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NGA: Access Regulation, Investment, and Welfare

A Model Based Comparative Analysis

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Für eine Zusammenfassung und Hauptergebnisse der Studie in deutscher Sprache klicken Sie bitte hier:
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Executive summary

This study analyses the performance of regulatory regimes with respect to their impact on investment into Next Generation Networks and the Information Society's welfare. Analytical evidence reveals that the various regulatory regimes, such as traditional Long-Run-Incremental-Cost (LRIC) based regulation, fully distributed cost regimes (FDC), regulation with Risk-Sharing components or Risk-Premiums, a regulatory holiday as well as corresponding non-margin squeeze obligations, yield significant differences in terms of NGA investment, consumer surplus, investor surplus and total surplus. The results suggest to amending existing LRIC-based regulatory regime towards alternative approaches such as Risk-Sharing and FDC as well as to modifying traditional margin-squeeze tests. The results contribute to the ongoing debate on one of the most important elements of Europe's Digital Agenda: How to design the right regulatory regime that allows the timely deployment of advanced high speed broadband networks in Europe?

The telecommunication industry is currently in the midst of a disruptive technological development. Next generation networks (NGN) allow the increase of data transmission speeds in the local fixed network from the current 16Mbit/s to—at least—100MBit/s and more. This enables modern advanced applications such as multiple HDTV, high-end interactive gaming, 3D entertainment, comfortable networking with large upstream bandwidths as well as software as a service and cloud computing. While the technology exists today, it is uncertain when and to what extent it will be deployed by operators.

European telecommunication incumbents cite a tight regulatory regime as a major barrier to investment, in which the investor bears the risk alone but has to share potential benefits. Entrants on the other hand argue in favour of maintaining the traditional regulatory regime, condemning suggestions to share the benefits and the costs of investment.[2] There is also a debate on whether the forthcoming European Commission's Recommendation on the future regulation of

[2] See European Competitive Telecommunications Association (ECTA), "ECTA condemns Commission u-turn on telecoms competition", Press release 12 June 2009.

Next Generation Access Networks does provide the right solutions. Further, the European Parliament and Council require national regulators to account for the risk taken by the investor and to support approaches towards Risk-Sharing, whilst safeguarding competition and non-discriminatory access conditions.[3] Against this highly sensitive and political background this study assesses the comparative performance of various regulatory regimes on NGA investment and consumer surplus. These regulatory regimes are:

- **Traditional regulatory Long-Run-Incremental-Cost regime ("LRIC"):** The investor incurs the cost of risky NGA deployment. If NGA is successful, the investor is obliged to grant entrants access anytime, to any extend and priced at efficient costs. If NGA is not successful (fails), the entrants are free to adjust their volumes or to exit the market without comparable sunk costs. The investor might not be able to recoup any investment costs through wholesale prices. Hence, the investor bears the risk of failure alone.
- **Fully Distributed Costs ("FDC"):** The investor incurs the cost of risky NGA deployment. In contrast to LRIC, the investor can recoup investments through wholesale prices in both the success and failure case. The risk is spread across all industry participants and hence reduced from the investor's point of view. This approach is comparable to an insurance-based perspective.
- **Risk-Sharing ("RS"):** Risk-Sharing is an option that is currently discussed by operators and regulators alike. Under this mode potential investors (not necessarily the incumbent) decide jointly to deploy NGA in a certain region and to share the costs and risks of this investment. The results in this study are based on comprehensive analysis of a broad range of possible Risk-Sharing scenarios. All forms of Risk-Sharing are characterized by two or more firms that jointly deploy and exploit NGA; or one firm invests and a partner commits to a certain purchasing volume and contract duration ex ante (financing). Variations are considered with respect to wholesale prices each partner has to pay (cost based prices, surplus value based prices and profit maximising prices) and assumptions concerning the market structure (number of risk bearing investors (insiders) and non-investors (outsiders); market shares of in- and outsiders). All these Risk-Sharing consortia spread the risk and potential benefits among partners.
- **Risk-Premium ("RP"**): In its pure form, this version resembles LRIC but, in the success case, the investor is allowed to charge a Risk-Premium above the cost based access price. This mechanism can also be used for outsider access in Risk-Sharing regimes.
- **Regulatory Holiday ("HOL"):** The investor deploys NGA unilaterally and faces no access obligations. We assume throughout that entrants would not obtain NGA at the wholesale level.

[3] See European Union, Official Journal L 337/51 (d).

This study provides comprehensive extensions of an existing academic model[4] including, among other, an assessment of investors' surplus, the role of non-margin-squeeze obligations and detailed approaches towards Risk-Sharing. What is probably most important, the report synthesises various strands of analyses in order to derive overriding policy implications for investors and regulators as well as to identify open questions and avenues for future research.

Each approach to derive management and policy advice has its advantages and disadvantages. We believe that the model based approach presented here has decisive advantages as we attempt to take into account institutional details of different regulatory regimes that are usually not modelled in academic papers. As a result we can apply analytical rigour to settings which come close to the real world. As our simulations show, we can identify several effects that may influence incentives of market participants and market outcomes in opposing ways. Non model based advise can only resolve such "trade-offs" intuitively. In contrast, our model based approach establishes the "net effect" after simultaneously accounting for many forces that are potentially pulling from different directions.

Nevertheless, important limitations remain. Our model is not "calibrated"; that is the numbers that we simulate allow conclusions regarding the ranking of different regimes within a given setting but cannot be interpreted as, for example, Euro-amounts of investment. Moreover, although we do take into account many institutional details, a purely model based approach will still have to simplify matters to keep the analysis tractable.

