *reverse* legal unbundling. This means they assume that the downstream firm has an independent management that maximizes own profits while the upstream firm maximizes joint profits.[6]

Sibley and Weisman analyse in a Cournot set-up whether an upstream monopolist has stronger incentives for sabotage under reverse legal unbundling than under vertical

[6]Despite some ambiguity in regulatory practice, the case of legal unbundling seems, in our opinion, closer to most existing regulatory requirements that prescribe legally independent network operators than the case of reverse legal unbundling.

integration, and find mixed results. Cremer et. al. compare reverse legal unbundling with ownership separation in a model that does not consider sabotage, but focuses on relationship-specific investments. In their model, reverse legal unbundling leads to higher total output than ownership separation.

Our analysis shows, however, that, for quite general forms of downstream competition and sabotage technologies, reverse legal unbundling always leads to (weakly) lower output than ownership separation, which suggests that, unlike legal unbundling of the upstream operations, reverse legal unbundling seems not to be an arrangement that is beneficial for consumers.

In a companion paper, Höffler and Kranz (2007), which is included as Chapter 3 in this dissertation, we analyze the effects of imperfections in legal unbundling. This provides a robustness check for our results and is briefly reviewed in Section 2.6.

Apart from this, our paper is related to the general literature on vertical integration, where an overview is provided, e.g., in Perry (1989). Vickers (1995) compares vertical integration with ownership separation under access price regulation and finds mixed welfare results. More recent papers compare investment incentives under vertical integration and separation, like Bühler, Schmutzler, and Benz (2004), who find that generally incentives for quality investments are higher under vertical integration.

Incentives for sabotage by a vertically integrated upstream monopolist have, for example, been studied by Economides (1998), Beard et. al. (2001) or Mandy and Sappington (2007) for different sabotage technologies and forms of downstream competition. The seminal analysis on the issue of cost raising strategies and sabotage of competitors is given by Salop and Scheffman (1983).

Studying legal unbundling also offers interesting insights into the role of ownership in the theory of the firm. The defining characteristic of ownership can be the right for residual cash-flows (i.e. profits) as in Alchian and Demsetz (1972) or, alternatively, a residual right of control as in Grossman and Hart (1986). Whereas under vertical integration both rights are granted to the incumbent, under legal unbundling ownership entitles to claim residual cash-flows, but grants no (or very limited) residual rights of control.

The remainder of the paper is organized as follows. Section 2.2 presents the basic model, where we assume a regulated linear access price, and where we derive the basic results. Section 2.3 examines the different types of upstream investments. Several results are illustrated for the case of price competition with homogenous goods in Section 2.4, which also includes a complete welfare analysis for this example. In Section 2.5, we present a general class of regulatory pricing schemes (including two-part tariffs for downstream firms), for which our results hold. Section 2.6 discusses the results, policy implications, and the effects of imperfect legal unbundling. Section 2.7 concludes. Unless otherwise stated, all proofs can be found in the appendix.

2.2 Basic model and results

2.2.1 Assumptions and main results

Structure and Regulation There is a monopolistic upstream firm F_0 that produces a good at constant marginal costs c_0, which is used as input good for n competing downstream firms, $F_1, ..., F_n$. Each downstream firm needs a constant and identical amount of the input good to create an output good. For simplicity, we normalize input quantities such that each firm needs exactly one unit of the input good to create one unit of an output good.

Non-tariff Discrimination We assume F_0 is a regulated natural monopoly, e.g. the owner of an essential transmission network in electricity or telecommunication markets. The regulator fixes a per-unit access price $a > c_0$ that F_0 must charge from all downstream firms (in Section 2.5, more general pricing schemes are considered). The regulator can enforce the access price but cannot prevent F_0 from hindering some or all downstream firms in some other way. F_0 chooses an action $h \in H$ that specifies some sabotage strategy against downstream firms, like non-disclosure of essential information or undue delays in the provision of ancillary services. Sabotage can increase access costs for certain downstream firms or reduce their demand by creating inconveniences for customers. We assume that the choice of h has no direct impact on the profit of F_0, although perhaps indirectly it does, if it changes the total quantity sold.

Timing First, F_0 chooses its sabotage strategy h. In the extensions of Section 2.3, F_0 also makes investment decisions. Then, downstream firms engage in downstream competition. An action of downstream firm i is denoted by x_i and $x = (x_1, ..., x_n)$ denotes a profile of actions selected by the downstream firms. Downstream actions can describe a broad range of decisions, for example about quantities, prices, investments, entry or sabotage against competitors.

Unless otherwise stated, we assume that the downstream incumbent F_1 moves first and that $F_2, ..., F_n$ can observe the chosen action x_1. Whether the other downstream firms afterwards move simultaneously or sequentially does not matter for our results. The assumption that the incumbent moves first significantly facilitates the analysis. The basic intuition carries over also to simultaneous move games; however, for these games some additional standard regularity assumptions are required, as we exemplify for Cournot competition.

We are focusing on subgame perfect equilibria in each of the different games.

Downstream Market and Payoffs Downstream actions, together with sabotage, determine downstream firm i's output $q_i(x,h)$, its market price $p_i(x,h)$ and total costs $C_i(x,h|a)$. Total output quantity is given by $Q(h,x) = \sum_{i=1}^{n} q_i(x,h)$.[7] F_0's profits are given by

$$\pi_0(x,h|a) = (a - c_0)Q(x,h) - K + S \qquad (2.1)$$

The constant K represents fixed costs and the constant S possible state subsidies. Note that these upstream profits π_0 are strictly increasing in total output Q. Profits of downstream firm i are given by

$$\pi_i(x,h|a) = p_i(x,h)q_i(x,h) - C_i(x,h|a) \text{ for } i = 1, ..., n \qquad (2.2)$$

Besides a regularity condition that subgame-perfect equilibria exist in every continuation game (Condition C1 below), we make no restrictions on functional forms.

Vertical structures We compare the following four vertical structures.

v : Vertical integration. F_0 and F_1 maximize their joint profits π_{01}, given by

$$\pi_{01} = \pi_1 + \pi_0 \qquad (2.3)$$

s : Vertical separation. All firms maximize their own profits π_i.

u : Legal unbundling: F_0 maximizes its own profits, whereas F_1 maximizes the joint profits π_{01}.

r : Reverse legal unbundling: For comparison reasons, we also consider this case where F_0 maximizes joint profits π_{01} and F_1 maximizes its own profits π_1.

The entering downstream firms $i = 2, ..., n$ maximize their own profits π_i under all vertical structures.

Legal unbundling requires that the network part, or more generally, the part of the company controlling the essential facility, has to be separated into a legally independent entity. The EU legislation explicitly states, however, that legal unbundling does not imply that the integrated firm has to sell the network operations. Thus, 100% ownership of the network operations F_0 by the incumbent F_1 is current practice under legal unbundling in many European countries (e.g. in the energy industries in France and Germany).

Legal unbundling in our model is perfect in the sense that we assume that regulators are able to incentivize the management of F_0 such that it maximizes only upstream

[7]If firms play mixed strategies, these variables denote expected values. In that case, we assume that all firms are risk-neutral.

profits π_0 without considering the incumbent's downstream profits π_1. Arguably, this does not always mirror the actual practice of legal unbundling; however, existing legislation explicitly excludes direct instructions of the mother company (Directive 2003/54/EC, Article 10 and 15) or prescribes arm's-length relations (US Telecommunications Act 1996, Section 272 (b) [5]). A couple of other rules and initiatives may help to implement legal unbundling in a way that comes closer to the "ideal" form assumed in the model. This includes the current requirement in the EU energy industry to have strict personnel separation, ensuring that professional interests of the upstream firm's employees are separated from downstream interests (e.g. the network unit's managers should not participate in the group's stock option programs). Furthermore, strict compliance with these independence requirements are compulsory for 'Independent System Operators' in the new EU proposal for an amendment of Directive 2003/54/EC (issued 2007-09-19). However, to see how our results are affected by a less stringent separation of interests, we discuss the effects of "imperfect legal unbundling" in Section 2.6.

Access prices When we compare the different vertical structures, we consider a given access price a that is the same in every vertical structure. We will perform this comparison for every possible access price $a > c_0$. As we will discuss below, our results are more general than if we had compared only the optimum access price for each vertical structure.

Regularity conditions Since we compare different vertical structures, we essentially compare outcomes of different games. Note, however, that — although payoffs of F_0 and F_1 differ — the timing, the set of players and the strategy space is the same under every vertical structure. To facilitate the comparison of different vertical structures, we introduce two regularity conditions. A *situation* shall describe a vertical structure and a non-terminal history of the multi-stage game, i.e. a history where at least one player still has to move. In order to avoid technical complications that could arise if some continuation games have no subgame-perfect equilibrium, we require:

C1 *In every situation there is a subgame-perfect continuation equilibrium.*

Note that for some forms of downstream competition and sabotage technologies, a given situation can have multiple subgame-perfect continuation equilibria. To simplify comparison between vertical structures in those cases, we also make a regularity condition on equilibrium selection:

C2 *Assume two situations have an identical set of subgame-perfect continuation equilibria. Then in both situations the same subgame-perfect continuation equilibrium shall* *be selected from this identical set.*[8]

This regularity condition avoids tedious comparison of sets of equilibria. Note that C2 is obviously not needed when, in every situation, there is a unique continuation equilibrium. The following remark summarizes the essential implications of the regularity conditions for the subgame-perfect equilibria in our model:

Remark *Since downstream entrants' profits do depend on h and x, but not directly on the vertical structure, our regularity condition implies that the equilibrium actions of downstream entrants are a function of h and x_1 only. Furthermore, assuming the same sabotage strategy h is chosen under legal unbundling and vertical integration, then downstream firms choose the same equilibrium actions x, since the incumbent maximizes joint profits $\pi_0 + \pi_1$ under both vertical structures.*

We are now ready to state our first basic result.

Proposition 2.1 *Under legal unbundling, total output Q and upstream profits π_0 are (weakly) higher than under vertical integration. The result still holds under downstream competition in simultaneous moves.*

Intuitively, total output is higher under legal unbundling than under vertical integration, because vertical integration can cause a *sabotage effect*. Recall from the remark that the outcome under legal unbundling and vertical integration can differ only if F_0's sabotage strategy h differs. (This still holds if the downstream incumbent moves simultaneously with downstream entrants.) Under legal unbundling, F_0 considers only upstream profits π_0 and therefore chooses h in order to maximize total output Q. This choice can usually be interpreted as performing no sabotage. Under vertical integration, however, F_0 has incentives to sabotage downstream competitors whenever sabotage sufficiently increases the incumbent's downstream profits π_1 — even though the sabotage may decrease upstream profits π_0 and total output Q. We now state our second basic result:

Proposition 2.2 *Under legal unbundling total output Q and upstream profits π_0 are (weakly) higher than under separation.*

The intuition for Proposition 2.2 differs from that of Proposition 2.1. Under both legal unbundling and separation, the upstream firm F_0 wants to maximize total output Q, i.e. there is no sabotage effect. In contrast to separation, under legal unbundling

[8] Note that there is no conceptual problem in determining whether continuation equilibria under different vertical structures are identical or not, since equilibria are strategy profiles and the strategy space is the same under every vertical structure.

the downstream incumbent F_1 participates in the upstream profits π_0 and therefore has an interest to select a decision x_1 that expands total output Q. We call this the *downstream expansion effect.*

To gain further intuition for the downstream expansion effect, we consider some specific examples of downstream competition. It is helpful to decompose the output expansion under legal unbundling into two parts: the change in the incumbent's own output q_1 and an *induced output effect* that measures the aggregate change in downstream entrants' output.

Consider first the simple case that there are no entrants and F_1 is a downstream monopolist, i.e. there is no induced output effect. Then the output expansion under legal unbundling is due to the intuition known from the double marginalization problem: Under legal unbundling F_1 considers only the true marginal costs c_0 instead of the higher access price a and therefore chooses a higher output than under separation.

In the presence of entrants, the incumbent additionally takes the induced output effect into account. In Section 2.4, we discuss in detail an example where firms compete in prices. Basically, the incumbent sets an aggressively low price in order to induce higher output by the downstream entrants who match the low price. Even if the access price a converges to the marginal cost c_0, the quantity under legal unbundling is still larger than under vertical separation since—although the double marginalization problem vanishes—the induced output effect is still present.

If firms compete in quantities, a quantity expansion by the incumbent typically induces an output reduction by the entrants. Since the incumbent moves first, he will always take the induced output effect into account and we will thus never find that F_1 takes an action such that total output is lower under legal unbundling than under separation. This means the downstream expansion effect will never be negative when F_1 moves first.

2.2.2 Additional results

Legal unbundling vs separation under simultaneous moves If the incumbent and entrants move simultaneously, F_1 still prefers higher total output under legal unbundling than under separation. We cannot, however, in general exclude that the incumbent's desire to have higher total output may paradoxically lead to lower total output in equilibrium. Thus, the result of Proposition 2.2 will typically hold only under additional assumptions when downstream firms move simultaneously. An example for this is to consider Cournot competition downstream and to assume a specific sabotage technology: Assume that sabotage linearly increases costs, i.e. $h =$

$\{h_1, ..., h_n\} \in R^n$ such that the costs of firm i become $C_i(h) = (a + h_i) q_i + \widetilde{C}_i(q_i)$ where $\widetilde{C}_i(q_i)$ is just some arbitrary function of q_i. With this assumption, we retain our result of larger quantities under legal unbundling also for the case of simultaneous quantity competition:

Proposition 2.3 *Consider the special case of the linear sabotage technology. Assume downstream firms compete by simultaneously setting quantities (goods can be differentiated). Then total output is (weakly) higher under legal unbundling than under both separation and vertical integration.*

Under Cournot competition the incumbent does not directly take the induced output effect into account, i.e. its best reply function takes competitors' output as given. The downstream expansion effect is therefore driven by the double marginalization problem: Under legal unbundling, the incumbent calculates with true marginal costs c_0 instead of the higher access price a. Typically, a reduction in one firm's marginal costs will lead to a higher total output in the Cournot equilibrium (see, for example, Farell and Shapiro (1990) for weak regularity conditions for the case of homogeneous goods). The reason that Proposition 2.3 also holds for cases where total output is increasing in a firm's marginal cost, is that the upstream firm can then prevent output reduction by increasing the incumbent's marginal costs via the linear sabotage technology.
Let us finally discuss simultaneous price competition with differentiated products in the downstream market. Under price competition, the incumbent wants to set lower prices under legal unbundling than under separation, because lower prices increase output. As long as prices are strategic complements, i.e. entrants react to a lower price of the incumbent by lowering their own prices, and total output is weakly decreasing in each firm's price, we find that under legal unbundling no firm sets higher prices and total output is weakly higher than under separation.
Implications of the output results Our output results suggest that from the consumers' perspective, legal unbundling is likely to be superior to the other two vertical structures. In particular, if the downstream products are homogenous (like, e.g., voice calls, electricity, or gas) and if downstream firms charge linear tariffs, it is immediate that higher quantities yield also a higher consumer surplus.

Corollary 2.1 *If output goods are perfect substitutes and downstream firms use linear tariffs, consumer surplus is weakly highest under legal unbundling.*

Legal unbundling can also be preferred by taxpayers, since F_0 makes higher profits than under the other vertical structures: if the regulatory regime requires an ex ante subsidy that ensures that F_0 will break even, then such a subsidy would be lowest under legal unbundling.

Corollary 2.2 *The minimal state subsidy, which guarantees that F_0 makes no losses, is lowest under legal unbundling.*

Total welfare Without assumptions on how discrimination works and how downstream competition works, results on total welfare are not possible. Clearly there are cases where legal unbundling leads to higher output but to lower welfare, for example if there are sunk costs and legal unbundling facilitates excess entry (see the seminal paper by Mankiw and Whinston, 1986). Nevertheless, there will be many cases where total welfare is also highest under legal unbundling. One such case — a homogeneous goods duopoly with price competition — is exemplified in Section 2.4.

Comparison under optimal access prices Assume consumer surplus (and / or total welfare) is increasing in total output and regulators consider an access price to be optimal if it maximizes total output under the restriction that the upstream firm can recover its fixed costs. In general, the optimal access price can depend on the vertical structure, and one may be interested to compare the total output, under the condition that under each vertical structure the optimal access price is selected. Our results imply that legal unbundling leads to (weakly) higher total output than separation and vertical integration also for the case that such optimal access prices are chosen in every vertical structure. Recall that we have shown that for every access price $a > c_0$ legal unbundling leads to (weakly) higher output than the other vertical structures. Thus even for the access prices that yield the highest output under separation or vertical integration, legal unbundling will lead to (weakly) higher output and (weakly) higher upstream profits. The output difference will even increase if for legal unbundling one would also choose the optimal access price.

Reverse legal unbundling In order to make our results comparable to Cremer et. al. (2006), what is left to discuss is the case of "reverse unbundling". Recall that reverse legal unbundling means F_0 maximizes $\pi_0 + \pi_1$, whereas F_1 has an independent management and maximizes π_1. In practice, this would imply that e.g. a integrated electricity company would have to form a legally independent sales unit which is owned by the network operations (or by the whole group, including generation facilities). The important point is that with reverse legal unbundling the essential facility would not be separated into an independent unit. We find that reverse unbundling leads to lower quantities in equilibrium compared to vertical separation and, by Proposition 2.1, also to lower quantities than legal unbundling.

Proposition 2.4 *Total output Q and upstream profits π_0 under reverse legal unbundling are weakly lower than under separation.*

This finding is different to the results of Cremer et. al. (2006), because they compare reverse legal unbundling with separation in a model that focuses on relation-specific investments; in this framework, reverse legal unbundling is better suited than separation to overcome the hold-up problem.

2.3 Investments

2.3.1 Capacity Investments and Discriminatory Investments

Many types of upstream investments will influence output by downstream firms, e.g. by changing the network capacity. Benefits and impediments from such investments can accrue differently to different downstream firms. For example, investments into interconnection capacity to a foreign country benefit foreign energy producers who want to sell in the domestic market of the network operator.