Key findings with respect to the comparative performance of the various regulatory regimes are:

- **The traditional LRIC regime is inferior to all other feasible regimes from an investor and consumer surplus perspective.**

  If investments are risky, the traditional LRIC implies that non-investors can free-ride on investors' risk-taking. In the success case, outsiders get cost-based access whereas in the failure case outsiders are protected from any loss. The free-ride lowers the investor's profit in the success case and renders market participants better-off by non-investing. Eventually, this may discourage or delay investments. Investors are better-off if the risk is spread across all potential beneficiaries through regimes involving Risk-Sharing or FDC.

  In the context of risky investments not only investors but also consumers benefit from other regimes such as Risk-Sharing, Fully-Distributed Costs and, to a lesser extent, Risk-Premium. As a stand-alone measure, Risk-Premium is

[4] Nitsche and Wiethaus (2009), "Access Regulation and Investment in Next Generation Networks: A Ranking of Regulatory Regimes," ESMT Research Working Paper ESMT-09-003 and Conference Paper Annual Meeting of the European Economic Association 2009.

less effective from a consumer surplus perspective but it can complement for instance Risk-Sharing approaches in a useful manner.

It is noteworthy that under risky investments LRIC indeed seems to undermine its very idea, namely to replicate competition. Under competition all firms would face the same (structural) risks and expected surplus.

- **Fully distributed costs (FDC) is well-suited for investors and consumers and is easy to implement.**

  FDC appears unambiguously better than LRIC if investments are risky. It spreads investments across all industry participants, regardless of NGA success. FDC functions like an insurance for the investor: If NGA fails, the investor can still distribute investment costs through the wholesale prices. As such it avoids the possibility that non-investors free-ride on investors' risk-taking. It allows substantial investments in NGA, even if product market competition is intense, because wholesale prices will always contribute to recovery of investment costs. FDC may be a particularly good alternative if i) Risk-Sharing would have to involve many firms, ii) retail competition is very intense and iii) a Risk-Sharing consortium would only involve little more market share relative to a sole investor. FDC stimulates investments in NGA and consequently benefits consumers relative to LRIC although full cost distribution relaxes retail competition somewhat.

  The FDC regime is particularly prone to margin squeeze situations if NGA turns out less successful than expected: the investor might have an incentive to retail NGA below a cost based wholesale price. It is important that in such cases low prices are not ruled out by a standard margin-squeeze test. Otherwise investment incentives are reduced and, in addition, consumers are worse off than in the failure case.

  Within our modelling framework, an FDC regime seems comparatively easy to implement. As in all other alternatives that provide access for non-investors, one has to determine a cost-based wholesale price. However, FDC does not require specifying an appropriate Risk-Premium or similar conditions. As a drawback, FDC implicitly obliges each player to cover its share of NGA investment costs.

- **Risk-Sharing is better for investors and consumers than traditional LRIC.**

  Risk-Sharing is helpful to foster NGA investments by spreading the risk of the investment across several market participants. Further, Risk-Sharing removes free-rider effects and restores investment incentives. At the same time Risk-Sharing may promote NGA penetration and is beneficial for retail competition. Our results suggest that Risk-Sharing is robustly better than LRIC when investments are risky.

Risk-Sharing insiders' surplus is higher without outsider access than with equal or non-risk-adjusted cost-based outsider access. This means insiders are better off if they are allowed to enforce higher than cost-based prices for outsider access.

If a Risk-Sharing consortium is deemed to grant access to non-investors (outsiders), margin-squeeze issues may arise. In a nutshell the following advice then applies: Risk-Sharing insiders should be assured (retail) pricing flexibility if NGA is not successful. Specifically, Risk-Sharing insiders should be allowed to retail NGA at a price below an external risk-adjusted cost-based wholesale price. Conversely, a non-margin squeeze obligation would distort insiders' investment incentives and, in addition, directly harm consumers due to relatively high retail prices in the failure case. Of course, non-margin squeeze obligations should remain valid if NGA is a success.

Access conditions for outsiders, if any, must be determined with caution. As a primer principle, the expected investor surplus as an outsider must not be higher than the expected non-investor surplus as an insider (incentive compatibility). If this condition is not satisfied, firms have little incentive to participate in Risk-Sharing; potential investors find themselves back in the default, e.g. LRIC, mode and consumers are worse off. In particular, incentive compatibility rules out (ex-post) access equality because this would render non-participation systematically more profitable than sharing part of the risk. Further, wholesale prices for outsiders should not be determined with reference to wholesale prices that insiders might charge each other. With such a link insiders may be incentivised to increase their internal wholesale price to the ultimate detriment of consumers. Therefore, wholesale prices for outsiders should be referenced to something else, e.g. unit investment costs plus a Risk-Premium.

- **Risk-Premium is better than traditional LRIC but in most instances of risky investments less beneficial for consumers than Risk-Sharing or FDC. Risk-Premium is not the best stand-alone policy for consumers but it may complement other regimes.**

  An appropriate Risk-Premium may benefit consumers in comparison to the LRIC counterfactual. However, seen in isolation a Risk-Premium regime does not appear as good as Risk-Sharing and FDC from a consumer's perspective. The main reason for this is that a Risk-Premium only leverages investments if the NGA success probability is rather larger. In contrast, Risk-Sharing and FDC become effective for lower success probabilities and yield higher expected consumer surplus.

However, a Risk-Premium regime can be combined with other regimes. For example, combining a Risk-Premium for outsiders with Risk-Sharing may be required to provide adequate incentives to participate in Risk-Sharing (become an insider).

- **Regulatory Holiday appears as one of the best options for investors but may be worse for consumers compared to other regimes.**

  Regulatory Holiday would be the first best option for investors. The analytical results confirm that a Regulatory Holiday would lead to the best outcome for investors. However, this option jars with consumers' interests and does not seem to be feasible in Europe. Regulators might be concerned with the effect, that Regulatory Holiday likely induces an asymmetric market structure, reduces competition and makes consumers worse off than under the traditional LRIC counterfactual.

- **Very cautions approach with respect to margin squeeze required. Standard margin-squeeze approaches are to the detriment of investments and consumers in the context of risky investments. If NGA fails investors should obtain pricing flexibility.**

  It is important to take into account, that investors are also prone to ex-post regulation, notably in the form of non-margin squeeze obligations. The results of the study reveal that traditional non margin-squeeze obligations can substantially distort investment decisions and harm consumers, if they are applied in the context of uncertain investments in NGA. Moreover, the analysis shows that traditional margin squeeze tests may counter the positive effects on consumer surplus that stem from introducing FDC, Risk-Sharing or Risk-Premium regulation.

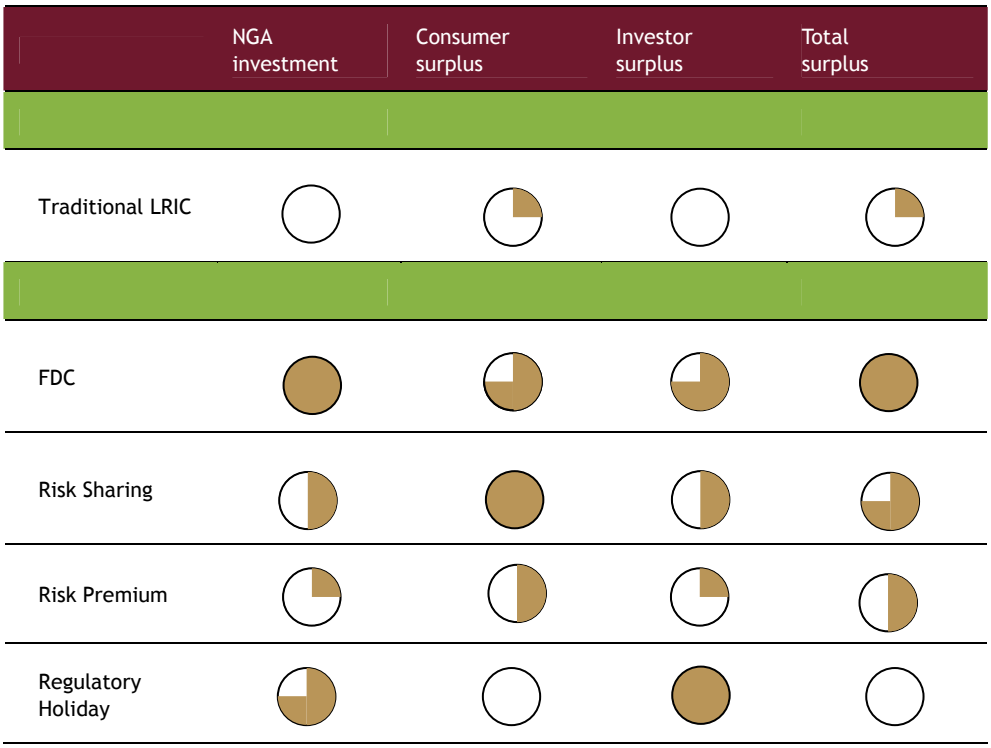
  Risky investments may 'automatically' lead into (formal) margin-squeeze situations if NGA is less successful than anticipated. If NGA fails investors may optimally retail NGA below cost-based wholesale prices, once investments are sunk. The same logic applies to NGA failure under a Risk-Premium regime and under Risk-Sharing with outsider access.

  Investors should therefore maintain pricing flexibility in cases of NGA failure, not being subject to margin-squeeze scrutiny. Pricing flexibility may concern both, the wholesale level (e.g. Risk-Sharing insiders obtaining lower access prices than outsiders in order to reflect the amount of risk being shared) and the retail level (e.g. lowered prices in the NGA failure case). In contrast, if investors anticipate that they will be scrutinized in NGA failure situations, they will reduce NGA investments to the detriment of consumers. In addition, consumers will suffer whenever NGA is not successful and a non-margin-squeeze obligation forces the investor(s) to increase retail prices above the optimal level.

However, the possibility for pro-competitive margin squeezes (in the failure case) does not rule out anti-competitive margin squeezes (e.g. in the success case). Authorities should still prosecute the latter.

Developing a new practicable margin squeeze test was not within the scope of this study. However, our results indicate three dimensions in which traditional margin squeeze tests could potentially be amended, some of which appear complementary: 1) The competition authority adjusts the margin squeeze test in the failure case. For this approach it would be required to identify failure and success cases, respectively, e.g. by using investors' business case calculations. In particular, if both an investor's NGA retail price *and* NGA penetration remain below expected levels, then this would point towards a failure case. 2) Alternatively, to arrive at a more practical margin squeeze test, regulators could consider abolishing the test as soon as there is sufficient competition between investors (e.g. insiders to a Risk-Sharing arrangement). 3) Margin squeeze tests could move to a risk-adjusted cost benchmark, which would be lower than the access price (which may include a Risk-Premium).

At a glance: Performance of the various regimes with respect to investment and welfare



With the exception of Regulatory Holiday all regulatory regimes are better for consumers than LRIC. In particular, Risk-Sharing appears as an option that should be attractive to regulators that focus on consumer surplus. The main insights are as follows:

- **NGA investments:** All regulatory alternatives tend to induce more investments than the traditional LRIC counterfactual if investments are risky. In particular, a FDC regime induces most investment in NGA because i) the investor is ensured to recover its investment costs and ii) as investment costs are allocated to firms' (marginal) cost base, investments tend to relax product market competition. Second, Regulatory Holiday induces substantial investment because the investor envisages a competitive advantage vis à vis non-investors. Third, Risk-Sharing induces more investment than LRIC because the former aligns the incentives of investors and non-investors (i.e. removes a free-rider problem). Fourth, a Risk-Premium yields more investments than LRIC, albeit to a lesser extent than the other regimes because this instrument is only effective if there is rather little uncertainty about NGA success.