In the policy debate, there are severe concerns that vertical integration and legal unbundling lead to socially inefficient allocations of such investments, because of overlapping interests of the network operator and the downstream incumbent. The EU Commission states:

> Vertically integrated network operators have no incentive for developing the network in the overall interests of the market and hence for facilitating new entry at generation or supply levels; on the contrary, they have an inherent interest to limit new investment when this will benefit its competitors and bring new competition onto the incumbent's "home market". Instead, the investment decisions made by vertically integrated companies tend to be biased to the needs of supply affiliates. Such companies seem particularly disinclined to increase interconnection or gas import capacity and thereby boosting competition in the incumbent's home market to the detriment of the internal market.[9]

The Commission also makes clear that in its opinion only ownership unbundling, i.e. complete separation, can effectively solve this problem:

[9]Proposal for amending Directive 2003/54/EC concerning common rules for the internal market in electricity, (issued 2007-09-19), p.5.

> Economic evidence shows that ownership unbundling is the most effective means to ensure choice for energy users and encourage investment. This is because separate network companies are not influenced by overlapping supply/generation interests as regards investment decisions.[10]

As we have shown in our basic model, not all overlapping interests are problematic. Under legal unbundling, the downstream expansion effect as one sort of an overlapping interest, is rather beneficial. Therefore, a more careful analysis of the investment incentives may turn out to be useful.
For the theoretical analysis it is helpful to split F_0's investment decisions into two steps. One step is to decide on the allocation of investment if the total amount that shall be invested is given. The other step is to decide which total amount shall be invested.
Investment allocation with given budget We first analyze F_0's allocation decision, assuming that the total amount of investment spending is given. We simply take our basic model and interpret F_0's strategic variable h not only as a sabotage strategy, but also as a decision about the investment allocation, which influences downstream firms' costs and output. This interpretation is completely consistent with our model where downstream firms' output, prices and costs are given by some general functions $q_i(x, h)$, $p_i(x, h)$ and $C_i(x, h|a)$. It is also fulfilled that the allocation of investment has no influence on F_0's costs, because the total amount invested is assumed to be given in this step.
Thus, our output results also apply, i.e., for a given sum of investment, F_0 will under legal unbundling always choose that allocation of investment that maximizes total output.
Endogenous investment budget Examining the second step, we cannot rule out, however, that the total amount of investment is lower under legal unbundling than under the alternative vertical structures. There even exist cases, where the resulting quantities can be lower under legal unbundling.
We first illustrate why investments I^s and resulting total output Q^s under separation may exceed the investments I^u and total output Q^u under legal unbundling in some circumstances. Assume that (i) the incumbent is more efficient than the entrants, such that absent an investment, no entrants would be active and (ii) an investment would yield a level playing field for entrants and the incumbent. Under separation and without investment, the double marginalization problem would lead to a quantity

[10] EU Commission, An Energy Policy for Europe, p. 7, Brussels, 10.1.2007, COM(2007) 1 final.

lower than under legal unbundling. Thus, investing would yield a large increase in downstream quantities if, due to the investment, we moved from, say, a downstream monopoly to a Bertrand duopoly with identical costs. This increases upstream profits significantly and implies that the investment would be undertaken even if it is relatively costly. With legal unbundling, however, the network unit F_0 might find it optimal not to invest, since it can anticipate that in the quantity decision of the incumbent F_1, the double marginalization problem is internalized and the quantity is relatively large already without an investment.

That investments under vertical integration, I^v, can be higher than under legal unbundling, $I^u < I^v$, is less surprising and applies already in quite intuitive examples. Consider an investment that benefits only the incumbent F_1, who might then be able to drive competitors out of the market. This might reduce overall quantity, such that with legal unbundling the network unit F_0 would abstain from such an investment. While, in this case, investments are lower under legal unbundling, quantities will (typically) be higher under legal unbundling. However, it is not possible to generally rule out that legal unbundling with discriminatory investments can yield lower quantities than vertical integration.

Although total output may be lower under legal unbundling when the investment budget is endogenous, we can establish the following results:

Proposition 2.5 *With capacity investments F_0's profits from network operations π_0 minus investment costs are weakly higher under legal unbundling than under both separation and vertical integration. Total output fulfills the following inequalities:*

$$(a - c_0)(Q^s - Q^u) \leq I^s - I^u \text{ and } (a - c_0)(Q^v - Q^u) \leq I^v - I^u.$$

Concerns for the incumbent's downstream profits play no role in those cases where investment levels are lower under legal unbundling. If investments and total output are lower under legal unbundling this is because higher investment is not worthwhile for the network operator itself.

The inequalities of Proposition 2.5 show that the output differences $Q^s - Q^u$ and $Q^v - Q^u$ can become large only if the difference in investment costs becomes large. One can, therefore, conjecture that such "expensive" expansions of downstream quantities are not welfare-enhancing. However, a comprehensive welfare analysis is not possible in our general framework.

The inequality also shows that possible under-investment may be reduced by increasing the access price a. This might be done in ways that do not distort downstream firms' demand when using the more general regulatory schemes illustrated in Section 2.5.

2.3.2 Investments in reducing upstream marginal costs

We now consider process innovations, i.e., investments of F_0 which reduce its marginal costs c_0 by some amount δ. Investment costs $I(\delta)$ are strictly increasing in the level of marginal costs reduction δ. We first establish the following helpful lemma, which just proves the intuitive idea that for a lower level of upstream marginal costs total output will be weakly higher.

Lemma 2.1 *Total output under legal unbundling is weakly decreasing in F_0's marginal cost c_0.*

Provided with this intuitive result, we can show that investments and resulting output are highest with legal unbundling.

Proposition 2.6 *Investment into marginal cost reduction and total output under legal unbundling are weakly higher than under vertical separation and vertical integration.*

This investment result is, of course, mainly driven by the output results of Propositions 2.1 and 2.2. When a higher quantity is sold under legal unbundling there are obviously higher gains from cost reduction. Although intuitive, Proposition 2.6 is not completely trivial, since investments change the output and the extent to which marginal cost reduction increases output can be larger under vertical integration than under legal unbundling. Proposition 2.6 shows that investments are nevertheless always weakly higher under legal unbundling.

2.3.3 Investments into network safety and reliability

An important issue for energy and railway networks is safety and reliability. If the network breaks down, severe costs may be inflicted upon the network operator itself, on downstream firms, as well as on final consumers and other members of society.

Appropriate investments into network reliability are therefore an important issue. Integrated electricity companies sometimes claim that vertical integration is essential to guarantee reliable network operations. One may argue that reliability investments could, indeed, be larger under vertical integration, since not only losses of the network operator but also losses of the own downstream operations are taken into account. However, as long as the losses for the rest of society are not considered, reliability investments will be too low under all vertical structures, including vertical integration.

Sufficient levels of reliability investments therefore require contractual solutions that can impose fines in case of network break-downs or — in cases where contractual solutions are not feasible — fines imposed by the regulator or direct regulation. We do not see a compelling reason why such contractual and regulatory arrangements should be more difficult to achieve under legal unbundling than under the other vertical structures.

Sometimes, however, there may be problems to identify who was responsible for some network failure. Was it a mistake on the part of the upstream firm or on the part of the downstream firm that led to the break-down? In those cases there may be welfare losses due to costly litigation. When F_0 and F_1 are vertically integrated there may be some advantage, because for outsiders it is not important whether the upstream or downstream operations of the integrated firm were responsible for some failure. But also under legal unbundling there should be less costly litigation between F_0 and F_1, since F_1 receives all profits from F_0 and has therefore no interests in a costly law suit.

2.4 Example: Duopolistic Price Competition

In the following, we illustrate the output result for a downstream duopoly that sells a homogeneous product, like electricity, and competes in prices (with F_1 moving first). This example provides two additional insights. First, it allows for a full welfare analysis, showing that indeed legal unbundling yields the highest level of social surplus. Second, it illustrates that the downstream expansion effect is not exclusively driven by the double marginalization problem. We will make precise that the downstream expansion effect is "significant" even when the double marginalization problem becomes arbitrarily small.

Assumptions There are two downstream firms selling perfect substitutes. Total demand is given by a downward sloping demand function $Q(p)$, $Q'(p) < 0$. We maintain the assumption that the incumbent F_1 moves first. We assume constant marginal cost of the downstream firms, with a cost disadvantage for the incumbent. Sabotage linearly increases downstream costs. Thus, cost functions are given by

$$C_i\left(q_i\right) = \left(c_i + a + h_i\right) q_i \text{ for } i = 1, 2$$

with $c_1 > c_2$. Considering a cost disadvantage for the incumbent is of interest since a standard argument for liberalizing markets is to allow more efficient firms to enter the downstream market.

To avoid uninteresting case distinctions, we make some regularity conditions. First, we assume that for some prices above the incumbent's marginal cost plus access price

$a + c_1$ there is still positive demand, i.e. a separated incumbent could make positive profits if it were a downstream monopolist. Second, we assume that if F_2 were a monopolist on the downstream market, its optimal monopoly price lies above $a + c_1$. Third, we assume that the access price a is not so high that it is Pareto-dominated by some lower access price. This means it is not the case that all firms and consumers would be weakly better off (and at least one of them strictly better off) by some lower access price.

As is well known, in this set-up multiple equilibria can arise. We only consider equilibria in which firms do not play weakly dominated strategies.

Finally, for the question of how the market is split between the two firms in case they choose identical prices, we make the following tie-breaking assumptions. If the price is above F_2's marginal costs, i.e. $p > c_2 + a$, we assume that F_2 gets the whole market (for the out-of-equilibrium event that $p_1 = p_2 < c_2 + a$, we assume F_1 gets the whole market). This captures the idea that if prices were discrete on a sufficiently fine grid then F_2 as second mover would prefer minimally to undercut the price if $p > c_2 + a$ and prefer not to sell any output if $p < c_2 + a$.

If the price is equal to F_2's marginal cost, i.e. $p = c_2 + a$, then F_1 can decide whether F_1 gets the whole market, F_2 gets the whole market, or the market is split equally, i.e. $q_1 = q_2 = \frac{1}{2}Q$. This captures the idea that if prices were discrete, F_1 could either set a price slightly above F_2's marginal cost, in which case F_2 gets the whole market, exactly split the market at F_2's marginal cost, or slightly undercut F_2's marginal cost to get the whole market.

Vertical separation This is the typical Bertrand case, except for the fact that F_1 moves first. We find the following result:

Lemma 2.2 *Under separation in every equilibrium F_2 gets the whole market. The infimum of the market prices from all equilibria where no firm plays a weakly dominated strategy is given $p = a + c_1$.*

The price $p = a + c_1$, which equals the high cost firm's marginal cost, is the typical Bertrand outcome. Nevertheless there are additional equilibria. As under simultaneous moves, there are equilibria with prices between $a + c_2$ and $a + c_1$, but those are equilibria where F_1 plays a weakly dominated strategy. If there is only a small doubt that F_2 will not undercut F_1, then F_1 will never set a price below its own marginal cost $a+c_1$. Since F_1 moves first and always makes zero profits, there are also equilibria with prices above $a + c_1$, i.e. a price of $a + c_1$ is not the only outcome but the welfare optimal outcome when we neglect weakly dominated strategies.[11]

Legal unbundling Under legal unbundling, F_0 again wants to maximize total output and therefore will not sabotage. Contrary to vertical separation, now the downstream incumbent F_1 has an incentive to increase total output, since F_0's profits will accrue to F_1 under legal unbundling. Therefore F_1 will price more aggressively in order to increase output and thereby upstream profits sufficiently. This form of aggressive pricing is taken to the extreme in our case of price competition with homogeneous goods, because here F_1 prices more aggressively without even having some positive market share:

Lemma 2.3 *Under legal unbundling F_0 sets $h_2 = 0$. F_1 and F_2 both set prices $c_2 + a$ and F_2 gets the whole market.*

Note that even though the price set by F_1, $p_1 = a + c_2$, can be below F_1's true marginal costs $c_0 + c_1$, it is not a weakly dominated strategy for F_1 to set such a price — in contrast to what we found under vertical separation. This is because if F_1 would set a higher price, F_2 would react with a higher price. That would reduce total output, and therefore also the profit of the integrated firm.

Vertical integration With vertical integration, there are two candidates for an equilibrium. Either the upstream firm uses sabotage in order to drive F_2 out of the market (the "monopolistic" outcome), or F_0 does not sabotage F_2 and then F_1 acts in the same way as under legal unbundling (the "competitive" outcome).

Lemma 2.4 *If F_0 and F_1 are integrated. There are two candidates for equilibrium:*
(m) monopoly case: Set $h_2 = \infty$ and let F_1 serve the whole market at the monopoly price of the integrated firm, denoted by p_{01}^m.
(u) competitive case: The same as under legal unbundling. Set $h_2 = 0$ and $p_1 = p_2 = c_2 + a$ and let F_2 get the whole market.

In the monopoly case profits of the integrated firm are given by

$$\pi_{01}^m = (p_{01}^m - c_0 - c_1)\, Q\,(p_{01}^m)$$

In the competitive case its profits are given by

$$\pi_{01}^u = (a - c_0) Q(c_2 + a)$$

[11] To be precise, in the equilibrium with a price of exactly $a + c_1$, F_1 also plays a weakly dominated strategy since for no action of F_2 will F_1 make positive profits. But there is a sequence of equilibrium prices that converges from above to $a + c_1$, where in no such equilibrium a firm plays a weakly dominated strategy.

We find $\frac{\partial(\pi_{01}^u - \pi_{01}^m)}{\partial c_1} > 0$ and $\frac{\partial(\pi_{01}^u - \pi_{01}^m)}{\partial c_2} < 0$. This means the competitive outcome occurs whenever the cost disadvantage of the own downstream operations is sufficiently large. With very inefficient own downstream operations, even the integrated firm might find it optimal to use F_2 as its "sales channel" and live only on the upstream profits. In this case, clearly, sabotage would not make sense.

Reverse legal unbundling The following lemma shows that under reverse legal unbundling we either have the same market price as under separation or the monopoly price of an integrated firm. In fact, the worse of these two outcomes is realized, i.e. reverse legal unbundling is weakly worse than both separation and vertical integration.

Lemma 2.5 *Under reverse legal unbundling the market price will be* $p = \max\{p_{01}^m, a + c_1\}$. *At price* $a + c_1$ *firms* F_1 *or* F_2 *may produce, but at price* p_{01}^m, F_1 *will serve the whole market.*

The intuition is that under reverse legal unbundling, F_0 maximizes joint profits and therefore has incentives for sabotage, and at the same time F_1 only maximizes its own profits and therefore has no incentives to lower prices in order to increase output.

Comparison of the four cases Equipped with the solutions for the four cases we see that in this example legal unbundling is strictly superior to all other vertical structures (except for the competitive case of vertical integration, which yields an outcome identical to legal unbundling). Total output and consumer surplus are inversely related to the market price and therefore highest under legal unbundling. Profits of F_0 are increasing in total output and hence also highest under legal unbundling. Production is efficient since F_2 produces everything. Total welfare is increasing in total output as long as market prices are weakly above marginal cost of production $c_0 + c_2$, which is always the case. Thus we can state the following proposition:

Proposition 2.7 *Under legal unbundling, prices are strictly lower, and total output, profit of* F_0, *consumer surplus and total welfare are strictly higher than under separation, reverse legal unbundling and the monopoly case of vertical integration. (In the competitive case of vertical integration, we have identical outcomes to legal unbundling).*

Proof.

Immediate from comparing the outcomes of the four cases. ∎

Finally, we turn to the question what happens when the double marginalization problem becomes negligible. This happens when $a \to c_0$, since then also in the case of separation the downstream firm calculates with (almost) the true marginal cost of the input good. Only under legal unbundling, the outcome will approach the welfare-optimal outcome, i.e. a first-best market price of c_0+c_2. Under separation, the market price converges to a higher level of $c_0 + c_1$ and under vertical integration always the sub-optimal monopoly case arises.

Proposition 2.8 *For $a \to c_0$, the welfare-optimal outcome is approached under legal unbundling, but not under the other vertical structures.*

What is responsible for this striking difference is the induced output effect: In this example, it yields significantly larger quantities under legal unbundling, i.e. a significant downstream expansion effect, even when the double marginalization problem becomes arbitrarily small.[12]

2.5 Alternative regulatory pricing schemes

2.5.1 A general class of price regulation schemes where legal unbundling is optimal

So far we assumed that the regulator sets a linear access price $a > c_0$. Such linear access prices fulfill two conditions:

(L1) F_0's profits π_0 only depend on total output Q, but it does not matter which downstream firms produce how much of it.

(L2) F_0's profits π_0 are strictly increasing in total output Q.

It turns out that our main results hold for every price regulation scheme that fulfills conditions (L1) and (L2). Let α denote a price regulation scheme that fulfills (L1) and (L2). It determines how much money F_0 receives when selling a total output Q, which we denote by a revenue function $R(Q|\alpha)$. Furthermore the scheme α specifies how much downstream firms have to pay when actions x are chosen (which imply quantities q_i). Thus profits are given by

$$\pi_0(x, h|\alpha) = R(Q(x, h)|\alpha) - c_0Q(x, h) - K + S$$

$$\pi_i(x, h|\alpha) = p_i(x, h)q_i(x, h) - C_i(x, h|\alpha) \text{ for } i = 1, ..., n$$

[12] We also have extended the price competition example for allowing investments into marginal cost reduction. Legal unbundling then always yields the welfare-optimal level of investments. A proof is available from the authors upon request.

To ensure that (L2) is fulfilled, we require that for all Q', Q with $Q' > Q$ it holds that $R(Q'|\alpha) - c_0 Q' > R(Q|a) - c_0 Q$.
For these more general regulatory schemes, which provide scope for additional desirable features, all the results proven in Section 2.3 and 2.4 still hold.