  If the investor anticipates having to avoid a formal margin squeeze in the case of NGA failure, investments will be reduced. Traditional margin squeeze tests are therefore ill-suited in the context of new infrastructure developments.

- **Consumer surplus:** Risk-Sharing induces most consumer surplus due to a combination of reasonable investments in NGA and relatively intensive product market competition. The FDC regime ranks second, driven by large investments in NGA. The regime of a Risk-Premium increases consumer surplus over LRIC, again, due to higher investments. Regulatory Holiday, in contrast, results in lower consumer surplus than LRIC because the former creates an asymmetric market structure in which a single investor monopolises NGA based services.[5]

  If the investor anticipates that he must avoid a formal margin squeeze in the case of NGA failure, also consumer surplus will be reduced substantially. Traditional margin squeeze tests are therefore also from the consumer's perspective ill-suited in the context of new infrastructure developments.

- **Investor surplus**: Not surprisingly, Regulatory Holiday would be the best option for the investor. A regime of FDC appears second-best as it forces non-investors to cover investments costs (with certainty rather than contingent on NGA success) and relaxes product market competition somewhat. The investor seems still better off under Risk-Sharing than under LRIC, because the former regime aligns investment incentives, removing the free-riding problem. Finally, a Risk-Premium certainly benefits the investor relative to LRIC, albeit only marginally if the probability of success is low.

[5] Notice that the non-investor is still assumed to compete with services based on the legacy network.

- **Total surplus:** As the sum of consumer surplus, investor and non-investor surplus, total surplus is the aggregate welfare measure. Our analysis reveals that neither Regulatory Holiday nor a (traditional) LRIC approach appears most efficient, investors and regulators should be interested in scenarios that (1) spread the risk and (2) balance prices and profits to ensure investment and (3) eliminate the free-rider problem. Total surplus appears highest under a FDC regime. Risk-Sharing ranks second best, followed by a Risk-Premium regime, LRIC and Regulatory Holiday.

Conclusions with regard to an optimal policy mix:

The results of this study hint towards an optimal policy mix that involves several elements:

- Given the significant and risky investment required to deploy NGA networks, the results suggest to amending the existing regulatory regime in order to promote Europe's Digital Agenda. To that end the traditional LRIC regime involves downsides as it imposes the entire risk on the investor, thereby creating free-rider effects and, eventually, reducing NGA investments and consumer surplus.
- Risk-Sharing appears as a well suited alternative for it spreads the risk among a number of interested parties. Yet, participation in Risk-Sharing must be attractive in the first place (incentive compatibility). This means access conditions for non-participating firms must be treated with caution and should, at least, involve the appropriate Risk-Premium over a cost-based access price.
- FDC has also proven as a good regulatory alternative. As a drawback this regime appears slightly less beneficial from the consumers' perspective and implicitly obliges all players to participate in NGA deployment.
- Alternative regulatory regimes, such as Risk-Sharing and FDC should not be countervailed by means of a formalistic traditional margin-squeeze test. We suggest to revise the existing margin squeeze tests in order to adapt them to the NGA environment. Specifically, such revision should (i) consider differentiated wholesale price schemes where ex-ante risk-takers pay lower wholesale prices ex-post (and vice versa) and (ii) investors maintain retail price flexibility in the case of NGA failure.
- Needless to say, regulatory alternatives will only become effective through regulatory commitment. Therefore, timely commitment is the key to induce substantial NGA deployment in an equally timely fashion.

1. Introduction to the basic model

1.1 Introduction and summary

The telecommunication industry is currently in the midst of a disruptive technological development. Next generation networks (NGN) allow the increase of data transmission speeds in the local fixed network from the current 16Mbit/s to—at least—100MBit/s. This enables new applications such as IP based and high definition TV as well as interactive gaming and TV. While the technology exists today, it is uncertain when and to what extent it will be deployed by operators.

European telecommunication incumbents cite a tight regulatory regime, in which the investor bears the risk alone but has to share potential benefits, as a major barrier to investment. Indeed the European Commission's most recent draft recommendation on regulated access to NGN seems to recognize such concerns as it suggests weaker access regulation provided that a sufficient number of firms deploy NGN jointly and share the costs and benefits of that investment (e.g. Risk-Sharing). Entrants condemned this approach in turn.[6]

The public debate on different regulatory regimes strongly builds on arguments that were derived in a world with existing infrastructure. Under the standard regulatory approach an incumbent is obliged to grant entrants infrastructure access on the basis Long-Run-Incremental-Cost (LRIC). One essential element of Long-Run-Incremental-Cost regulation is that the regulated firm may allocate investment costs to its wholesale price, but only to the extent that the

[6] See European Competitive Telecommunications Association (ECTA), "ECTA condems Commission u-turn on telecoms competition", Press release 12 June 2009.

investment relates to the most efficient technology to provide a certain retail service. This form of regulation is aimed at replicating competition where an investor is only able to cash in on efficient investments. While such regulation has its merits when infrastructure already exists, it does not provide optimal investment incentives when infrastructure has to be build and demand ("the success") is uncertain. To see why consider a simplified setting where NGA either turns out to be a great success or consumers do not value the service. Then in the success state the access seeker who did not invest gets access at cost, whereas in the failure state the costs of the failed investment are solely born by the investor. In such a situation potential investors may prefer not to invest or at least to delay investment until demand uncertainty is reduced.

This problem has already been identified and described by a number of scientists.[7] However, this literature does not provide a coherent comparison of consumer surplus in different regulatory regimes. This is the main contribution of Nitsche and Wiethaus (2009) who explore the effects of four different regulatory regimes, i) LRIC, ii) Fully-Distributed-Costs (FDC), iii) Risk-Sharing (RS) and iv) Regulatory Holiday (HOL), on investment incentives and consumer surplus.

One key message that results from this paper is that, with the exception of Regulatory Holiday, LRIC regulation leads to the worst outcome for consumers. This result should raise regulators' interests and lay the ground for a constructive discussion of alternative regulatory regimes.

The paper by Nitsche and Wiethaus (2009)[8] assumes:

- Two firms; one investors, one non-investor[9]
- Symmetry among firms; that is both firms have the same market share and costs before[10] investment takes place
- No ex-post (i.e. non-margin squeeze) regulation
- Basic Risk-Sharing; that is there are no wholesale price arrangements among Risk-Sharing partners

This section incorporates two extensions, namely an additional Risk-Premium scenario and an analysis of producer surplus and total surplus.[11] Subsequent sections will, separately, relax each of the assumptions specified above. Thus, we refer to the model developed in this section as the "basic model."

Our results confirm the strong result derived in academic paper: With the exception of Regulatory Holiday all other regimes are better for consumers than

7 See Nitsche and Wiethaus 2009 for a survey.

8 The formal set-up and a review of the literature is contained in Nitsche and Wiethaus (2009).

9 In the Risk-Sharing regime the second firm is also assumed to invest.

10 Except for Regulatory Holiday, firms have also symmetric market shares after NGA has been deployed. That is we assume no structural differences such as incumbency in conjunction with customer loyalty.

11 Here and throughout, our results are based on a specific parameterization of our model. While we have no reason to believe that our parameterization is not representative, we can only claim generality for the results contained in the academic paper, subject to the underlying assumptions of the academic paper.

LRIC. In particular, Risk-Sharing appears as an option that should be attractive to regulators that focus on consumer surplus.

The main findings of the basic model are summarised in the table below. The left column specifies regulatory regimes. The numbers reflect their ranking in terms of NGA investments, consumer surplus, producer surplus and total surplus (as specified by the first row). A number refers to the performance rank; that is the regime of Fully Distributed Costs ranks first in terms of NGA investments, leading to highest investments.

Table 1: Ranking of regulatory regimes in the basic model

	NGA investments	Consumer surplus	Producer surplus	Total surplus
LRIC	5	4	5	4
Risk-Sharing (RS)	3	1	3	2
Fully distributed costs (FDC)	1	2	2	1
Risk-Premium (RP 10%)	4	3	4	3
Holiday (HOL)	2	5	1	5

Source: ESMT CA model, compressed and incomplete view, please consult graphs for details.

The main insights from the basic model are as follows:

1.1.1 NGA investments

All regulatory alternatives induce more investments than the LRIC counterfactual. In particular, a regime of Fully Distributed Costs induces most investment in NGA because

i. the investor is ensured to recover its investment costs as there will be a return in the failure case too, and

ii. as investment costs are allocated to firms' (marginal) cost base, investments tend to relax product market competition, which increases the returns on investment compared to, say, a Risk-Sharing regime as it is modelled here.

Regulatory Holiday, which is second in the ranking, induces substantial investment because the investor envisages a competitive advantage vis à vis non-investors. This significantly increases returns in the success state (but does not help in the failure state).

Risk-Sharing induces more investment than LRIC because the former aligns the incentives of investors and non-investors. That is, it removes the incentives of non-investors to free-ride on the investors' efforts by inviting them to share the risk. Here we assume that both firms engage in Risk-Sharing.

Lastly, a **Risk-Premium** yields more investments than LRIC, as it tilts the balance in favour of investors by increasing returns in the successful state. It increases investment to a lesser extent than the other regimes because this instrument is only effective if there is rather little uncertainty about NGA success.

The analysis provides some more general intuitions. First, the regulatory regimes' performance regarding the investment levels depend on the extent to which risks are spread, the impact on the relative payoffs of investors and non-investors and the expected future returns which are higher if product market competition is relaxed. Thus, one key insight from this analysis is that optimal regulation requires more than a simple trade-off between product market competition and investments: the impact on risk, relative returns and the positive effect of investment on demand need to be considered as well.

1.1.2 Consumer surplus

Consumer surplus is not just a function of the prices at which NGA based services are provided but also depends on the level of investment. At a given price, for example, consumers are likely to value faster infrastructure. Accordingly, at a given price, consumers benefit from additional investments laying fibre e.g. to their premises.

Risk-Sharing induces most consumer surplus due to a combination of reasonable investments in NGA and relatively intensive product market competition. Notice that in the basic model, access costs are assumed to be zero with Risk-Sharing because the shared investment is sunk. Allowing for positive internal access prices affects consumer surplus in two ways: negatively, as it increases prices for NGA based services and positively, as it leads to more investment compared to the regime discussed here (see Section 2.5).

The **FDC** regime ranks second, driven by large investments in NGA. The regime of a **Risk-Premium** increases consumer surplus over LRIC, again, due to higher investments. **Regulatory Holiday**, in contrast, results in lower consumer surplus than LRIC, because the former creates an asymmetric market structure in which a single investor monopolises NGA based services.[12]

[12] Notice that the non-investor is still assumed to compete with services based on the legacy network.

The results show that in the basic model the high prices induced in a world without regulation over-compensate the benefits of increased investment compared to a LRIC-regime. This shows the advantage of the simulation approach taken here: one can compare the beneficial effect of higher investment with the negative effect of higher prices and compute the net-effect for consumers. As the discussion of the investment results have shown, more effects have to be taken into account when considering the other regulatory regimes, namely the effects on risk and relative returns. Here the Risk-Sharing approach performs best as it combines reasonable investments with low prices. Despite higher prices FDC performs also well as it induces the highest investment levels.