Proposition 2.9 *The following results hold for every regulatory pricing scheme that fulfills (L1) and (L2): Proposition 2.1, 2.2, 2.4, 2.5 (first sentence) and 2.6.*

Our proofs for the mentioned propositions in the appendix all use the more general class of regulatory schemes illustrated in this section. Thus, we find that also for the larger class of regulatory schemes, legal unbundling can be seen as a golden mean between separation and vertical integration as it still delivers higher quantities and good investment incentives.
Example Consider the following example for such a pricing scheme: The regulator pays the upstream firm a linear access price $a > c_0$, but charges the downstream firms a two-part tariff with an access price equal to c_0 plus a fixed fee. It is not necessary that the regulators' revenues have to equal expenditures, i.e. the higher marginal price paid to F_0 may also be (partly) financed by subsidies.[13] This scheme has two benefits: First, a high access price a provides F_0 strong incentives to maximize total output, which may be a good way to induce a sufficient high budget for capacity investments (see Section 3.1). Second, output in downstream markets is increased because, for the downstream firms, access is priced at its true marginal costs c_0.
Although under this regulatory scheme there is no double marginalization problem, output under legal unbundling may still be *strictly* above the output under separation. For an illustration consider the price competition example from the previous section. If we assume that F_0's markup $a - c_0$ is financed by a subsidy (rather than a fixed fee), the analysis under this regulatory scheme is very similar to the original analysis and the results are straightforward: Under legal unbundling the entrant serves the whole market at the welfare-optimal price of $c_0 + c_2$, while under separation the entrant serves the market at a higher price of $c_0 + c_1$.

2.5.2 Inappropriateness of legal unbundling in the absence of access regulation

It is important to note that legal unbundling can yield very bad outcomes if access prices are unregulated. If F_0 could freely decide on access prices, the strategy that

[13] Imposing high fixed fees can be problematic, because they may foreclose market entry by small downstream firms. In such cases subsidies may be preferred.

maximizes upstream profits π_0 would be to charge the incumbent F_1 a very high access price and at the same time use all available measures to maximize F_1's output, which could involve massive sabotage of downstream competitors. F_1 is willing to pay such a high access price, because it gets the money back through F_0's profits. Although in reality this mechanism will likely not appear in this extreme way, the basic incentive distortions are nevertheless likely to exist without price regulation. Along the lines of this example, a seemingly harmless rule that only prescribes a maximum access price for downstream competitors, but allows (or requires) higher access prices for the downstream incumbent may have quite negative outcomes. Hence, whenever there is no access price regulation or the conditions (L1) and (L2) from above are violated, legal unbundling may lose its appealing properties.

2.6 Discussion

The analysis so far has shown that under rather general assumptions, legal unbundling exhibits desirable properties. Nevertheless, regulatory authorities often evaluate legal unbundling negatively. For instance, Neelie Kroes, European Competition Commissioner, expressed her views as follows:

> Speaking very personally, I see only one way forward if we are to restore credibility and faith in the market. Europe has had enough of "Chinese walls" and quasiindependence. There has to be a structural solution that once and for all separates infrastructure from supply and generation. In other words: ownership unbundling.[14]

A key concern in the European policy debate on vertical industry structures are investment incentives, in particular, for investments in cross-border transmission capacities. Such investments could pave the way for an integrated European market for electricity with an increased level of competition. Also for this issue, the EU Commission prefers vertical separation over legal unbundling. In the words of Commissioner Kroes:

> As you will know, where interconnector capacity is scarce, it is auctioned off to the highest bidder, generating congestion revenues. If you look at our report, you will find that from 2001 to 2005, three German TSOs generated congestion revenues of over 400 million Euros. Of these

[14]Speech Neelie Kroes, A new energy policy for a new era, Conference on European Energy Strategy – the Geopolitical Challenges, Lisbon, 30th October 2006.

> revenues, under 30 million Euros were used to build new interconnectors- that's less than 10%!
>
> In contrast, our experience shows that fully unbundled operators see clearer incentives for investment in interconnectivity, and act on those incentives, because they are focused on optimizing the use of the network.[15]

Although the European Commission views vertical separation (or ownership unbundling) as the most preferred vertical industry structure, it has positively considered an alternative structure with an "independent systems operator":

> [...] the Commission has also examined an alternative approach known as 'ISO' or Independent System Operator, whereby the vertically integrated company maintains ownership of the network assets and receives a regulated return on them, but is not responsible for their operation, maintenance or development.[16]

We believe that our analysis helps to understand better the effects from measures mentioned in the three quotes. We discuss the three points in turn.

First, our theoretical analysis assumed that legal unbundling works perfectly in separating the interests of the network company from the rest of the integrated group. This seems often not to be the case. Thus, it is important to understand what happens if the network company acts not completely independently and also takes into account the profits of the downstream firm F_1. This is analyzed in detail in Höffler and Kranz (2007). There it is shown that reducing the independence of the network firm yields the expected result of lowering total output. Put differently: more independence, i.e. a stronger regulation, increases the output. The optimum ownership structure therefore can depend on the strength of regulation. Höffler and Kranz (2007) show that if regulation is weak, vertical separation can indeed yield higher quantities than legal unbundling. However, if regulation is sufficiently strong, the results of the current paper apply (i.e. highest quantities under legal unbundling).

Since the effect of legal unbundling therefore seems to depend on the strength of regulation, the negative experiences of regulators may well be explained by insufficiently strong regulation. Although "sufficiently strong" regulation might not be

[15] Neelie Kroes, European Commissioner for Competition Policy, 'A new European Energy Policy; reaping the benefits of open and competitive markets' Energy conference: E-world energy & water' Essen, 5th February 2007

[16] Neelie Kroes European Commissioner for Competition Policy 'A new European Energy Policy; reaping the benefits of open and competitive markets' Energy conference: E-world energy & water' Essen, 5th February 2007.

implementable as such,[17] it might also be the case that intensifying regulation is possible and that such a strengthening of regulation will lead to a situation where legal unbundling is the preferred vertical structure. This could be done either by stronger legal requirements or by stricter implementation of existing rules. The second quote illustrates the point. Only since 2005 have German network companies been legally obliged to reinvest profits from the interconnector auctions[18] — thus, legal requirements have become more strict (irrespective of the question whether this particular tightening of regulation is sensible — below we propose an alternative approach to this problem). If the integrated companies still get away with not reinvesting, this would be due to a lack of enforcement of legal rules. The European Commission itself states that the existing rules are not yet fully implemented.[19] Thus, too little independence might at least partially be due to too weak implementation of existing regulation.

The resulting policy implication, therefore, is to strengthen regulation and to thoroughly implement the existing regulations in order to increase the independence before changing the regime towards full separation. Additionally, requiring legally unbundled firms to take on a minority outside investor, could help to increase independence. Consider a minority stake of, say 10%, of an institutional investor in the network company. The interest of the downstream firm in the network profits would still be large, such that beneficial effects of legal unbundling are still significant; at the same time, the investor has an interest in enforcing that the network company maximizes only its own profits.

The issue of investments, addressed in the second quote, is also interesting in light of our findings. From a theoretical perspective, completely separated network operators will also have incentives to provide only a monopoly amount of interconnector capacity — below the socially optimal level — if they directly receive the congestion revenues from the interconnector auctions.[20] Theory can also predict that legal unbundling can

[17]Although many legal rules exist to ensure independence (mentioned in section two), reaching perfect independence might nevertheless be difficult. For instance, even if the management of the network company today has no incentive to privilege the incumbent's downstream operations, career concerns within the group might bias decisions towards such a discriminatory behavior.

[18]In Germany, according to the *Netzzugangsverordnung* § 15 (3).

[19]That legal unbundling requirements are not yet fully implemented is explicitly noticed by the European Commission: "Even where Member States have adopted unbundling provisions required under the Second Gas Directive, this does not mean that TSOs necessarily comply with them." (Sector Inquiry, Part 1, para 153, p. 57).

[20]See Höffler and Wittmann (2007) for a discussion of "supply reduction" in interconnector auctions.

exaggerate this problem, since under legal unbundling the downstream incumbent may bid higher prices in the capacity auction in order to increase congestion revenues and thereby the profits of the network operator.
In this context, our discussion of more general regulatory schemes proves useful. One suggestion is to modify the capacity auction as follows: The regulator receives the revenues from the capacity auction and pays the network operator a regulated fixed access price for every unit that is sold in the auction. Then the network operator cannot influence the price it receives and therefore has no incentives to act like a capacity-reducing monopolist. Such a regime satisfies the assumptions of section 5.1; thus, we expect that legal unbundling will yield a higher output than separation under this modified regulation scheme.
Finally, consider the issue of independent system operators, subject to a rate of return regulation, mentioned in the third quote. The driving force for the benefits of legal unbundling over separation in our model is the fact that the downstream incumbent receives the network operator's profits and therefore wants to increase total output. But if, as suggested, the downstream incumbent only receives a regulated return on its network assets (independent of the profits from network operations), it has no incentive to increase total output, and the benefits of legal unbundling compared to separation would not arise.
To conclude the discussion, let us remark that we have left out some important issues. For instance, we have not discussed "vertical economies", i.e. possible efficiency gains from vertical integration from a technological or transaction cost point of view. The evidence for their existence is somewhat unclear, however. Fraquelli et. al. (2005), Kowka (2002), or Kaserman and Mayo (1991), for example, find evidence for more or less economically significant vertical economies. Although such economies of vertical integration may not be fully realized under legal unbundling, they should be realized to a larger extent than under complete separation. For example, the hold-up problem is likely to be reduced under legal unbundling, since F_1 would in an investment decision take into account the surplus accruing to F_0 and also has no interest in costly ex-post bargaining with F_0.

2.7 Conclusion

In this paper, we have demonstrated that, from a theoretical point, legal unbundling can be seen as a "golden mean" between complete separation and full vertical integration. If access prices are regulated and legal unbundling can ensure that the network company, controlling the essential facility, maximizes only the own profits, legal unbundling ensures higher quantities than the other vertical structures. This result is important, since higher quantities typically imply that also consumer surplus will be higher under legal unbundling.

A key message of our analysis is that, in addition to the sabotage effect, policy makers should also consider the *downstream expansion effect*: Under legal unbundling — compared to separation — the incumbent's downstream operations not only internalize the double marginalization problem but additionally can induce an output expansion by competitors. Most pronounced, in the case of downstream price competition, the incumbent prices more aggressively compared to a vertically separated downstream company, since this leads to a price reduction and higher quantities of downstream competitors and thereby to higher profits of the upstream operations.

We also analyzed investment incentives. Legal unbundling provides the better incentives for investments into the reduction of marginal costs and for the allocation of a given budget for capacity investments. Although, we cannot generally rule out cases where legal unbundling leads to lower budgets for capacity investments, our results suggest that even in those cases legal unbundling may often be welfare superior. Concerning investments into network reliability, we argued that contractual solutions or appropriate regulation are needed under all vertical structures to ensure sufficient levels of investment.

We demonstrated that our results not only apply for linear access prices, but also for more general regulatory regimes. In the absence of price regulation, legal unbundling loses its appealing properties, however.

Policy recommendations cannot ignore the negative experiences regulators have made so far with legal unbundling. Our contribution is to offer a fairly general economic analysis of legal unbundling which helps to see potential benefits and to identify the necessary prerequisites for these benefits to apply. Our tentative policy recommendation would therefore be: Regulators should first try to implement legal unbundling rigorously, with particular emphasis on the independent decision making in the unbundled network unit, considering also to oblige legally unbundled network operators to take on minority shareholders. Only if experiences after full implementation are still negative, a regime shift towards full vertical separation should be considered.

Chapter 3

Imperfect Legal Unbundling of Monopolistic Bottlenecks

3.1 Introduction

In many network industries like energy, rail, or telecommunications the network is a naturally monopoly and network access is an essential input for firms competing in downstream markets. Monopolistic bottlenecks are also an issue in other industries, like the software industry where undiscriminating access to the functionality of an operation system is an essential input for firms competing in the application markets. An important question for regulatory policy is whether a firm active in the downstream market is allowed to operate the monopolistic bottleneck or to have ownership shares in the upstream firm that controls this bottleneck. While most academic research focuses only on the comparison between vertical integration and full ownership separation, there is an important alternative: legal unbundling.

Legal unbundling means that the monopolistic bottleneck must be operated by a legally independent upstream firm, but the upstream firm may be fully or partially owned by a firm active in the downstream market. The downstream mother is not allowed to interfere in the upstream operations, but its ownership share gives entitlement to the corresponding proportion of upstream profits.

In Europe, legal unbundling is the standard requirement for the energy industry[1], and similar forms of "partial separation" are common in the telecommunications industry in Europe and the US.[2].

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[1]For the electricity market see Directive 2003/54/EC, Articles 10 (1) and 15 (1), for the gas market see Directive 2003/55/EC, Articles 9 (1) and 13 (1).

[2]For the US see Section 272 of the Telecommunications Act of 1996; for the European Union see

We know so far of only two papers — Höffler and Kranz (2007) and Cremer et. al. (2006) — that perform a theoretical analysis of legal unbundling (Cremer et. al. consider, however, the reverse case where the downstream firm is legally unbundled and owned by the upstream firm). Both papers assume that legal unbundling is perfect in the sense that the unbundled firm maximizes only its own profits, while only the mother company maximizes joint profits.

Höffler and Kranz show that under this assumption and regulated access prices legal unbundling leads to highest output quantities in a model where the upstream firm can hamper the operations of downstream firms. They also show that the attractive features of legal unbundling persist when upstream investments into capacity, marginal cost reduction or network reliability are considered.

In this paper we extend their basic model to analyze cases of imperfect legal unbundling and partial ownership. There is one upstream monopolist (F_0), a downstream incumbent (F_1) that can have a positive ownership share σ in F_0 and possible has some influence on F_0's management, and $n-1$ potential downstream competitors. The upstream firm produces an essential input at constant marginal cost c_0 which the downstream firms need in a fixed proportion (1:1) to produce the final output. Downstream competition is modeled quite generally. Downstream decisions could, for example, be made about quantities, (non-linear) prices, investments or market entry. Access prices are set by the regulator. Our results hold for all price regulation schemes where profits from upstream operations are strictly increasing in total output. One example is a linear access price above the marginal costs of the upstream firm. F_0 can perform non-tariff discrimination by sabotaging downstream firms or allocating investments in areas that benefit only specific downstream firms. Imperfect unbundling is modeled by a non-negative weight ω that F_0's management attaches in its decisions on the downstream profits of the incumbent F_1.

In Section 3.3, we analyze how total output depends on this weight and on the incumbent's ownership share in F_0. We find that total output weakly increases when the upstream firm F_0 attaches lower weight on incumbent's downstream profit. This result holds for every ownership share that F_1 can have in F_0. Thus, regulations that increase independence of the upstream firm (but do not change ownership shares) seem in general beneficial to consumers. When the weight that F_0 attaches on downstream profits is sufficiently low then total output also weakly increases in F_1's ownership share. When this weight is higher, i.e. legal unbundling is less perfect, an increase in F_1's ownership share has ambiguous effects: total output may increase or decrease.

Directive 2002/21/EC, Article 13 (1b).

Hence, although legislation that forces F_1 to give up ownership in F_0 may increase output under weak regulation (high ω), under more effective regulation (lower ω) higher output can be achieved when the downstream incumbent F_1 keeps ownership shares in the upstream firm F_0.

In Section 3.4, we examine a micro-foundation for the weight ω that the upstream firm attaches on downstream profits of the incumbent. We especially want to gain insight about plausible relations between this weight and F_1's ownership share in F_0. We derive an endogenous formula for ω from a model where F_0 can either make a decision that maximizes upstream profits, or is be manipulated by F_1 and then makes a decision that leads to higher downstream profits of the incumbent. For F_1 manipulation is costly. Manipulation costs can decrease in F_0's ownership share whenever it becomes so large that no outside investors has any substantial stakes in F_0 that would give incentives to control F_0's management. Still, the model shows that higher ownership shares of F_1's in the upstream firm F_0 can cause F_0 to put lesser weight on F_1's downstream profits. The intuition for this — at first sight surprising — result is that under larger ownership shares the incumbent F_1 receives a higher share of upstream profits and therefore has smaller incentives for manipulations that reduce upstream profits.

The remaining paper is structured as follows. In Section 3.2 we present the model. Section 3.3 derives the general results and illustrates why total output may fall in F_1's ownership share when ω is high. In Section 3.4 we give a micro-foundation for the weight ω and examine its relation with F_1's ownership share. Section 3.5 summarizes the results and concludes. Proofs are delegated to the appendix.

3.2 The model

Active firms There is a monopolistic upstream firm F_0 that produces a good at constant marginal costs c_0, which is used as input good for n competing downstream firms, $F_1, ..., F_n$. Each downstream firm needs a constant and identical amount of the input good to create an output good. For simplicity, we normalize input quantities such that each firm needs exactly one unit of the input good to create one unit of an output good.

Non-tariff discrimination We assume F_0 is a regulated natural monopoly, e.g. the owner of an essential transmission network in electricity or telecommunication markets. Access prices are regulated such that upstream profits π_0 are strictly increasing in total output (details are given below). We assume that F_0 can perform the operation of the network in ways that may discriminate distinct downstream firms. Formally, F_0 chooses a discrimination (or sabotage) strategy $h \in H$ that influences output, costs and consumer prices of downstream firms. The strategy h can describe measures like disclosure of confidential information to competitors, delay or excessive formalities when dealing with requests, or network repairs at times that are especially inconvenient for some downstream firms. We make the simplifying assumption that the choice of h has no direct impact on the profits of F_0, although perhaps indirectly if it changes the total quantity sold. The variable h can also be interpreted as the allocation of a fixed budget of capacity investments that influences the maximal output of different downstream firms. For example, F_0 can increase interconnection capacity between countries or alternatively extend the domestic network. We do not consider decisions about the total size of the investment budget. Those issues are analyzed, however, in the related model of Höffler and Kranz (2007).

Downstream market The decision of downstream firm i is denoted by $x_i \in X_i$ and $x = (x_1, ..., x_n) \in X_1 \times ... \times X_n$ denotes the vector of chosen downstream actions. These downstream actions describe very general decisions, e.g. about quantities, prices, investments, entry or sabotage against competitors. Downstream actions x together with upstream discrimination h determine downstream firms' output $q_i(x, h)$, their market prices $p_i(x, h)$ and their total costs $C_i(x, h|a)$. Total output quantity is given by $Q(h, x) = \sum_{i=1}^{n} q_i(x, h)$.[3] Profits of downstream firm i are given by

$$\pi_i(x, h|\alpha) = p_i(x, h)q_i(x, h) - C_i(x, h|\alpha) \text{ for } i = 1, ..., n \tag{3.1}$$

We assume that no downstream firm can make infinite high profits or losses, i.e. the set of possible downstream profits is bounded. Furthermore the regularity condition C1 (see below) will require existence of subgame perfect equilibria. Otherwise, there are no further restrictions on functional forms.