1.1.3 Producer surplus

Not surprisingly, **Regulatory Holiday** would be the best option for the investor. A regime of **FDC** appears second-best as it forces non-investors to cover investments costs (with certainty rather than contingent on NGA success) and relaxes product market competition somewhat. The investor seems still better off under **Risk-Sharing** than under LRIC, because the former regime aligns investment incentives, removing the free-riding problem. Finally, a **Risk-Premium** certainly benefits the investor relative to LRIC, albeit only marginally if the probability of success is not high.

1.1.4 Total surplus

As the sum of consumer surplus, investor and non-investor surplus, total surplus appears highest under a **FDC** regime. **Risk-Sharing** ranks second best, followed by a **Risk-Premium** regime, **LRIC** and **Regulatory Holiday**.

The remainder of this section is organised as follows. First we explain the investment problem inhibited in the LRIC regime. Second we describe the regulatory alternatives to LRIC. The third subsection reports the results in terms of i) investment levels, ii) consumer surplus, iii) investor surplus and iv) total surplus that we obtain from the basic model in comparing LRIC to the regulatory alternatives.

1.2 The LRIC counterfactual—asymmetric investor—non-investor surplus

One essential element of Long-Run-Incremental-Cost regulation is that the regulated firm may allocate investment costs to its wholesale price, but only to the extent that the investment relates to the most efficient technology to provide a certain retail service.[13] This form of regulation is aimed at replicating

[13] In 2008 LRIC or Long-Run-Average-Incremental-Cost-Regulation (LRAIC) was the approach most often applied to Europen markets for unbundled wholesale access (64%) and wholesale broadband access (54%). The second most important approach was FDC with a share of 32% and

competition where an investor is only able to cash in on efficient investments. To this end, LRIC should induce efficient investments; in particular, avoiding over-investment in terms of what is known as 'gold-plating'.[14]

In discouraging gold-plating, LRIC regulation may have its merits if the nature of investment is certain. Maintenance of a legacy network that provides the infrastructure for well-known retail services comes into mind. However, if investments are substantial and relate to new retail services for which demand cannot be known prior to the investment (e.g. NGA), LRIC regulation may structurally disadvantage the (regulated) investor; in particular, *not* replicating the competitive outcome and distorting investment incentives. We illustrate this in turn.

As for NGA, a LRIC regime leads to the following situation. A regulated firm may invest substantial amounts in next generation networks. Once the high speed network is built, related retail products such as IP-TV can be offered to end-customers. If end-customers value the new products, retail prices exceed per unit costs of NGA deployment. Non-investors obtain regulated cost-based access and earn a positive margin. However, this is not certain. With some probability consumers do not value the new services.[15] As a consequence retail prices may not cover per unit costs of NGA deployment and cost-based wholesale prices, respectively.[16] Non-investors will not demand NGA based wholesale products. The investor bears the investment costs alone. Notice that this scenario will be well present in the minds of many telecom firms that are also active in mobile telephony: having spent high amounts on second generation (UMTS) licences and infrastructure, many firms had to depreciate significant parts of the investments as demand turned out much more sluggish than expected.

Due to the uncertainty of NGA success, LRIC regulation structurally disadvantages the investor for it requires contributions from non-investors only if NGA is successful. It is noteworthy that this outcome indeed seems to undermine the very idea of LRIC: to replicate competition. Under competition all firms would face the same (structural) risks and expected surplus.

Figure 1 below illustrates the difference in investor and non-investor (entrant) surplus depending on the probability of success, β. For β=0 the probability of NGA success is zero, i.e. the investment is certainly not successful. For β=1 the probability of NGA success is 100%, i.e. the investment is certainly successful. In between these two extremes, the success of NGA investments is uncertain. For

46%, respectively. See European Regulatory Group (2008), "Regulatory Accounting in Practice 2008", ERG (08) 47 final RA in Practice 081016.

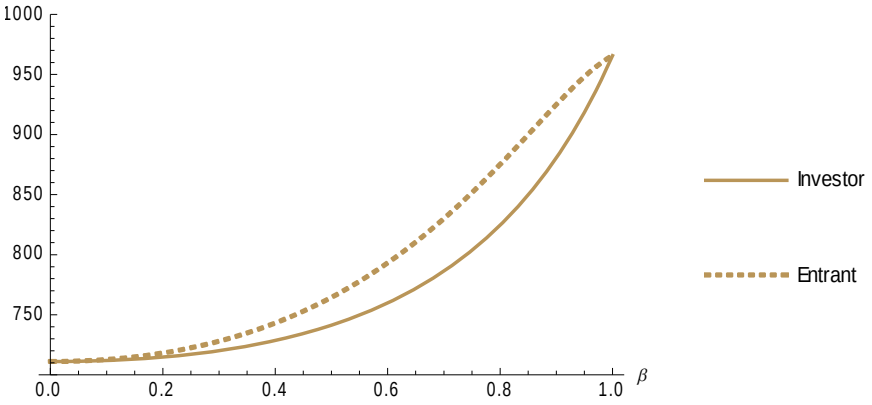
[14] See A Fair Deal for Consumers, UK Government Green Paper on Modernizing the Framework for Utility Regulation, Cm 3898, March 1998

[15] We illustrate the case by means of two extreme discrete states of the nature: i) consumers value NGA and ii) consumers do not value NGA. However, the logic applies to intermediate cases just as well; i.e. consumers do not value NGA as much as expected. All we need for the sake of the argument is that there is uncertainty about consumers' exact valuation of NGA based retail services.

[16] Note that in practice the request for access in the failure state may drop for two reasons. First, low valuation of consumers reduces their willingness to pay and forces providers of NGA-based services to lower their prices. Second, given the reduced demand, the investment cost is spread over a smaller base, which leads to higher access cost.

example, if β=0.4, then with 40% probability NGA will be successful and with 60% probability NGA will not be successful.

Figure 1: Investor and non-investor (entrant) surplus in the LRIC counterfactual



Source: ESMT CA model, A=100, c=20, y=5.

Figure 1 illustrates that expected surplus of both the investor and the non-investor (entrant) increases as the probability of success increases up to 100% (β=1.0). In particular, if there is no uncertainty in that NGA is either (certainly) not successful or successful, the investor's and the non-investor's expected surplus is equal. However, in the uncertain region, the non-investor is structurally better-off because, under LRIC, because he only covers investment costs if NGA is successful. By the same token the investor is worse off, bearing the entire risk (of non-success) alone.

This disadvantage distorts investment incentives and leads to sub-optimal outcomes for consumers. The next section introduces regulatory alternatives and subsequently we analyse whether they remedy the shortcomings of LRIC regulation in the context of uncertain investments in NGA.

1.3 Regulatory alternatives

1.3.1 Risk-Sharing (RS)

Risk-Sharing is an option that is currently discussed by operators and regulators alike. Under this mode interested firms (e.g. the incumbent and the entrant) decide jointly to deploy NGA in a certain region and to share the costs and risks

of this investment. Practically, a joint-venture might deploy NGA in a region and whoever wins a customer has the right to utilize NGN. Alternatively one could require the entrant to commit to a certain number of NGAs ex ante. Under this option it makes sense to assume that the incumbent (or whoever carries out the actual investment) invests, so as to maximise all participants' joint profits. In the basic Risk-Sharing form, presented in this section, we assume that the incumbent and the entrant agree ex-ante how they share the costs and benefits of the investment; there are no ex-post access arrangements. As a result the perceived marginal access costs of the Risk-Sharing partners are zero. We explore the effects of alternative scenarios with positive access prices for Risk-Sharing partners in Section 2.5 and Section 3.

1.3.2 Fully distributed costs (FDC)

As another regulatory option we consider FDC. Under this regime the investor may recoup NGA investment costs in both the success case and the failure case. The latter case could be implemented, for example, if the investor solely wholesales fibre based access (where it is available), so as to recoup its costs.[17] Alternatively, an incumbent could be allowed to allocate NGA investment costs to copper based or other forms of wholesale access.[18] In any event, the FDC regime functions as insurance for the investor in that it allows to recoup NGA investment even if NGA is not a success.[19]

1.3.3 Regulatory Holiday (HOL)

Under Regulatory Holiday the investor obtains the right to exploit its investments exclusively. The non-investor cannot offer high quality NGA based services. Of course, the non-investor does not have to cover any investment costs. European regulators do not seem to consider Regulatory Holiday as a viable alternative to the existing regulatory regime. We still report the outcomes of such regulation as a plausibility check and benchmark to other regimes.

1.3.4 Risk-Premium (RP)

A Risk-Premium regime by and large resembles LRIC regulation. The difference is that, should the investment turn out successful, the investor can add a premium relative to a (risk-free) cost-based access price. The premium is deemed to account for the risk taken by the investor. Below we suppose a Risk-Premium of 10%; that is, if NGA is successful, the non-investor would have to pay a cost-based access price, multiplied by (1+10%). It is important to note that the 10% chosen here, just like alternative cases contained in the appendix, cannot be

[17] We understand that at some point services would migrate from the legacy network to the new NGA based network anyway (by pure cost considerations). However, there might be some discretion on the speed of migration. Also, the question of whether an incumbent may (FDC) or may not (LRIC) be allowed to charge higher wholesale prices for the new network in cases where it does not provide benefits to consumers, remains equally valid.

[18] In order to avoid any misunderstanding note that the positive "insurance" effect vanishes if copper based services are inflated before the investment. Indeed, ex ante inflated prices for copper reduce investment incentives for the incumbent.

[19] Recoupment means that investment costs are allocated to wholesale prices so that, effectively, all firms in the industry bear investment costs according to their market-shares.

compared to any real-world premium for that such a premium had to account for number of additional factors. Rather, the 10% premium should hint to the effects of a Risk-Premium tool. The appendix contains alternative scenarios (3% to 60% premium) so as to further explore the direction of changes caused be a lower and higher premium, respectively.

1.4 Results from the basic model

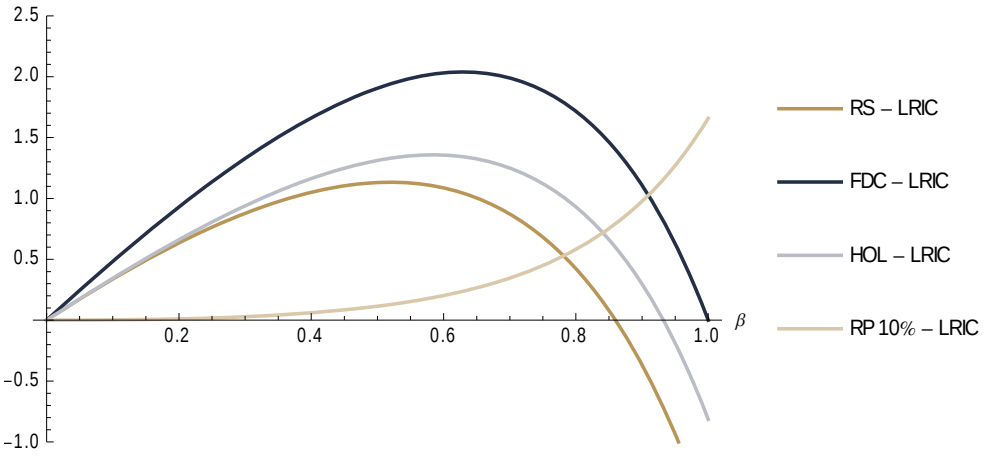
In this section we report the results from simulations conducted with the basic model. While all figures presented show the results for the entire range of investment uncertainty, the interpretation provided in the descriptive text focuses on model outcomes when uncertainty is significant (in most cases the rankings hold if the probability of success is below 80%. Some settings require slightly higher uncertainty).