Access price regulation and upstream profits

The parameter α in downstream costs functions denotes an access price regulation scheme. We assume that the access price regulation schemes α fulfills two conditions. First, the profits of F_0 shall depend only on total output Q, i.e. it does not matter which downstream firm contributed how much to the total output Q. This is a sensible requirement, since otherwise the regulator would give the upstream firm explicit incentives to prefer output from specific downstream firms, which may cause sabotage of competitors of those firms. Second, we require that F_0's profits are strictly

[3] If firms play mixed strategies these variables denote expected values. In that case, we assume that all firms are risk-neutral.

increasing in total output. This also seems sensible, since there is typically a problem of underprovision of output, because of downstream market power.
Thus upstream profits are given by a function

$$\pi_0(x, h|\alpha) = \pi_0(Q(x, h)|\alpha) \tag{3.2}$$

that is strictly increasing in total output Q. A simple example for such a price scheme is a common linear access price a above marginal costs c_0. Another example is that the regulator pays a linear access price above marginal costs to F_0 but charges downstream firms a two-part tariff with marginal access price of c_0 plus a fixed fee. It is not necessary that downstream payments have to equal the payments the upstream firm receives; part of the payments may also be subsidies.
Timing The price regulation scheme is exogenously given in our model. Then F_0 chooses its discrimination strategy h. Afterwards the downstream incumbent F_1 chooses its action x_1. These decisions are observed by the downstream entrants $F_2, ..., F_n$ who then make their downstream decisions. Whether downstream entrants move simultaneously or sequentially does not matter for our model.
Ownership by downstream incumbent The downstream incumbent F_1 can own some or the complete share of the upstream firm F_0. We denote F_1's ownership share by σ and assume that F_1 maximizes its totally received profits, given by

$$u_1 = \pi_1 + \sigma\pi_0 \text{ with } 0 \leq \sigma \leq 1. \tag{3.3}$$

Imperfect legal unbundling Under perfect legal unbundling the upstream firm F_0 has an independent management, which maximizes only upstream profits π_0, even if F_0 is wholly or partially owned by the downstream incumbent. Existing legislation, for example, explicitly forbids direct interference by the mother company (Directive 2003/54/EC, Article 10 and 15) or prescribes arm's length relations (US Telecommunications Act 1996, Section 272 (b) [5]). Still field evidence suggests that legal unbundling is not always perfect. We model imperfect legal unbundling by assuming that F_0 attaches a positive weight ω on the downstream profits of the incumbent. Thus F_0 maximizes

$$u_0 = \pi_0 + \omega\pi_1 \text{ with } 0 \leq \omega. \tag{3.4}$$

Our model encompasses the 4 vertical structures studied in Höffler and Kranz (2007) as special cases, which are vertical separation: $\sigma = 0, \omega = 0$, (perfect) legal unbundling (with full ownership): $\sigma = 0, \omega = 1$, (perfect) reverse legal unbundling: $\sigma = 0, \omega = 1$ and vertical integration: $\sigma = 1, \omega = 1$.
Regularity conditions For every pair (σ, ω) our model formally consists of a multi-stage game. The timing and strategy-space of these games is the same for all (σ, ω)

and only the payoff functions for F_0 and F_1 differ. We call a *situation* a pair of (σ,ω) and some history of the corresponding multi-stage game, where at least one player still has to move. To avoid technical complications that could arise if some continuation games have no subgame-perfect equilibrium, we require:

C1 *In every situation there is a subgame-perfect continuation equilibrium.*

Note that a given situation may have multiple subgame-perfect continuation equilibria. We also make a regularity condition on equilibrium selection for those cases:

C2 *Assume two situations have an identical set of subgame-perfect continuation equilibria. Then in both situations the same subgame-perfect continuation equilibrium shall be selected from this identical set.*

This regularity condition avoids tedious comparison of sets of equilibria. Note that C2 is obviously not needed when in every situation there is a unique continuation equilibrium.

We want to remark the following direct implications of our model under these regularity conditions.

Remark *Under the condition above entrants equilibrium decisions only depend on h and the decision of the incumbent x_1. This means given h firm 1 can choose between different decision profiles $x = (x_1, x_2(x_1, h), ..., x_n(x_1, h))$. Furthermore the incumbent's decision x_1 only depends on h and on his ownership share σ. Thus the equilibrium choices in the downstream markets x can be described as a function of h and σ.*

3.3 Results

3.3.1 General output results

In this section we analyze the comparative statics of total output with respect to changes in the degree of imperfection in legal unbundling ω and F_1's ownership share σ. The results are formalized in Propositions 3.1 and 3.2 and illustrated in Figure 3.1. The arrows in Figure 3.1 indicate the direction of weakly increasing total output. The downward oriented vertical arrows indicate that making F_0 more independent, i.e. reducing ω weakly increases output for any given ownership share of F_1. This is formally stated in Proposition 3.1:

Proposition 3.1 *For every given ownership share σ the total output is weakly decreasing in ω.*

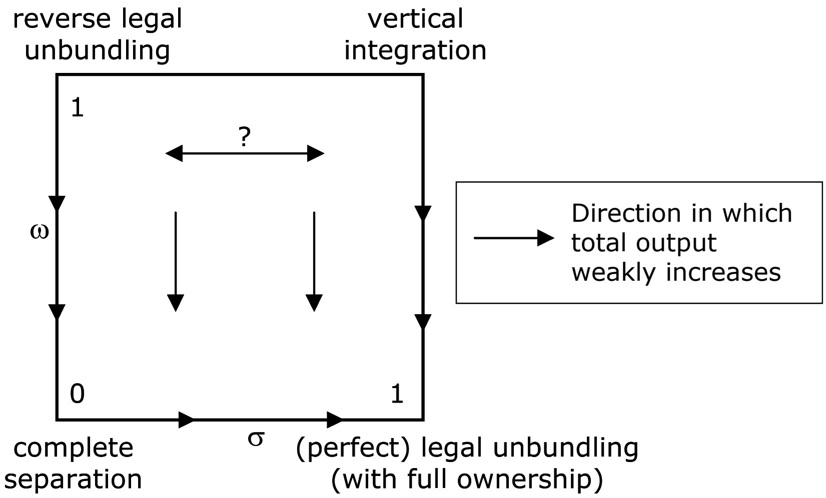

Figure 3.1: Effects of ω and σ on total output Q.

The horizontal arrows in Figure 3.1 have the following meaning: When F_0 acts completely independent, i.e. $\omega = 0$, we find that total output is weakly increasing in F_1's ownership share σ. This result also holds approximately for small ω, but for high levels of ω the effects of σ can be ambiguous, as we illustrate in the example of Section 3.3.2. Formally, we find:

Proposition 3.2 *If $\omega = 0$ then total output is weakly increasing in the incumbent's ownership share σ. Furthermore, the following limit result holds: Consider two ownership shares σ^a and σ^b with $\sigma^a < \sigma^b$ and let Q^a and Q^b be the corresponding resulting total outputs. Then $Q^b - Q^a$ has a lower bound that converges to zero as $\omega \to 0$.*

The two results imply that perfect legal unbundling with full ownership ($\sigma = 1, \omega = 0$) leads to a weakly higher output than every other combination of σ and ω. Thus whenever higher total output is linked to higher welfare it would indeed be desirable to achieve such perfect legal unbundling with full ownership.

The main results are quite intuitive. Output increases when F_0 becomes more independent, since for lower ω the upstream firm attaches a smaller weight on F_1's downstream profits and therefore a relatively bigger weight on output maximization. Similarly, when F_1's ownership share σ increases, F_1 attaches greater weight on upstream profits, which increase in total output. Intuitively, this should lead to an increase in total output.

3.3.2 Example of ambiguous effects of σ when ω is large

Given this intuition it is somewhat surprising that there can be cases where for a given high level of ω an increase in ownership share σ may decrease total output. We illustrate such a case with the following example. Assume there are two downstream firms with constant marginal costs $c_1 = 0.4$ and $c_2 = 0.3$ who compete by setting simultaneously quantities (Cournot).[4] The inverse demand is given by $p = 1 - q_1 - q_2$. There is a linear access price of 0.25 per input unit and F_0 produces at zero marginal costs $c_0 = 0$. F_0 can hamper downstream firm i by increasing marginal costs to an arbitrary level $c_i + h_i$. Figure 3.2 illustrates the resulting total output for all combinations of ω and σ.

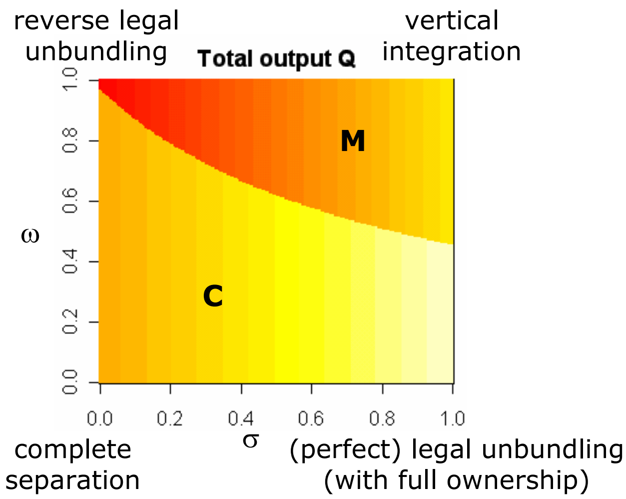

Figure 3.2: Total output Q in Cournot example. Brighter colors indicate higher levels of total output.

There are two classes of equilibria corresponding to the areas C and M in Figure 3.2. Either there is no sabotage and both downstream firms compete (area C) or we have a downstream monopoly of F_1 where the downstream competitor F_2 will be strongly sabotaged and therefore produces 0 (area M). As is intuitively clear, the monopoly outcome arises only for sufficiently high levels of ω. Within the sets of monopoly outcomes and competitive outcomes total output is always increasing in F_1's ownership share σ, which is in line with the intuition that higher σ give F_1 stronger incentives to increase total output. But for high levels of ω an increase in

[4] Although simultaneous quantity setting violates our assumption that F_1 moves first, Cournot competition nicely illustrates the intuition. Similar examples can be found where F_1 moves first.

σ may lead from a competitive outcome to a monopoly outcome with lower total output. The intuition is that achieving the monopoly outcome by sabotaging F_2 is more attractive for F_0 when F_1's ownership share σ is high, since for higher σ output losses due to double marginalization are less severe. If ω is low this effect does not arise because then F_0 mainly cares about high output and therefore always prefers the competitive solution.

3.4 A micro-foundation for imperfections in legal unbundling and the relation with downstream ownership

In this section we give an example for a simple a micro-foundation for the weight ω that F_0 attaches on downstream profits of the incumbent F_1. The example also provides insights how this weight may depend on F_1's ownership share σ in the upstream firm F_0.

Assume F_0 can make a binary decision $d \in \{d_0, d_1\}$. Decision d_0 will lead to a higher total output Q and higher upstream profits π_0 than d_1, whereas d_1 leads to higher downstream profits π_1 for the incumbent. Let $\Delta_0 < 0$ and $\Delta_1 > 0$ denote the change in profits π_0 and π_1, respectively, when the decision changes from d_0 to d_1. Under perfect legal unbundling F_0 will always select decision d_0. Assume that under imperfect legal unbundling F_1 has the opportunity to manipulate decision makers of F_0 such that they will change the decision to d_1. For successful manipulation F_1 has to spend an amount $-\Delta_0 c$ (with $c > 0$) of money, which is proportional to the loss $-\Delta_0$ that F_0 makes when the decision changes from d_0 to d_1.

These proportional costs capture the idea that detection risk and possible punishment by the regulator are higher for manipulations that are very costly for the upstream firm F_0. Proportional costs are also plausible when the management of F_0 directly participates in the upstream profits of via incentive contracts and therefore needs higher bribes to change decision from d_0 to d_1 whenever this reduces upstream profits to a large extend.

In addition to the costs of manipulation, the downstream incumbent F_1 will also take into account that changing the decision from d_0 to d_1 reduces its share $\sigma\pi_0$ of received upstream profits. Considering these two kinds of costs, we find that manipulating the decision from d_0 to d_1 is profitable for F_1 if and only if

$$(\sigma + c)\,\Delta_0 + \Delta_1 > 0 \tag{3.5}$$

Thus whenever this inequality is fulfilled, d_1 is selected instead of d_0. It is straightforward to see that resulting behavior corresponds to the optimal decision rule for maximizing the following weighted sum of profits $\pi_0 + \frac{1}{\sigma+c}\pi_1$. Hence, the actual decisions of F_0 look like F_0 maximizes $u_0 = \pi_0 + \omega\pi_1$ with ω now being endogenously given by

$$\omega = \frac{1}{\sigma + c}. \tag{3.6}$$

If manipulation costs c are independent of F_1's ownership share σ, we therefore find that ω is strictly decreasing (!) in F_1's ownership share σ. Thus higher ownership shares of the downstream incumbent cause the upstream firm to attach less weight on the incumbent's downstream profits. The intuition for this result is that with a higher ownership share the downstream incumbent takes upstream profits more strongly into account and has therefore less incentives to manipulate the upstream firm in a way that decreases total output.

It is plausible, however, that F_1's manipulation costs c are decreasing in its ownership share σ. One reason is the following: Assume F_1 has not complete ownership of F_0, but there is also an independent outside investor that holds shares in F_0 and has no stakes in firms that operate downstream. Since such an outside investor participates only in the upstream profits π_0, he has incentives to effectively control that the management of F_0 does indeed maximize π_0 and is not manipulated by the downstream incumbent. If σ is lower, then outside investors have higher ownership shares, control should be tougher and therefore manipulation costs for F_1 should be higher than for higher levels of σ. In result, if c is decreasing in σ, the total effect of a change in σ on the weight ω becomes ambiguous.

It is perceivable that outside investors already have sufficient interests to control F_0's management for a substantial minority share, like 20% ownership in F_0 and that higher shares of outside ownership do not increase control effort much. Assuming that control costs are continuously decreasing in σ and strictly concave i.e. $c'(\sigma) < 0$ and $c''(\sigma) < 0$ may therefore not be a bad approximation. Under this assumption we find $\frac{d\omega}{d\sigma} = -\frac{1}{(\sigma+c)^2}\left(1 + c'\right)$ for $0 < \sigma < 1$ and ω is minimized either by the corner solutions $\sigma^* = 0$ or $\sigma^* = 1$ or we have an interior solution σ^* given by the simple condition

$$c'(\sigma^*) = -1.$$

Considering the results from Section 3.3, we should note that the ownership fraction σ^* that minimizes the weight ω that F_0 attaches on downstream profits π_1 is in general not that ownership fraction that maximizes total output. If the minimal level of ω is sufficiently small, increasing σ will weakly increase total output and therefore the level of σ that maximizes total output is likely above σ^*. If the minimal level of ω is quite high, it may, however, be the case that total output is maximized for ownership shares below σ^*.

3.5 Summary

We analyzed imperfect legal unbundling of a monopolistic provider of a bottleneck input. The upstream monopoly is price regulated and fully or partially owned by an incumbent active in the downstream markets. While under perfect legal unbundling the upstream monopolist maximizes only its own profits, under imperfect legal unbundling the upstream firm can be manipulated by the incumbent and then attaches a positive weight to the incumbent's downstream profits. For every given ownership share of the downstream incumbent we find that total output weakly increases when manipulation is made more difficult by stronger regulatory requirements. If regulation is sufficiently strong, such that the upstream firm attaches only a small weight to the incumbent's downstream profits, total output also weakly increases in the incumbent's ownership share. If regulation is weak the effect of incumbent's ownership share on total output can be ambiguous, however. Furthermore, we show that the incumbent's ownership share also has ambiguous effects on the weight that the upstream firm attaches to the incumbent's downstream profits.
We show that total output can be maximized under legal unbundling with partial ownership by the incumbent and an additional independent outside investor in the upstream firm. Since typically consumer surplus increases in total output, our analysis suggest that these arrangements may be optimal for consumers.

Chapter 4

Decision Structures in Franchise Systems of the Plural Form

4.1 Introduction

Franchising is a widespread phenomena. According to estimates for the year 2001 (IFA and PWC, 2004), there were more than 760,000 franchised businesses in the US, which generated a total economic output of more than \$1.53 trillion.

One puzzling empirical regularity in franchising is the stable coexistence of franchised and company-owned stores within a chain. Following Bradach & Eccles (1989), we call this arrangement a *plural form.*[1] In an extensive panel-data study Lafontaine and Shaw (2005) show that after some adjustment period the fraction of company-owned stores remains relatively stable in most franchise chains and seems to be deliberately targeted.[2] On average 15% of stores of established franchise chains are directly company-owned, but this numbers varies considerably between and within sectors. Several alternative explanations for the plural form have been discussed in the existing literature, which we will review in Section 4.2.

We have collected contract, interview and background data from the US fast-food industry to motivate a game-theoretic analysis that illustrates an additional reason for the plural form. The analysis is based on two stylized facts about franchise contracts, which hold in our sample and are more generally observed in franchising (see e.g. Bradach, 1998, or Blair & Lafontaine, 2005, for overviews): First, contracts typically give the chain strong power to decide upon certain activities, like introduction of new

[1] This arrangement is also known as *dual distribution* or *contract mixing.*

[2] For previous empirical studies, see e.g. Lutz (1992), Lafontaine (1992), Thompson (1994), Scott (1995) and Lafontaine and Shaw (1999).

products or changes in building requirements. Once a chain selects such an activity, it must be implemented by franchisees. Second, franchisees have to pay royalties, which are fraction of sales-revenues, to the chain.[3]

These two contractual features create a source of inefficiencies in decision making. Since royalties are based on revenues, and costs are born only by franchisees, the chain has incentives to choose inefficient activities that lead to high revenues but can be very costly for a store. A substantial fraction of company-stores can function as a commitment device for the chain to select more efficient activities, however. Such a commitment effect is present when the chain is obliged to uniform standards that require that the same activities must be selected for company-owned stores as for franchise stores. The reason is simply that for the fraction of the chain's total income that is contributed by company-owned stores, the cost of activities are fully internalized. Therefore, inefficient activities that lead to high revenues — but are very costly — become less attractive as the fraction of company-owned stores increases.[4]

In Section 4.3, we perform the game theoretic analysis in which we consider three cases. In the first case, we assume that the chain is obliged to uniform standards between company-owned and franchise stores and chooses endogenously the optimal fraction of company-owned stores. We model the interaction between the chain and franchisees via a three stage game. In the first stage, the chain commits to a fraction of company-owned stores and offers a franchise contract that specifies the royalty. When franchisees accept the contract in Stage 2, nature draws a state of the world that determines revenues and costs, as well as the optimal chain-wide activities. In Stage 3, the chain observes the state of the world and selects a chain-wide activity. Finally revenues and costs are realized and split according to the franchise contract. We show that the chain may select a positive fraction of company-owned stores, even if company-owned stores are run less efficiently than franchise stores. Thus, the plural form endogenously results from our model.

In the second case, the chain selects not only the fraction of company-owned stores, but also decides whether to commit to uniform standards between franchise and company-owned stores. The analysis straightforwardly shows that in this case it is always optimal for the chain to contractually commit itself to such uniform standards.

Finally, we analyse the case where the optimal fraction of company-owned stores is

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[3]The literature discuss several reasons for royalties on revenues, which we review in Section 4.2.

[4]The basic idea that company-owned stores may lead to to selection of more efficient activities has already been previously examined in two unpublished papers, including a case study of 5 franchise chains, by the second author — see Lewin-Solomons (2000a and 2000b).

determined by factors outside our model (the literature review in Section 4.2 summarizes several such factors). We consider the extreme case where the fraction of company-owned stores is completely exogenous and analyse when it is optimal for the chain to have a contractual commitment to uniform standards. We show that for a sufficiently high fraction of company-owned stores, it is optimal to include such a commitment into the contract whereas for a sufficiently low fraction of company-owned stores, it is optimal not to have such a commitment.

This prediction is supported by our empirical analysis in Section 4.4. We find a significant correlation between the fraction of company-owned stores and the strength of a contractual commitment to uniform standards in the data. We confirm in an ordered probit regression that this positive relation is robust to the inclusion of several control variables like a chain's size, age or its main product. Furthermore, Section 4.4 gives a descriptive overview of the contract contents and interview responses with respect to questions about the plural form, decision structures, and commitment to uniform standards. Section 4.5 briefly concludes. Unless stated otherwise, all proofs can be found in the appendix.

4.2 Background and Related Literature

4.2.1 Company-owned Stores and Franchise Stores

Before we can explore how the mix of franchised and company-owned stores affects a chain's dynamic efficiency, we must understand the defining characteristics of these two forms.

Probably the most important distinction can be found in the different incentives induced by franchise contracts and employment contracts of company-stores manager: A franchisee has to pay a fraction of revenues to the chain as a royalty. (Often there is also an initial fee upon opening a store, which is mainly used to cover setup and training costs — see Scott, 1995 or Lafontaine, 1992.) The remainder of profits are hers to keep, however. By contrast, a company manager is an employee with a mainly fixed salary.

Therefore, franchisees' incentives for profit maximization are very strong, whereas a company manager's incentives are quite weak. In result, as even company representatives often readily admit,[5] franchised stores typically outperform those that are

[5] Profit statistics are not readily available due to their sensitivity. However, among five chains studied in an in-depth case study by Lewin-Solomons (2000a), the staff of two chains reported

company-owned.
A second issue is whether company-owned stores substantially differ from franchise stores in so far that direct ownership grants additional residual rights of control. Such residual rights of controls are an key element if ownership structures are compared from a perspective of incomplete contracts, see e.g. Grossman and Hart (1986).
Overall, differences in control rights seem not to be very pronounced in franchise chains, however, because the chain has typically also very strong control rights over franchise stores. A franchisee is contractually bound to adhere to the chain's "operations manual", which specifies how the store is to be run. Any deviation from this manual occurs only with the permission or acquiescence of the chain, and most chains have the power to change this manual unilaterally (more on this later in the empirical section).

4.2.2 Reasons for Royalties on Revenues

Although royalties on revenues yield high powered incentives for franchisees, similar incentives could also be created by alternative contractual arrangements like royalties on profits or fixed annual fees. Considering the drawbacks outlined in the introduction, it seems therefore somewhat puzzling that royalties on revenues are the standard arrangement in franchising.
One important reason for their popularity is the impossibility to effectively monitor costs (see e.g. Rubin, 1978 or Maness, 1996). Therefore, royalties on profits are usually not implementable. Fixed annual payments are suboptimal when both franchisees and the chain must exert costly effort to increase chain wide profits, as is analysed by Lal (1990) and Bhattacharyya & Lafontaine (1995). Royalties can also be preferable when franchisees are risk-averse (see e.g. Norton, 1988 or Mathewson and Winter, 1992). For an general overview on the topic see e.g. the surveys by Dnes (1996) and Lafontaine & Raynaud (2002) or Chapter 3 in Blair & Lafontaine (2005). To keep our theoretical analysis simple, we do not include these factors that make revenue-based royalties optimal, but rather take the empirical fact that royalties are revenue-based as given.

unambiguously that franchised units were more efficient (in terms of profit), one chain claimed that franchisee profits were more variable, one gave ambivalent answers, and in the final chain, no company units existed for comparison. Franchisees themselves almost uniformly claimed that franchises were more efficient.

4.2.3 Alternative Explanations for the Plural Form in the Literature

The literature discusses several alternative explanations for the plural form, which we briefly review. An early branch of literature (e.g. Oxenfeldt & Kelly, 1969) considered franchising and the plural form to be transitory phenomena that facilitate access to initially scarce resources like capital (Caves & Murphy, 1976), managerial talent (Norton, 1988) or local information (Minkler, 1990). In the model of Gallini and Lutz (1992) the transition is reversed: chains start with company-ownership to signal profitable business to franchisees but once signalling is successful they can move towards a higher fraction of franchised stores.

To explain the long-run coexistence of company-owned and franchised stores, some literature focus on differences between locations of individual stores. For example, Brickely and Dark (1987) find empirically that a smaller distance to chain headquarters or a lower proportion of repeat business makes a store more likely to be company-owned. Chakrabarty et. al. (2002) theoretically analyze how the plural form can arise if the chain has better information about the profitability of different store locations.

Affuso (2002) adopts a different approach where the plural form can be optimal when managers are heterogeneous and self-select into franchise or company-employment contracts. She shows empirically that characteristics of store managers indeed significantly differ between franchise and company-owned stores.

Other papers focus on chain wide implications of the decision to have some company-owned stores. Scott (1995) and especially Lafontaine and Shaw (2005) have strong empirical arguments that company ownership is important to protect a chain's brand value. Bai and Tao (2000) provide a corresponding theoretical model for the plural form, where goodwill-effort of company-owned stores protects a chain's brand name, while franchise stores have higher sales efforts. Sorensen and Sorensen (2001) explain the plural form by focusing on the different roles of franchise and company-owned stores in exploration and organizational learning.

Our analysis, which focuses on the role of the plural form as a commitment device for the chain and on the interaction with contractual commitments to uniform standards, is definitely not targeted to substitute those existing explanations about the plural form, but is meant to complement the previous insights.

4.3 Theoretical Analysis

We first model the case where the chain decides endogenously on the fraction of company-owned stores, but is obliged to uniform standards between franchise and company-owned stores. Then, we briefly verify that within this set-up, it is indeed, optimal for the chain to always make a contractual commitment to uniform standards. Finally, we assume that the fraction of company-owned stores is exogenously given and examine under which conditions the chain prefers to commit to uniform standards.

4.3.1 Case 1: Endogenous fraction of company-owned stores when uniform standards are obligatory

We assume a store's revenues and costs depend on external factors like customers' preferences or input prices, and on the chain's activities such as its choice of products, advertisement, price-policy and the appearance of stores. The actual state of the world, which characterizes all external factors, is denoted by x. Ex-ante, x is unknown and will be randomly drawn from a commonly known distribution on a set of states X.

The chain headquarters observes the state and can decide on chain wide activities. For a given state x a real number a is assigned to each activity, which can be interpreted as the "size" of an activity. Activities of higher size yield higher revenues, but also lead to higher costs. For all franchise stores, costs are identically given by a function $C(a|x)$ that is twice differentiable, strictly increasing and strictly convex in a for all x, i.e. $C'(a|x) > 0$ and $C''(a|x) > 0$. Furthermore, the Inada conditions $C'(0|x) = 0$ and $\lim_{a\to\infty} C'(a|x) = \infty$ shall hold for all x. A store's revenues are given by a twice differentiable, strictly increasing, and concave function $R(a|x)$.

A chain consists of a continuum of stores with mass normalized to 1 (thus a chain's total size is fixed). The fraction of company-owned stores in the chain is denoted by γ, so that the fraction of franchised stores is $1 - \gamma$.

Following the arguments given in Section 4.2, we assume that company-owned stores are run less efficiently than franchise stores. This is incorporated simply by assuming that profits of a company-owned store are by a fixed amount L lower than profits of a franchise store.

When the state of the world is x and all stores of a chain implement activities a, total profits are thus given by

$$\pi(a|x) = R(a|x) - C(a|x) - \gamma L. \tag{4.1}$$

An activity that maximizes total profits at a state x is called *efficient* and denoted by $a_e(x)$. It follows from the assumptions on the cost and revenue functions that the efficient size of activity is uniquely defined by the condition that marginal cost equal marginal revenues, i.e.

$$C'(a_e|x) = R'(a_e|x). \tag{4.2}$$

We model the interaction between the chain headquarters H and a representative franchisee F by an extensive form game with the following timing:

1. The chain-headquarters H chooses a fraction of company-owned stores γ. Furthermore, H chooses a royalty $\rho \in [0, 1]$, which denotes the share of revenues that franchisees have to pay to the chain.

2. F accepts or rejects the offered franchise contract. If F rejects, H and F get both an outside payoff of 0.

3. Nature draws the state of the world x. H observes the state and chooses an activity $a_u \leq \overline{a}(x)$, which is uniformly implemented in all company and franchise stores.

Franchisee's final payoffs are its profits net of the royalty payments:

$$\pi_F = (1 - \rho)R(a_u|x) - C(a_u|x) \tag{4.3}$$

The chain's payoff consists of the royalty income from franchisees plus the profits from company-owned stores:

$$\pi_H = (1 - \gamma)\rho R(a_u|x) + \gamma(R(a_u|x) - C(a_u|x) - L) \tag{4.4}$$

We assume that both F and H are risk-neutral and maximize their expected payoff. Depending on the state of the world x, there is an upper limit $\overline{a}(x)$ on the maximal possible size of an activity. Without such a limit, the chain could impose activities of arbitrarily high costs upon the franchisees, which is surely unrealistic, since franchisees always have the option to breach the contract or to drop out of the chain. Furthermore, reputational concerns of the chain may impose a limit on activities' size even if the state of the world is imperfectly observable by the franchisees. We implicitly capture these considerations by imposing this upper bound $\overline{a}(x)$.
We now solve this game via backward induction.

Stage 3

Since π_H is concave in a, the activity that maximizes the chain's payoff, denoted by a_u^*, is implicitly given by the first order condition

$$C'(a_u^*|x) = \left(1 + \frac{(1-\gamma)\rho}{\gamma}\right) R'(a_u^*|x) \tag{4.5}$$

Comparing with Equation (4.2), we find that the chain's preferred level of activity a_u^* is weakly higher than the efficient level of activities a_e, and strictly higher whenever there are positive royalties ($\rho > 0$) and some franchised stores ($\gamma < 1$). The gap between a_u^* and the efficient activity, is decreasing in the fraction of company-owned stores γ. Especially, a_u^* converges to the efficient activity as the fraction of company-owned stores γ converges to 1.

The intuition behind these results is that an increased level of activity increases franchisees' revenues and thereby royalty payments to the chain, which gives H incentives to demand activity levels above the efficient level a_e. On the other hand, an activity level above a_e reduces profits of company-owned stores. A higher fraction of company-owned stores makes the chain therefore prefer more efficient activities. H selects a_u^* unless the upper bound on activities' size $\overline{a}(x)$ is binding. The selected activity is thus given by

$$a_u(x, \gamma, \rho) = \begin{cases} a_u^*(x, \gamma, \rho) & \text{if } a_u^* \leq \overline{a} \\ \overline{a}(x) & \text{if } a_u^* > \overline{a} \end{cases} . \tag{4.6}$$

Stage 2

Franchisees accept the contract if and only if their expected payoff, denoted by $\Pi_F(\gamma, \rho)$ is non-negative, where expectations are taken over the possible states of the world x and the choice of a_u at Stage 3 is rationally predicted.

Stage 1

We denote the expected payoff of the chain, conditionally on the contract being accepted, by $\Pi_H(\gamma, \rho)$. To avoid tedious case distinctions about whether it is profitable to open up a chain or not, the following regularity condition is imposed:

Condition 6 *There exist a combination of γ and ρ such that franchisees accept the contract and H's expected payoff $\Pi_H(\gamma, \rho)$ is strictly positive.*

Lemma 4.1 characterizes the selected royalty rate ρ given γ :

Lemma 4.1 *For any given fraction of compand-stores $\gamma < 1$ it holds true that*

1. *the chain's expected payoff (conditional on the contract being accepted)* $\Pi_H(\gamma, \rho)$ *is strictly increasing in the royalty* ρ,

2. *the franchisee's expected payoff* $\Pi_F(\gamma, \rho)$ *is strictly decreasing in the royalty* ρ,

3. *there is a unique royalty* $\rho_u(\gamma)$ *such that* $F's\ expected\, payoff$ *is zero,*

4. *H chooses* $\rho_u(\gamma)$ *at Stage 1.*

Since the royalty is set to the level $\rho_u(\gamma)$ where franchisees have zero expected payoff, the chain's expected payoff is identical to the expected total profit in the chain. The optimal choice of the fraction of company-owned stores γ now balances two factors: On the one hand, company-owned stores are less profitable than franchise stores, but on the other hand, a higher fraction of company-owned stores leads to the selection of more efficient activities at Stage 3. The second effect is especially pronounced when the upper bounds on sizes of activities $\overline{a}(x)$ are high, since without company-owned stores inefficiencies would be quite large for high $\overline{a}(x)$. One the other hand, the marginal gains from more efficient activities converge to zero as the fraction of company-owned stores goes to 1. That is the intuition behind the following result:

Proposition 4.1 *If there is an obligation to uniform standards and the upper bounds on the size of activities* $\overline{a}(x)$ *are sufficiently large, the chain will be of the plural form, i.e. H chooses* $\gamma \in (0, 1)$.

We thus have shown that the plural form can endogenously arise in our model, even though company-owned stores are less profitable than franchise stores.

4.3.2 Case 2: Both commitment to uniform standards and fraction of company-owned stores are endogenously determined

To see whether the chain prefers a commitment to uniform standards, we briefly examine the outcome of our model when the chain can select different activities for franchise stores than for company-owned stores. The previous model is modified such that at Stage 3 the chain headquarters can select different activities for company-owned stores and franchise stores.

Now, the chain selects for company-owned stores the efficient level of activities a_e at Stage 3, in order to maximize company-owned stores' profits. For franchise stores the chain selects the maximum activity $\overline{a}(x)$ in order to maximize royalty payments (unless the royalty ρ is 0). As before, franchisees accept the contract at Stage 2 if and only if their expected payoff is non-negative.

The analysis of Stage 1 is straightforward because the selected activities in Stage 3 do neither depend on the fraction of company-owned stores γ nor on the royalty ρ. Obviously, the chain sets the royalty on that level where expected payoff of franchisees is zero. Thus, the headquarters' expected income from a franchise store is given by $E_x[R(\overline{a}|x) - C(\overline{a}|x)]$ and from a company-owned store by $E_x[(R(a_e|x) - C(a_e|x)) - L]$. Neither of the two expressions does depend on the fraction of company-owned stores γ. Hence, the chain will be completely franchised if expected income from franchise stores is higher than that of company-owned stores, and completely company-owned if the reverse is true. A plural form can at most be equally profitable, but this happens only in the non-generic case where both types of stores make the same expected profits.

This implies that it is weakly dominant for the chain to include a commitment to uniform standards into the contract. Without uniform standards either complete franchising or complete ownership is the optimal structure, but in those cases a commitment to select the same activities for franchise and company-owned stores has obviously no effect. This means a commitment to uniform standards can never harm. Furthermore, it directly follows that whenever the plural form is strictly optimal under a commitment to uniform standards, making such a commitment is also strictly optimal. We summarize this result in Proposition 4.2:

Proposition 4.2 *When the fraction of company-owned stores is endogenously selected at Stage 1, it is always optimal for the chain to include a commitment to uniform standards into the franchise contract.*

Proof.

(see derivation above) ■

4.3.3 Case 3: Fraction of company-owned stores is exogenously given

We now analyse the case where the optimal fraction of company-owned stores is determined by factors outside our model, like those factors reviewed in Section 4.2. We consider the extreme case where the fraction of company-owned stores is completely exogenously given and examine under which conditions the chain optimally includes a commitment to uniform standards between franchise and company-owned stores into the franchise contracts at Stage 1. We especially analyse whether — ceteris paribus — such a commitment is optimal rather for a low or for a high fraction of company-owned stores.

Since the fraction of companies stores is exogenously given, it does not matter for the analysis whether franchise stores are more efficient than company-owned stores. To simplify the exposition, we therefore assume that both type of stores are equally efficient (i.e. $L = 0$).

Behavior in Stages 2 and 3 with uniformity requirement is the same as analyzed in Case 1 and without a uniformity requirement the same as analyzed in Case 2. Furthermore, royalties are again uniquely determined by the condition that franchisee's expected payoff at Stage 2 is zero. The headquarters' expected payoff is therefore given by the expected profits of franchised restaurants plus expected profits of company-owned restaurants and can be written as

$$\Pi_H^u(\gamma) \equiv E_x[\pi(a_u|x)] \tag{4.7}$$

$$\Pi_H^n(\gamma) \equiv E_x[(1-\gamma)\pi(\overline{a}|x) + \gamma\pi(a_e|x)] \tag{4.8}$$

for the cases with (superscript u) and without (superscript n) a commitment to uniformity standards, respectively. A commitment to uniform standards is optimal whenever $\Pi_H^u(\gamma) \geq \Pi_H^n(\gamma)$.

Before presenting the general results, consider a simple example. Assume costs and revenues do not depend on the state of the world and are given by $R(a|x) = a$ and $C(a|x) = a^2$. The efficient size of activities is then given by $a_e = 0.5$. Assume the chain can force activities up to a maximum size of $\overline{a} = 0.75$. Figure 4.1 shows the chains' payoff with and without uniformity requirement as a function of the fraction of company-owned stores.

Two features of the example are generally true: First, if the chain is completely franchised or completely company-owned then uniform standards are obviously irrelevant and have no effect on the chains' expected payoff. Second, the chains' expected payoff (weakly) increases in the fraction of company-owned stores in both cases: with and without a uniformity requirement.

With a uniformity requirement the chain's payoff $\Pi_H^u(\gamma)$ increases in γ because a higher fraction of company-owned stores leads to the selection of more efficient activities a_u at Stage 3. This effect occurs whenever the fraction of company-owned stores is sufficiently high, such that the headquarter sets at Stage 3 activity $a_u = a_u^*$. For a small fraction of company-owned stores (in the example for $\gamma \leq 0.25$) we find that $\Pi_H^u(\gamma)$ is constant, because $a_u^* > \overline{a}$. This means the chain selects activities of maximal possible size $\overline{a}(x)$, which does not depend on γ.

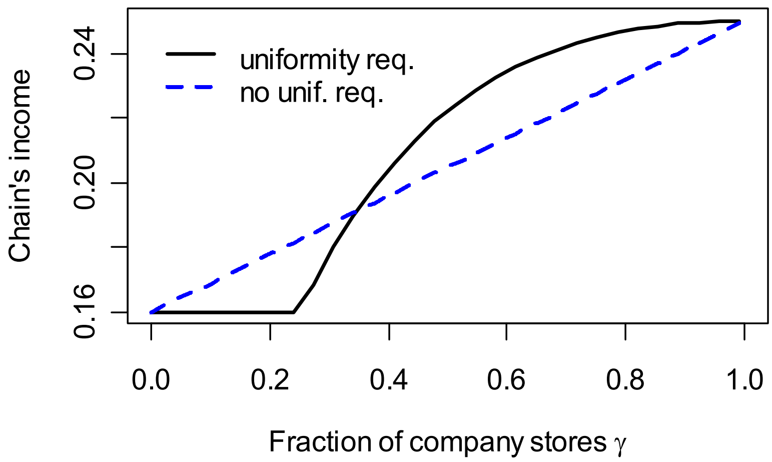

Figure 4.1: Example: Chain's income in cases with and without uniformity requirement as a function of the fraction of company stores.

Without a uniformity requirement, the chain's payoff $\Pi_H^n(\gamma)$ increases in γ because company-stores implement efficient activities whereas franchised stores are forced to implement the inefficient activities $\overline{a}(x)$. In the example $\Pi_H^u(\gamma)$ crosses $\Pi_H^n(\gamma)$ from below at $\gamma = \frac{1}{3}$.

Thus, it is optimal for the chain to include a uniformity requirement into the contract whenever the fraction of company-owned stores is higher than a third.

Parts of this result carry over to the general case. Under the sufficient condition that the upper bound on activities is higher than the efficient level of activities, i.e. $\overline{a}(x) > a_e(x)$, for all possible states x, we can show that for sufficiently high levels of γ it is optimal to commit to uniform standards and that for sufficiently low levels of γ it is optimal not being committed to uniform standards. We cannot, however, generally exclude the possibility that $\Pi_H^u(\gamma)$ and $\Pi_H^n(\gamma)$ cross more than once. Proposition 4.3 states this result:

Proposition 4.3 *If the fraction of company-owned stores γ is exogenously given, there are thresholds $\overline{\gamma} < 1$ and $\underline{\gamma} > 0$, such that for all sufficiently high γ, i.e. $\overline{\gamma} < \gamma < 1$, committing to uniform standards is strictly optimal for the chain and for all sufficiently low γ, i.e. $0 < \gamma < \underline{\gamma}$, it is strictly optimal not to be committed to uniform standards.*

This result suggests a positive correlation between the fraction of company-owned stores and the existence of a uniformity requirement in contracts. This is one of the questions we analyse in the following section.

4.4 Empirical Analysis

4.4.1 Data

The data of our empirical analysis is derived from a study of franchise systems that were selected using Entrepreneur Magazine's 1997 Franchise 500. The data was collected in the year 1999. Chains were limited to the food industry, and were also included only if they contained a minimum number of franchised stores (40), had begun franchising no later than 1987, and were reasonably stable in that they remained in the Franchise 500 for at least three consecutive years. Chains that began franchising in 1985 or later were included only if the ratio between franchised and company-owned stores was stable. Of the 70 chains fitting these criteria, 24 were entirely franchised or almost entirely franchised (5 or fewer company-owned stores or more than 99.5% franchised). Due to the time-consuming nature of data collection and processing, we included only 12 of such chains, chosen at random, resulting in a stratified sample of 58 chains. For these chains, we attempted to obtain the UFOC (Uniform Franchise Offering Circular) and other documents. This information proved impossible to obtain or inadequate in 21 chains (36.2%). The dataset therefore consists of 37 chains.

For each of these chains, the UFOC and other documents were analysed in order to obtain measures for the decision power of the chain headquarters and the strength of a contractual commitment to uniform standards. Different measures were created for changes related to new products and changes related to building work. Furthermore, for each chain two franchisees were chosen at random to be interviewed by telephone or fax.[6] These interviews focused on the extent of chain's headquarters' decision power and franchisees influence, as well as the role of uniform standards between franchise and company-owned stores. To avoid selection bias, the same franchisees were contacted repeatedly until a response was obtained; thus the participation rate was close to 100%. Basic statistics on each chain were also collected, including the numbers of franchised and company-owned stores for 1998. Table 1 shows the distribution of fraction of company-owned stores in the sample.

Table 1: Distribution of fraction of company stores in the sample

$\gamma \in$	0	(0,.1]	(.1,.2]	(.2,.3]	(.3,.4]	(.5,.6]	(.6,.7]	(.7,.8]	(.8,.9]	(.9,1]
No. of chains	6	11	5	2	4	3	2	3	0	1

[6] In one chain, only one such interview could be obtained.

4.4.2 Structure of the analysis

We first give a descriptive overview of the contract analysis and the interview results that shows that the decision power of the chain headquarters is indeed very strong in most chains. Then we analyze whether a commitment to uniform standards between franchise and company-owned stores appears in franchise contracts and how such a commitment is related to a chain's fraction of company-owned stores.

4.4.3 Decision power within a chain

Franchise contracts were classified according to the chain's decision power in two areas: the introduction of new products and changes in building requirements. Table 2 summarizes the results:

Table 2: Decision power according to franchise contracts	prod.	build.
1: Nothing can be found in the contract suggesting that franchisees play a role in decisions about changes in products / building requirements. No franchise association exists.	70%	62%
2: Contract indicates that changes must be reasonable or that a franchisee body (such as a franchise association) exists (that must be consulted or is normally consulted as a matter of routine)	24%	32%
3: Contract indicates that the chain cannot enforce changes of this sort on franchisee unless franchisees agree, or unless a representative franchisee body agrees.	5%	5%

The left column shows the classification category and the right columns the fractions of chains whose contracts fall into these categories with respect to product and building decisions. Overall, franchisees have slightly more rights with respect to changes in building requirements, but nevertheless in most chains the contracts give very strong or exclusive decision rights to the chain.

Note that although contracts usually grant franchisees only little decision power, the chain nevertheless often seeks advice from franchisees. Table 3 summarizes results of an interview question addressing this issue.

Table 3: Influence of franchisees on product decisions

Q: In deciding whether to introduce new products or change existing products, how much does your chain rely on advice from franchisees? Which of the following statements comes closest describing your chain?	
1: Franchisees do not provide important advice. The chain relies on its own experts.	9%
2: Franchisees sometimes provide important feedback, but our influence is limited.	36%
3: The chain actively seeks out feedback from franchisees because often they are very critical and/or knowledgeable and the chain appreciates that. Our influence is substantial.	35%
4: The chain always seeks advice from our franchisees, and a change rarely takes place if franchisees don't think it's a good idea. Our influence is tremendous.	19%
Rank order correlation (Spearman's ρ) between the two interviews of a chain: 0.62	

More than half of the answers state that franchisees chain often seeks advice from franchisees, which can also give franchisees influence on actual decisions. Nevertheless, still 45% of franchisees characterize their actual influence in the decision process as limited or not existent. Also, in our opinion such forms of informal influence provide no guarantee that franchisees will not be exploited by the decisions made by the franchise chain.

An important question for actual decision power in a chain is how strictly franchisees must adhere to decisions made by the chain headquarters. Corresponding interview results are summarized in Table 4.

Table 4: Leeway in diverging from official requirements

Q: I want to understand how much informal leeway franchisees have when the chain makes a decision about new products or a change in an existing product. Suppose that such a change takes place and a franchisee does not like the change. Which of the following statements comes closest describing your chain?	
1: He has to go along with the change because that's part of the deal when you become a franchisee.	39%
2: If he doesn't want to implement the change, he can request an exemption and occasionally such exemptions are granted.	38%
3: If he doesn't want to implement the change, he can request an exemption, and very often such exemptions are granted.	12%
4: The chain trusts its experienced franchisees and often looks the other way when they do their own thing because it knows that they must have good reasons for doing so.	11%
Rank order correlation (Spearman's ρ) between the two interviews of a chain: 0.76	

The answers suggest that in most chains, franchisees have to follow the chain's decisions quite strictly, although in some chains exemptions are regularly granted.

Our theoretical analysis focuses on diverging interests of the chain and its franchisees in the selection of activities. Is dissatisfaction about chains' decisions a commonly observed element in franchise relations? Table 5 shows that indeed some, but also not overwhelming much, dissatisfaction is reported by franchisees.

Table 5: Franchisees' satisfaction with chain's decisions

Q: In some chains, franchisees are very satisfied with decisions made by the chain. In others, there is some conflict over certain decisions, or franchisees might quietly not like some of the things the chain asks them to do. I want to understand how much conflict exists. (There may be none at all.) Read all of the following choices and tell me which is closest to being your opinion:	
1: The chain is pretty much always right on. I hardly even have any problem with their policies, and I wouldn't object, even if I could.	30%
2: I hardly ever have a problem with the chain's policies, but occasionally, they ask me to do something that I'd rather not do.	49%
3: They often ask me do something I would rather not do. It's happened quite a few times.	22%
Rank order correlation (Spearman's ρ) between the two interviews of a chain: 0.09 (not signifcant)	

The low correlation of the answers from the interviewed franchisees of the same chains, suggests, that satisfaction levels are specific for each franchisee and are not necessarily a characteristic element of certain chains. We also do not find a significant correlation between dissatisfaction and the fraction of company-owned stores in a chain.

4.4.4 Uniform standards between franchise and company-owned stores

Next, we examined whether a clause on uniform standards can be found in the franchise contract and how strong is the commitment to uniform standards with respect to product innovations and building requirements. The analysis is based on those 31 chains in our sample that have a positive number of company-owned stores. Table 6 summarizes the results.

Table 6: Uniformity requirement in franchise contracts	prod.	build.
1: Nothing in the contract indicates a commitment to uniformity. No mentioning of a system of uniform units.	13%	13%
2: The contract mentions a system of uniform units.	23%	16%
3: Contract indicates that the chain cannot enforce activities on franchisees unless those activities are chain wide. Typically the contract includes a commitment by the chain to maintain uniform standards.	55%	52%
4: The contract is explicit about its statement connected to uniform standards, with no room for interpretation.	10%	19%

Overall, uniformity is mentioned in 83% of contracts and a commitment to uniform standards can be found in a majority of chains, although often with some room for interpretation.

We now examine the theoretical prediction that a commitment to uniform standards is more likely to be beneficial when the fraction of company-owned stores is high. There are indeed positive rank order correlations (Spearman's ρ) between the fraction of company-owned stores and our measures of commitment to uniform standards of 0.54 (product) and 0.53 (building), which both are significant at a one percent level. To control for additional factors, like the royalty or the main product of the chain, we perform ordered probit regressions, summarized in Table 7.

Table 7: Ordered probit regression for contractual commitment to uniform standards

Independent variables	Product		Building requirements	
	(1)	(2)	(3)	(4)
Fraction of company stores γ	3.85***	5.12***	3.37***	3.53***
	(1.23)	(1.64)	(1.10)	(1.27)
Royalty	-14.62	-9.88	-21.35	-10.94
	(23.88)	(31.95)	(23.41)	(29.93)
Number of stores (100s)	.001	-.004	.004	.003
	(.010)	(.012)	(.010)	(.011)
Age of chain	.010	.006	.006	.001
	(.015)	(.019)	(.015)	(.019)
Chain's main product				
Hamburger		-.345		-.525
		(1.042)		(1.00)
Sandwich		-.074		-.731
		(1.11)		(1.09)
Chicken		.447		.008
		(.743)		(.704)
Pizza		.311		-.082
		(.774)		(.749)
Familiy food		-.096		1.25
		(.928)		(.971)
Steak		-.691		.431
		(1.103		(1.21)
Ice cream		2.29*		1.16
		(1.39)		(1.21)
Mexican food		.141		.662
		(.993)		(.936)
Pseudo R^2	0.22	0.30	0.19	0.27

Notes: Estimated standard errors in parentheses. Number of observations: 31
*** / ** / * indicate statistical significance at the 1, 5 and 10 percent level, respectively.

Despite the small sample size, we find for all four specifications a strongly significant impact of the fraction of company-owned stores on the strength of a commitment to uniform standards. Except for the weakly significant dummy for chains with ice cream as main product (which may be due to spurious correlation), no other factor can significantly explain the degree of contractual commitment to uniform standards.

We also investigate the role of uniformity in our interview questions. Franchisees were asked whether uniform treatment of franchisees and company-owned stores is often violated or not.

Table 8: Uniform standards, interview results

Q: Most of the time when a chain introduces a product, the introduction is system-wide, in both company stores and franchised stores. I want to understand whether this is just the way things happen, or whether the chain actually has to do things this way, contractually. Which of the following statements comes closest to describing your chain?	
1: There is no policy to maintain uniform standards. Sometimes franchisees must adopt practices that are different from those adopted in company stores.	12%
2: The chain does not legally have to maintain uniform standards, but they do so as a matter of policy.	2%
3: The chain does maintain uniform standards (between company stores and franchised stores), but I'm not sure if they legally have to do this.	56%
4: The chain must maintain the same standards in franchised and company-owned stores. Franchisees cannot legally be forced to adopt any practice that is not also adopted in company stores.	31%
Rank order correlation (Spearman's ρ) between the two interviews of a chain: 0.57	

The results (see Table 8) show that uniformity standards generally seem quite strong, although still 12% of franchisees report that they sometimes have to adopt different practices than company-owned stores. Somewhat surprising, from our theoretical perspective, the answers to this question are neither significantly correlated with our contractual measure of uniformity, nor is there a significant correlation with the fraction of company-owned stores in a chain. This indicates that — at least for most decisions — adherence to uniform standards is driven also by alternative factors of the business-environment that seem to be to some degree independent of the actual contractual clauses.

In line with our model it is generally true, however, that the maintenance of uniform standards plays an important role for franchisees:

Table 9: Importance of uniform standards

Q: How important is it to you that the chain maintain uniform standards?	
1: This policy is not very important.	0%
2: This policy is moderately important.	35%
3: This policy is very important.	65%
Rank order correlation (Spearman's ρ) between the two interviews of a chain: -0.06 (not signif.)	

4.5 Summary

We presented a formal model that analyses the optimal choice of the fraction of company-owned stores and contractual commitments to uniform standards. The main idea is based on the well known fact that franchisees pay revenue-based royalties, which can lead to selection of inefficient activities by the chain. Since company-ownership allows the chain a credible commitment to select activities that are more efficient, a positive fraction of company-owned stores can arise in our model where franchise stores are always run more efficiently. This mechanism only works if the chain must maintain uniform standards that require to select the same activities in franchise and company-owned stores.

If the fraction of company-owned stores is determined by exogenous factors, the analysis showed that it is optimal for a chain to include a commitment to uniform standards into franchise contracts if the fraction of company-owned stores is high, but to omit such a commitment if the fraction of company-owned stores is low.

An empirical analysis of contract and interview data from the US fast-food industry gave an descriptive overview of the distribution of decision power within the chains and the importance of uniform standards and tested whether uniform standards are more often observed in chains where the fraction of company-owned stores is high. There is indeed a significantly positive correlation between the fraction of company-owned stores and the occurrence of a commitment to uniformity standards in the analysed franchise contracts. The positive relationship remained significant when controlling for additional chain-specific characteristics.

Appendices

Appendix of Chapter 1

Proof of Proposition 1.2: We first proof the existence of complier-optimal norm equilibria. The proof makes use of the existence result for subgame-perfect equilibria in games with continuous strategy spaces using discrete approximations by Börgers (1991).

To apply Börgers' result, we first construct for any given κ a two-stage game $\Gamma(\kappa)$ with $n+1$ players. Player 0 can be thought off as an agent for all compliers and players $1, ..., n$ correspond to selfish players. In stage 1, player 0 selects a norm $r \in S$. This move is perfectly observed by all players. In stage 2, players $i = 1, ..., n$ play the game $G^{\kappa,r}$, where they simultaneously choose a strategy $s_i \in S_i$. Final payoffs of players $1, ..., n$ are given by the payoffs of $G^{\kappa,r}$, i.e. by $u^{\kappa,r}(s)$. Final payoffs of player 0 are given by compliers expected payoffs in the game $G^{\kappa,r}$ when s is selected, i.e. by $\frac{1}{n}\sum_{i=1}^{n} u_i^{\kappa,r}(r_i, s_{-i})$.

In every subgame-perfect equilibrium of $\Gamma(\kappa)$, at stage 2 a Nash equilibrium of $G^{\kappa,r}$ is selected. At stage 1, player 0 chooses a norm r that maximizes compliers expected payoff given the specific selection of selfish Nash equilibria in stage 2. This implies that (r^*, s^*) is a subgame perfect equilibrium outcome of Γ^κ if and only if there exists some selfish equilibrium selection function ψ for which (r^*, s^*) is a complier optimal norm equilibrium for κ and G.

It remains to show that there always exists a subgame perfect equilibrium for the game $\Gamma(\kappa)$. Let $S^j \subset S$ be some finite subset of the strategy space and let $\Gamma^j(\kappa)$ be a game constructed like $\Gamma(\kappa)$ with the only difference that in stage 1 player 0 has to select a norm r from the finite set S^j. Since for every norm a continuation equilibrium exists at stage 2 (by Proposition 1.1) and out of a finite set there is always a norm that maximizes compliers expected utility, there always exists a subgame perfect equilibrium for the game $\Gamma^j(\kappa)$. Since S is compact, there exists a sequence of finite strategy spaces $\{S^j\}_{j=1}^{\infty}$ that converges to S in Hausdorff distance.[7] The corresponding sequence of games $\Gamma^j(\kappa)$ then converges to $\Gamma(\kappa)$ according to the definition of Börgers (1991). Existence of a subgame perfect equilibrium of $\Gamma(\kappa)$ then follows from Corollary 2 of Börgers (1991).

The proof for existence of rule-utilitarian norm equilibria proceeds similarly, with the only difference that $\Gamma(\kappa)$ is constructed such that player 0's final payoffs are given by $\frac{1}{n}\sum_{i=1}^{n}\left(\kappa u_i^{\kappa,r}(r_i, s_{-i}) + (1-\kappa)u_i^{\kappa,r}(s)\right)$.■

Proof of Proposition 1.6: We only proof the result for complier optimal norms, the proof for rule-utilitarian norms is then straightforward and ommited here. Take a norm r^o where a compliant player 1 offers x^o and a compliant player 2 accepts x^o for sure and rejects all other offers.

I. In the first part of the proof we show that in the norm equilibrium with r^o a selfish player 1 also offers x^o. When a selfish player 1 offers x, his expected utility is given by

$$u_1^{\kappa,r^o}(x) = \begin{cases} 0 & \text{if } x < x^* \\ (1-\kappa)(1-x) & \text{if } x^* \leq x < x^o \\ 1-x & \text{if } x^o \leq x \leq 0.5 \\ 1-x-\alpha(2x-1) & \text{if } 0.5 < x \end{cases}.$$

There are only two candidates for maxima: x^* and x^o. The selfish player offers x^o if and only if $(1-\kappa)(1-x^*) \leq 1-x^o \Leftrightarrow x^o \leq \kappa + (1-\kappa)x^*$, which is fulfilled by the definition of x^o.

II. In the second part of the proof we show that every norm equilibrium with a different equilibrium outcome than under r^o yields a strictly lower compliers' expected utility. We start by discussing some upper bounds on compliers' expected utility. The expected sum of utility of player 1 and 2 is given by $T := 2\left[(1-\kappa)U + \kappa V\right]$. We call T *total utility.* Since $V_1 \leq U_1$ and $V_2 \leq U_2$ has to hold, compliers' expected utility is bounded from above by $\frac{1}{2}T$. If we know that a compliant player 1 has strictly lower expect utility than a selfish player 1, i.e. $\Delta_1 := U_1 - V_1 > 0$, the upper bound decreases to $\frac{1}{2}(T-\Delta_1)$, because $V_2 \leq U_2$ must still hold. For a given norm equilibrium, let A denote the expected total disutility caused by envy and let R be the expected share of rejected offers. Total utility is then given by $T = 1 - A - R$. This implies $\frac{1}{2}(1 - A - R - \Delta_1)$ as upper bound for compliers' expected utility.

Consider first the case $x^o = 0.5$. Under r^o no player ever feels envious and therefore total utility is given by 1 and compliers' expected utility reaches its upper bound of

[7] The Hausdorff distance between a set S^j and S is given by $\max_{s\in S}\min_{s^j\in S^j} d(s, s^j)$, where $d(.)$ is the metric on the strategy space S.

0.5. In any other equilibrium outcome there would either be some envy or rejected offers, which would lead to a strictly lower compliers' expected utility.

Consider now the case $x^o < 0.5$. Compliers' expected utility under r^o is then given by $V^o = \frac{1}{2}(1-A^o)$, where $A^o = \alpha((1-x^o)-x^o) = \alpha(1-2x^o)$ is the total disutility by envy (experienced by player 2). In the following 5 steps we show that norms with different behavior on the equilibrium path must lead to strictly lower compliers' expected utility than r^o.

1. Let r' be a norm that differs from r^o such that with positive probability offers below x^o are made and accepted. Since there are lower offers under r', total envy A' under r' is strictly higher than under r^o. This means compliers' utility is bounded from above by $\frac{1}{2}(1 - A') < V^o$.

2. Consider a norm r' that differs from r^o such that with positive probability an offer of x^o is rejected on the equilibrium path. Rejecting an offer of x^o reduces total envy by $\alpha(1-2x^o)$ but also reduces total monetary payoff by 1. This reduction in monetary payoff reduces the total utility by more than the reduction of envy increases it. This is most easily seen by observing that $x^o > x^*$ and that therefore a player 2 considers the decrease in monetary payoff (already of his share) to be more severe than the positive effects of the reduction in envy. Hence, under r' total utility is bounded by a level strictly below V^o.

3. Consider a norm r' that differs from r^o such that with positive probability offers below x^o are made and accepted *and* offers of x^o are rejected on the equilibrium path. It is also straightforward to show that such a norm yields compliers' expected utility strictly below V^o (we omit the steps that are very similar to 1. and 2.).

4. There exists no norm where a selfish player 1 makes offers above x^o (in the actual case with $x^o < 0.5$). To see this, assume compliers want to induce a selfish player to offer some $x^s > x^o$. The best way to achieve this is to accept only offers of x^s and to reject all other offers. Using similar calculations like in the first part of the proof, we find, however, that a selfish player 1 offers x^* instead of x^s whenever $(1-\kappa)(1-x^*) > 1 - x^s \Leftrightarrow x^s > \kappa + (1-\kappa)x^* = x^o$.

5. Finally, we show that there is no complier optimal norm r' where compliers make offers above x^o with positive probability. Note that it cannot be complier optimal to make offers above 0.5, since total envy is minimized by offering 0.5. Further, a compliant player 2 should accept all offers $x \geq x^o$, since it is obviously not complier optimal to reject an offer between x^o and 0.5.

Let $F(x)$ denote the distribution function of compliant player 1's offers under r'. The difference in expected utility of a selfish player 1 to that of a compliant player 1 is given by $\Delta_1' = \int_{x^o}^{0.5}(x - x^o)dF(x)$. The difference in total envy between r^o and r' is given by $A^o - A' = 2\kappa\alpha \int_{x^o}^{0.5}(x - x^o)dF(x)$. Compliers' expected utility under r' is bounded from above by $\frac{1}{2}(1 - A' - \Delta_1) = \frac{1}{2}(1 - A^o) + \frac{1}{2}(A^o - A') - \Delta_1)$, which, therefore, can be written as $V^o + \frac{1}{2}[2\kappa\alpha - 1] \int_{x^o}^{0.5}(x - x^o)dF(x)$. This upper bound is greater or equal than V^o only if $2\kappa\alpha - 1 \geq 0$, i.e. $\alpha \geq \frac{1}{2\kappa}$. For $\alpha \geq \frac{1}{2\kappa}$ we find, however, $x^* \geq \frac{1}{2(1+\kappa)}$, which implies $\kappa + (1-\kappa)x^* \geq 0.5 + \frac{\kappa^2}{1+\kappa}$ and thus $x^o = 0.5$. This contradicts the assumption, made for this case, that $x^o < 0.5$.■

Proof of Proposition 1.8: Since it has only a single community, the described society is Nash-stable. It remains to show that there exists no successful announced migration. First note that no announcement that asks only selfish players to migrate can be successful, since they would get expected utility of $U_{\kappa=0}$ in the new community, if no one followed. Since by C3, $U_{\kappa=0} \leq V(\widehat{\kappa}, r^o(\widehat{\kappa})) \leq U(\widehat{\kappa}, r^o(\widehat{\kappa}))$ selfish players cannot be strictly better off by such migration.
Consider now the case that the announcement asks some compliers to migrate to a community C^d. This is only successful if compliers are strictly better off in C^d. Then if there are still compliers outside C^d, they want to follow to C^d by uncoordinated migration. In the (unlikely) case that $V(\kappa, r^d)$ is not weakly increasing in κ, compliers' expected utility in C^d may already drop after this uncoordinated migration below the initial level $V(\widehat{\kappa}, r^o(\widehat{\kappa}))$. Otherwise, the remaining selfish players outside C^d want to follow to C^d, since (using again C3) $U_{\kappa=0} \leq V(\widehat{\kappa}, r^o(\widehat{\kappa})) < V(\kappa^d, r^d) \leq U(V(\kappa^d, r^d))$. Now all inhabitants are in C^d and compliers of the announced migration cannot be strictly better off than initially.■

Proof of Proposition 1.9: We now show that in every migration-proof equilibrium compliers' expected utility equals $V(\widehat{\kappa}, r^o(\widehat{\kappa}))$ in all communities. It follows directly from the definition of a Nash-stable society that compliers' expected utility must be equal in all communities.
1. In no Nash-stable society can compliers have utility higher than $V(\widehat{\kappa}, r^o(\widehat{\kappa}))$. This is because in every society there is at least one populated community C' with a compliers' share $\kappa' \leq \widehat{\kappa}$ and by C4 compliers' expected utility in community C' cannot exceed $V(\widehat{\kappa}, r^o(\widehat{\kappa}))$.
2. It remains to check that there can exist no migration-proof equilibrium where compliers' expected utility is smaller than $V(\widehat{\kappa},\ r^o(\widehat{\kappa}))$. Denote compliers' expected utility in the original society by V_{orig}. Suppose for a proof by contradiction that this society is a migration-proof equilibrium with $V_{orig} < V(\widehat{\kappa}, r^o(\widehat{\kappa}))$. By C5 there exists a complier optimal norm $r^o(\widehat{\kappa})$ with $V(\kappa, r^o(\widehat{\kappa})) \geq V(\widehat{\kappa}, r^o(\widehat{\kappa})) > V_{orig}$ for all $\kappa \geq \widehat{\kappa}$. Consider an announced migration that asks all compliers to migrate to a new

community C^o with this norm $r^o(\widehat{\kappa})$. No matter how many selfish players follow to C^o, the compliers' share in C^o is always bigger than or equal to $\widehat{\kappa}$. By the inequality stated above, compliers' expected utility in C^o is therefore strictly higher than originally, which means the announced migration is strongly successful. The original society was therefore not a migration-proof equilibrium.■

Appendix of Chapter 2

We prove Propositions 2.1, 2.3, 2.4 (first sentence), 2.5, 2.6 and Lemma 2.1 and 2.2 directly for the more general regulatory schemes introduced in Section 2.5. The original propositions are a special case of this set-up, since a linear access price $a > c_0$ fulfills conditions (L1) and (L2). We will generally use the notation Q^u, Q^v and Q^s to denote the resulting outputs, under legal unbundling, vertical integration and separation, respectively and similarly h^u, h^v, h^s and x^u, x^v, x^s for firms' equilibrium choices in the different vertical structures.

Proof of Proposition 2.1: Under legal unbundling, F_0 sets h in order to maximize upstream profits π_0, and by choosing the same sabotage strategy than under vertical integration, F_0 can guarantee the same level of upstream profits — recall from the remark before Proposition 2.1 that the outcome under both structures will be the same whenever the sabotage strategy h is the same, even if downstream firms move simultaneously. Since π_0 is strictly increasing in total output Q and vice versa, also total output under legal unbundling is always as least as high as under vertical integration.

Proof of Proposition 2.2: We show that F_0 can guarantee a weakly higher total output under legal unbundling than under separation, i.e. $Q^u \geq Q^s$ by choosing under legal unbundling the same sabotage strategy than the optimal sabotage strategy h^s under separation, i.e. by setting $h^u = h^s$. Under full separation, the incumbent F_1 then chooses x^s to maximize $\pi_1(x, h^s)$, and under legal unbundling F_1 chooses x^u to maximize $\pi_1(x, h^s) + \pi_0(x, h^s)$. Optimal choice by F_1 thus implies

$$\pi_1(x^s, h^s) \geq \pi_1(x^u, h^s)$$

$$\pi_1(x^u, h^s) + \pi_0(x^u, h^s) \geq \pi_1(x^s, h^s) + \pi_0(x^s, h^s)$$

Adding both inequalities yields $\pi_0(x^u, h^s) \geq \pi_0(x^s, h^s)$ and since upstream profits π_0 are strictly increasing in total output, this implies that total output is weakly higher under legal unbundling than under separation, i.e. $Q(x^u, h^s) \geq Q(x^s, h^s)$.■

Proof of Proposition 2.3: (Cournot) F_0 can guarantee the same output under legal unbundling than under separation, an output of $Q^u = Q^s$, by setting $h_1^u = h_1^s + (a - c_0)$ and hampering all other entrants in the same way as under vertical separation, i.e. setting $h_i^u = h_i^s$ for all $i = 2, ..., n$. With such hampering F_1 maximizes under legal unbundling

$$\pi_1^s(q) + (a - c)q_2.$$

where $\pi_1^s(q)$ denotes F_1's profit function under vertical separation. The added term $(a - c)q_2$ has no influence on F_1's best reply function and therefore both firms have the same best reply functions as under vertical separation, leading to the same equilibrium outcome.■

Proof of Proposition 2.4: If F_0 sets the same sabotage strategy under separation than under reverse legal unbundling, i.e. $h^s = h^r$ the total output and π_0 will be the same, since downstream firms will act in the same way. Since under separation F_0 wants to maximize total output and π_0, it will at least achieve output and π_0 at least as high as under reverse legal unbundling, which is guaranteed by setting $h^s = h^r$.■

Proof of Proposition 2.5: If under legal unbundling the same total amount would be invested as under separation (vertical integration), we only have an investment allocation problem, which is equivalent to our basic model as explained in the text. Thus, Proposition 2.1 applies and we know that π_0 must be weakly higher under legal unbundling. F_0 chooses a different investment level under legal unbundling than the optimal level under separation (vertical integration), only if this would lead to even larger net profits $\pi_0 - I^u$. Therefore the first sentence is true. The second sentence follows directly from the first result, under a linear access price $a > c_0$, by inserting π_0 and rearranging the inequalities.■

Proof of Lemma 2.1: Let c_0^a and c_0^b be two marginal costs with $c_0^a > c_0^b$. Let h^a denote F_0's optimal h if marginal costs are c_a, and let x^a be the selected downstream equilibrium given h^a and c_a. We define h^a and x^b correspondingly. Under legal unbundling F_0 wants to maximize total output Q. We show that F_0 can guarantee $Q^b \geq Q^a$ by setting $h^b = h^a$. Optimal choice by F_1 then implies

$$\pi_1(x^a, h^a) + R\left(Q(x^a, h^a)\right) - c_0^a Q(x^a, h^a) \geq \pi_1(x^b, h^a) + R\left(Q(x^b, h^a)\right) - c_0^a Q(x^b, h^a)$$
$$\pi_1(x^b, h^a) + R\left(Q(x^b, h^a)\right) - c_0^b Q(x^b, h^a) \geq \pi_1(x^a, h^a) + R\left(Q(x^a, h^a)\right) - c_0^b Q(x^a, h^a)$$

Adding up the two inequalities yields $(c_0^a - c_0^b)Q(x^b, h^a) \geq (c_0^a - c_0^b)Q(x^a, h^a)$ and therefore $Q(x^b, h^a) \geq Q(x^a, h^a)$.■

Proof of Proposition 2.6: Let I_a and I_b be two investment levels with $I_a < I_b$ and let c_0^a and c_0^b with $c_0^a > c_0^b$ be the resulting marginal costs. Generally subscripts or superscripts a and b index the investment level that is considered, while u, v and s index in the vertical structure in the common way. Let $\Delta_{ab}^u := \pi_0^b(h_b^u, x_b^u) - \pi_0^a(h_a^u, x_a^u)$, $\Delta_{ab}^s := \pi_0^b(h_b^s, x_b^s) - \pi_0^a(h_a^s, x_a^s)$ and $\Delta_{ab}^v := \pi_{01}^b(h_b^v, x_b^v) - \pi_{01}^a(h_a^v, x_a^v)$ denote the changes in F_0's objective function when marginal costs change from c_a to c_b (excluding the change in investment costs $I_b - I_a$) under the different vertical structures.

We will first derive a lower bound on Δ_{ab}^u. Recall that π_0 is strictly increasing in total output. Therefore $Q(h_b^u, x_b^u)$ is the highest quantity that F_0 can achieve with marginal costs c_0^b and by Lemma 2.1 also no higher quantity can be achieved under marginal costs c_0^a. Therefore $\pi_0^a(h_a^u, x_a^u) \leq \pi_0^a(h_b^u, x_b^u)$. Furthermore, $\pi_0^b(h_b^u, x_b^u) - \pi_0^a(x_b^u, h_b^u) = \left(c_0^a - c_0^b\right)(Q(h_b^u, x_b^u))$. Together with the definition of Δ_{ab}^u, these two results imply

$$\Delta_{ab}^u \geq \left(c_0^a - c_0^b\right) Q(h_b^u, x_b^u).$$

We will now show that $\Delta_{ab}^u - \Delta_{ab}^s \geq 0$ and $\Delta_{ab}^u - \Delta_{ab}^v \geq 0$, which implies that under legal unbundling we will always find weakly higher investment than under separation as well as integration.

(i) $\Delta_{ab}^u - \Delta_{ab}^s \geq 0$: Under complete separation, the total quantity Q^s is independent of F_0's cost structure. Thus moving from c_a to c_b changes F_0's profits by

$$\Delta_{ab}^s = \left(c_0^a - c_0^b\right) Q^s.$$

By Proposition 2.1, $Q_b^u \geq Q^s$ and using the lower bound on Δ_{ab}^u we find

$$\Delta_{ab}^u - \Delta_{ab}^s \geq \left(c_0^a - c_0^b\right)(Q_b^u - Q^s) \geq 0.$$

(ii) $\Delta_{ab}^u - \Delta_{ab}^s \geq 0$: Since under vertical integration both F_0 and F_1 want to maximize π_{01}, we have $\pi_{01}^a(h_a^v, x_a^v) \geq \pi_{01}^a(h_b^v, x_b^v)$. Furthermore, $\pi_{01}^b(h_b^v, x_b^v) - \pi_{01}^a(h_b^v, x_b^v) = \left(c_0^a - c_0^b\right) Q(h_b^v, x_b^v)$. Together with the definition of Δ_{ab}^v, these two results imply $\Delta_{ab}^v \leq \left(c_0^a - c_0^b\right) Q(h_b^v, x_b^v)$. By Proposition 2.1, we have $Q(h_b^u, x_b^u) \geq Q(h_b^v, x_b^v)$ and using the lower bound on Δ_{ab}^u, we therefore find $\Delta_{ab}^u - \Delta_{ab}^v \geq \left(c_0^a - c_0^b\right)(Q_b^u - Q_b^v) \geq 0$.■

<u>Proof of Lemma 2.2:</u> Standard case of price competition, see derivation in Section 2.4.

<u>Proof of Lemma 2.3:</u> At price $c_2 + a$ the incumbent F_1 prefers to give the whole market to F_2, since π_1 is strictly negative for all prices below $c_1 + a$. F_0 can guarantee this outcome by not sabotaging F_2, and therefore no equilibrium with a higher price than $c_2 + a$ can exist. If a is large there could be cases, however, with an equilibrium price p' strictly between $c_0 + c_1$ and $c_2 + a$ where F_1 gets the whole market. Although π_1 would then be negative, joint profits $\pi_1 + \pi_0$ could be higher than under the outcome where F_2 gets the whole market at price $c_2 + a$, because output Q and upstream profits π_0 are higher. Such an equilibrium with a price $p' < c_2 + a$ can only arise, however, if the access price is Pareto-dominated by a lower access price. To see this, consider an access price $a' < a$ that fulfills $a' + c_2 = p'$. With such an access price, F_1 would prefer to give the whole market to F_2 at price p' instead of taking the market itself (since π_1 is negative under p'). Access price a' Pareto-dominates access price a, because no firm nor consumers are worse off and F_1 is strictly better off under this outcome with access price a'.■

<u>Proof of Lemma 2.4:</u> If F_1 gets the market, then the optimal price is F_1's monopoly price under costs $c_1 + c_0$. If F_2 gets the total market it is optimal that this happens at

the lowest possible price that F_2 is ever willing to pay, i.e. $c_2 + a$. Joint profit π_{01} can also not be higher in a situation where both firms split total output at some price p. Since goods are perfect substitutes and marginal costs linear, π_{01} from splitting the market is at least as high if either only F_1 or only F_2 gets the total market at the same price p.$\blacksquare$

Proof of Lemma 2.5: Since under reverse legal unbundling F_1 maximizes its own profits π_1 and by assumption plays no weakly dominated strategy, F_1 will never set a price below $a + c_1$, which implies that no equilibrium with a price below $a + c_1$ exists. Since F_0 maximizes joint profits $\pi_0 + \pi_1$ and π_1 is non-negative for all prices $p \geq a + c_1$, F_0 weakly prefers that F_1 serves the whole market. Joint profit π_{01} is then maximized by the monopoly price would be p_{10}^m. If $a + c_1 \leq p_{10}^m$, then F_0 can achieve this outcome by setting h_2 such that $a + c_2 + h_2 = p_{10}^m$. Then F_1 will a price equal to p_{10}^m and get the whole market. If $a + c_1 > p_{10}^m$ the from all prices achievable in equilibrium the price $p = a + c_1$ maximize π_{01}. This can be achieved by F_0 setting h_2 such that $a + c_2 + h_2 = a + c_1$. Whether F_1 or F_2 gets the market in this equilibrium does not matter.$\blacksquare$

Proof of Proposition 2.9: We prove the first sentence of the proposition for the case of legal unbundling; for vertical separation, the steps are similar. Total welfare, excluding investment costs, under legal unbundling is in our Bertrand model given by

$$W^u = CS(p^u) + p^u Q(p^u) - (c_0 - \delta + c_2)\, Q(p^u)$$

where the market price $p^u = a + c_2$ does not depend on c_0 and δ. We thus find $\frac{\partial W^u}{\partial \delta} = Q^u$ and $\frac{\partial^2 W^u}{\partial \delta^2} = 0$. Maximization of $W^u(\delta) - I(\delta)$ is therefore equivalent to the first order condition

$$I'(\delta_u^o) = Q^u.$$

F_0 will choose its actual level of cost reduction δ_u in order to maximize its profit $(a - c_0 + \delta)\, Q(p^u) - I(\delta)$. The profit-maximizing δ_u fulfills the same first order condition than δ_u^o, i.e.

$$I'(\delta_u) = Q^u.$$

Therefore $\delta_u = \delta_u^o$ and $I_u = I(\delta_u) = I(\delta_u^o) = I_u^o$.

The proof of the second sentence is by use of an example. Let $Q(p) = 1 - p$ and $I(\delta) = \frac{3}{4}\delta^2$ such that $I'(\delta) = \frac{6}{4}\delta$. Let $c_1 = 0.3$, $c_2 = 0.25$, $c_0 = 0.5$ an $a = 0.74$. Then for all δ the monopoly case will be selected under vertical integration since, $1 - 0.8 + \delta - 2\sqrt{(0.24 + \delta)\,(0.01)} \geq 0$ for all $\delta > 0$. We will get $\delta_m^o = 0.2$ and $\delta_m = 0.1$. As well as $\frac{I_m^o}{I_m} = 4$. This means the optimal investment would be 4 times higher than the actual investment under vertical integration.$\blacksquare$

Appendix of Chapter 3

Proof of Proposition 1: Consider two different ownership shares ω^a and ω^b with $\omega^a < \omega^b$. Since σ is the same in both cases, the action profile x selected by downstream firms only depends on the F_0's choice of h (see remark above). Let $\pi_i(h) = \pi_i(x(h,\sigma), h)$ denote the resulting profits of firm i as a function of h only. Let h^a and h^b denote those disctimination strategies that maximize F_0's objective function u_0 under ω^a and ω^b, respectively. Optimal choice by F_0 implies:

$$\pi_0(h^a) + \omega^a \pi_1(h^a) \geq \pi_0(h^b) + \omega^a \pi_1(h^b)$$
$$\pi_0(h^b) + \omega^b \pi_1(h^b) \geq \pi_0(h^a) + \omega^b \pi_1(h^a).$$

If $\omega^a = 0$, we find directly from the first inequality $\pi_0(h^a) \geq \pi_0(h^b)$. If $\omega^a > 0$ we divide the first inequality by ω^a and the second inequality by ω^b. Adding the two resulting inequalities yields $(\frac{1}{\omega^a} - \frac{1}{\omega^b})\pi_0(h^a) \geq (\frac{1}{\omega^a} - \frac{1}{\omega^b})\pi_0(h^b)$. Dividing by $(\frac{1}{\omega^a} - \frac{1}{\omega^b})$ yields again $\pi_0(h^a) \geq \pi_0(h^b)$. Since total output is strictly increasing in upstream profits π_0 this inequality implies that total output must be weakly higher under ω^a than under ω^b.■

Proof of Proposition 2: Let h^a and h^b denote the optimal choice of F_0 under σ^a and σ^b, respectively. Let x^a denote the resulting downstream equilibrium after optimal choice of F_1 given σ^a and h^a. We define x^b correspondingly. Furthermore, let x^{ba} denote the resulting downstream equilibrium after optimal choice of F_1 given σ^b and h^a. Optimal choice by the incumbent F_1 implies

$$\pi_1(x^a, h^a) + \sigma^a \pi_0(x^a, h^a) \geq \pi_1(x^{ba}, h^a) + \sigma^a \pi_0(x^{ba}, h^a)$$
$$\pi_1(x^{ba}, h^a) + \sigma^b \pi_0(x^{ba}, h^a) \geq \pi_1(x^a, h^a) + \sigma^b \pi_0(x^a, h^a)$$

Adding these two inequalities and dividing by $(\sigma^b - \sigma^a)$ yields:

$$\pi_0(x^{ba}, h^a) \geq \pi_0(x^a, h^a)$$

Optimal choice by the upstream firm F_0 implies

$$\pi_0(x^b, h^b) + \omega \pi_1(x^b, h^b) \geq \pi_0(x^{ba}, h^a) + \omega \pi_1(x^{ba}, h^a)$$

Combining with the previous inequality and rearranging yields

$$\pi_0(x^b, h^b) - \pi_0(x^a, h^a) \geq \omega \left(\pi_1(x^{ba}, h^a) - \pi_1(x^b, h^b)\right)$$

The term on the RHS equals 0 for $\omega = 0$. Also its limit for $\omega \to 0$ is 0, because we assumed that minimal and maximal downstream profits are bounded. Since π_0 only depends on total output Q and is strictly increasing in Q, this implies the proposition.■

Appendix of Chapter 4

Proof of Lemma 4.1: 1. We have the definition $\Pi_H(\lambda,\rho) := E_x[\pi_H(a_u(x,\gamma,\rho),\gamma,\rho|x)]$. Differentiating w.r.t. ρ we find

$$\frac{\partial \Pi_H}{\partial \rho} = E_x\left(\frac{\partial \pi_H(a|x)}{\partial a}_{|a=a_u}\frac{\partial a_u}{\partial \rho} + \frac{\partial \pi_H}{\partial \rho}\right).$$

Recall that for a given state of the world, H either selects $a_u = a_u^*$ or $a_u = \overline{a}$ (if $a_u^* \geq \overline{a}$). In the first case, we have $\frac{\partial \pi_H(a|x)}{\partial a}_{|a=a_u} = 0$, since a_u^* maximizes $\pi_H(a|x)$. In the second case, we have $\frac{\partial a_u}{\partial \rho} = 0$. In both cases the first term vanishes and hence,

$$\frac{\partial \Pi_H}{\partial \rho} = E_x\left(\frac{\partial \pi_H}{\partial \rho}\right) = (1-\gamma)E_x R(a_u|x) > 0.$$

2. Differentiating $\Pi_F(\gamma,\rho)$ w.r.t. ρ we find

$$\begin{aligned}\frac{\partial \Pi_F}{\partial \rho} &= E_x\left(\frac{\partial \pi_F(a|x)}{\partial a}_{|a=a_u}\frac{\partial a_u}{\partial \rho} + \frac{\partial \pi_F}{\partial \rho}\right)\\ &= E_x\left(\left((1-\rho)\,R'(a_u|x) - C'(a_u)\right)\frac{\partial a_u}{\partial \rho} - R(a_u|x)\right)\end{aligned}$$

If $a_u = \overline{a}$ then the derivative $\frac{\partial a_u}{\partial \rho}$ is zero. We then find $\frac{\partial \Pi_F}{\partial \rho} = -E_x R(a_u|x) < 0$. If $a_u = a_u^*$ we can use Equation (5) $C'(a_u^*|x) = \left(1 + \frac{(1-\gamma)\rho}{\gamma}\right) R'(a_u^*|x)$ to find $\frac{\partial \Pi_F}{\partial \rho} = -E_x\left[\frac{\rho}{\gamma}R'(a_u|x)\frac{\partial a_u^*}{\partial \rho} + R(a_u|x)\right] < 0$.

3. F's expected payoff $\Pi_F(\gamma,\rho)$ is non-positive for $\rho = 1$ (franchisees do not keep any revenues) and non-negative for $\rho = 0$ (follows from Condition 1 and the fact that efficient activities a_e are selected at Stage 3 if $\rho = 0$) . Since, furthermore, for every given γ the function $\Pi_F(\gamma,\rho)$ is continuous in ρ and strictly decreasing in ρ, there exists for every fraction of company-owned stores a unique royalty rate $\rho_u(\gamma)$ such that $\Pi_F(\gamma,\rho_u(\gamma)) = 0$.

4. As last step, we show that for H always selects a royalty of $\rho_u(\gamma)$. If $\Pi_F(\gamma,\rho) < 0$ then F would reject the contract, which cannot be optimal for H, since by Condition 1 there exists a contract under which H makes strictly positive profits. If $\Pi_F(\gamma,\rho) > 0$ then by continuity there exists a small increase in ρ such that $\Pi_F(\gamma,\rho)$ is still non-negative. Such a small increase in ρ, however, strictly increases $H's$ expected payoff.■

Proof of Proposition 4.1: We first show that the chain will not be completely franchised. Assume by contradiction H maximizes payoff with a completely franchised chain ($\gamma = 0$). In this case, H sets maximum activities $\overline{a}(x)$ at Stage 3 whenever there is a positive royalty $\rho > 0$. However, when these activities $\overline{a}(x)$ are sufficiently big, franchise stores' profits before royalties are paid, i.e. $R(\overline{a}(x)|x) - C(\overline{a}(x)|x)$, are already negative. This follows directly from our assumptions on cost and revenue functions. Thus, for sufficiently big $\overline{a}(x)$ and no company-ownership, franchisees accept a contract if and only if the royalty is $\rho = 0$. But for $\rho = 0$ and $\gamma = 0$, the chain has a payoff of zero. This cannot be optimal, since we assumed that there is a combination of γ and ρ such that contracts are accepted and the chain has a strictly positive expected payoff.

We now show that it is also not optimal to have a completely company-owned chain, since it always increases H's expected when at least a small fraction of stores is franchised. For any $\gamma < 1$, the royalty is set such that franchisees expected profits are 0. Thus, H's payoff per store equals the average profits per store, given by

$$\pi(\gamma|x) = R(a_u|x) - C(a_u(x, \gamma, \rho)|x) - \gamma L$$

Differentiating $\pi(\gamma|x)$ w.r.t. γ yields

$$\frac{d\pi(\gamma|x)}{d\gamma} = (R'(a_u|x) - C'(a_u|x))\frac{da_u}{d\gamma} - L$$

Consider first the case where the efficient activities can be implemented, i.e. $a_e(x) < \overline{a}(x)$. In a fully company-owned chain, efficient activities are selected at Stage 3, i.e. $a_u(x|\gamma = 1) = a_e(x)$. Since $R'(a_e|x) - C'(a_e|x) = 0$ (Equation 1), we find

$$\frac{d\pi(\gamma|x)}{d\gamma}_{|\gamma=1} = -L < 0$$

The same formula holds in the case $a_e(x) > \overline{a}(x)$, since then $a_u = \overline{a}$ and thus $\frac{da_u}{d\gamma} = 0$. In summary, a small decrease of γ below 1 strictly increases the chain's expected payoff.■

For the proof of Proposition 4.3, let

$$D(\gamma) \equiv \Pi_H^u(\gamma) - \Pi_H^n(\gamma)$$

denote the difference in the chain's payoff from the optimal contract with uniformity requirement compared to the optimal contract without uniformity requirement. We first establish Lemma 4.2, which characterizes the derivative of D :

Lemma 4.2:

$$\begin{aligned} D'(\gamma) = E_x[(1 - \rho_u + (1-\gamma)\frac{d\rho_u}{d\gamma})R(a_u|x) - C(a_u|x) \\ - ((1-\rho_n)R(a_e|x) - C(a_e|x))]. \end{aligned}$$

.

Proof of Lemma 4.2: The proof is based on straightforward calculation. First note that D can be written as

$$\begin{aligned} D(\gamma) &= E_x[(1-\gamma)\rho_u R(a_u|x) + \gamma(R(a_u|x) - C(a_u|x) - L)] \\ &\quad - E_x[(1-\gamma)\rho_n R(\overline{a}|x) + \gamma(R(a_e|x) - C(a_e|x) - L)] \end{aligned}$$

Differentiating w.r.t. γ yields

$$\begin{aligned} D'(\gamma) = E_x[&(1-\rho_u + (1-\gamma))\frac{d\rho_u}{d\gamma}R(a_u|x) - C(a_u|x) \\ &+ \left(((1-\gamma)\rho_u + \gamma)\, R'(a_u|x) - \gamma C'(a_u)\right)\frac{da_u}{d\gamma} \\ &- ((1-\rho_n)R(a_e|x) - C(a_e|x))] \end{aligned}$$

To evaluate this expressions we need two distinguish two sets of states. For those states where $a_u^*(x) \geq \overline{a}(x)$, we find $a_u(x) = \overline{a}(x)$ and thus $\frac{da_u}{d\gamma} = 0$, i.e. the term in the second line becomes 0. For those states with $a_u^*(x) < \overline{a}$ we find $a_u(x) = a_u^*(x)$ and the identity $C'(a_u|x) = \left(1 + \frac{(1-\gamma)\rho_u}{\gamma}\right) R'(a_u|x)$ holds. Inserting this equality into the expression for $D'(\gamma)$ above, we find that the term in the second line again becomes 0. Therefore, the equality stated in the lemma holds.■
We can now proof Proposition 4.3. As noted in the text, we assume that the condition $\overline{a}(x) > a_e(x)$ holds for all states x.

Proof of Proposition 4.3: Note that $D(\gamma)$ is a continuous function with $D(0) = D(1) = 0$. Therefore, it suffices to show that $D'(0) < 0$ and $D'(1) < 0$. First consider the case $\gamma = 0$. We then have $a_u = \overline{a}$, $\rho_u = \rho_n$ and $\frac{d\rho_u}{d\gamma} = 0$. Inserting into the expression of $D'(\gamma)$ from Lemma 4.2 yields

$$D'(0) = E_x\left[(1-\rho_n)\, R(\overline{a}|x) - C(\overline{a}|x) - ((1-\rho_n)R(a_e|x) - C(a_e|x))\right] < 0$$

This is the difference of F's payoff under the maximum size of activities and F's payoff under efficient activities. This difference is clearly negative.
Now consider the case $\gamma = 1$. Then $a_u = a_e$ and $\rho_u > \rho_n$, which gives

$$\begin{aligned} D'(1) &= E_x\left[(1-\rho_u)\, R(a_e|x) - C(a_e|x) - ((1-\rho_n)R(a_e|x) - C(a_e|x))\right] \\ &= -\left(\rho_u - \rho_n\right) E_x R(a_e|x) < 0.■ \end{aligned}$$

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