1.4.1 Investment levels

This subsection briefly presents the main results from the basic model. The first set of results regards NGA investment levels. Then we present the results for consumer surplus, investor surplus and total surplus, respectively.

Figure 2 below displays how much additional NGA investments a regulatory alternative induces over and above the LRIC regime. That is we have calculated (equilibrium) investment levels under each regulatory regime but present investments under a regulatory alternative, subtracting investment levels under LRIC. These figures are presented as a function of the NGA success probability, β, ranging between 0 and 100%.

Figure 2: Additional NGA investments: RS, FDC, HOL and RP compared to the LRIC counterfactual



Source: ESMT CA model, A=100, c=20, y=5.

The figure shows that, for as long as NGA success remains somewhat uncertain (e.g. β<0.8), a regime of fully distributed costs (FDC) induces highest investments in NGA, followed by Regulatory Holiday, Risk-Sharing, and Risk-Premium.

The intuition for these results is as follows. First, FDC induces more investments than Risk-Sharing because the latter does not allow firms to allocate investment costs to their second stage marginal costs. Indeed, under Risk-Sharing, NGA deployment costs are entirely sunk in the second stage, leading to intensive product market competition and, consequently, somewhat modest first stage investment incentives. This result, however, is likely to rely on our assumption that using an NGA involves no money transfers among firms once the investment is made. While this is a possible implementation of Risk-Sharing, there are alternatives. We discuss the implications in Section 2.5 and Section 3.

Second, Regulatory Holiday induces more investment than Risk-Sharing because, if NGA is successful, investments under forbearance create a competitive advantage to the incumbent. Driven by this possible advantage, the incumbent invests intensively.

Third, a Risk-Premium may stimulate investments, provided, however, that the probability of success is high.[20] If the probability of success is rather low, this tool has low investment leverage because it is unlikely to become effective. If the probability of success is relatively high, a Risk-Premium has strong leverage; however, it then distorts product market competition in precisely those situations where investment incentives were rather high in the first place.

Fourth, all modes lead to more investments than LRIC regulation, provided that risk matters, e.g. 0<ß<0.85. In particular, LRIC induces lower investments than Risk-Sharing, as under LRIC the incumbent has to share the benefits of success but bears the costs alone in the case of failure. Risk-Sharing, in contrast, allows firms to share the benefits and costs, thereby stimulating investments. The intuition with respect to FDC and Regulatory Holiday, as explained above, holds. Intuitively straightforward, the Risk-Premium case of 10% induces more investments than the LRIC regime; the latter resembling a Risk-Premium case of 0%.

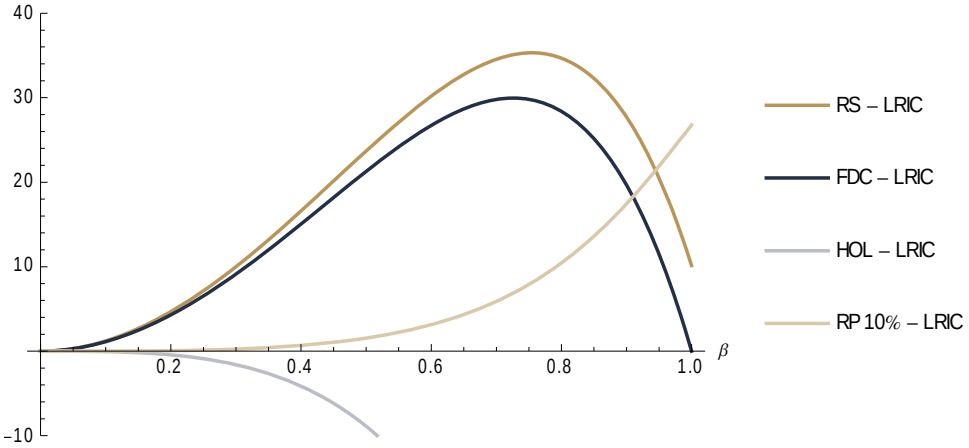
1.4.2 Consumer surplus

Consumer surplus measures the difference between a consumer's willingness to pay for a certain product or service and the actual product price. Noteworthy, consumer surplus thereby captures two dimensions: first, it increases the larger the extent of NGA deployment (higher expected willingness to pay) and, second, it increases the lower the (expected) price level in the industry. Figure 3 displays

[20] The appendix contains investment levels for alternative Risk-Premia, ranging from 3% up to 60%. The principle is always the same: a Risk-Premium stimulates investments if and only if the probability of success is rather high in the first place, albeit the higher the premium the higher investment levels for any given level of success probability.

consumer surplus levels in a similar fashion as above. That is we calculate the amount of consumer surplus that a regulatory alternative induces in addition to the LRIC counterfactual.

Figure 3: Consumer surplus: RS, FDC, HOL and RP compared to the LRIC counterfactual



Source: ESMT CA model, A=100, c=20, y=5.

If risk matters (e.g. ß<0.85), Risk-Sharing induces highest surplus for consumers, followed by FDC, Risk-Premium, LRIC and Regulatory Holiday. The intuition for these results is as follows. Risk-Sharing yields the highest expected consumer surplus due to a combination of strong competitive intensity and yet reasonable investment incentives. Strong competitive intensity stems from investment costs not increasing firms' second stage marginal costs while Risk-Sharing allows firms to jointly internalise all costs and benefits associated with the risky investment.

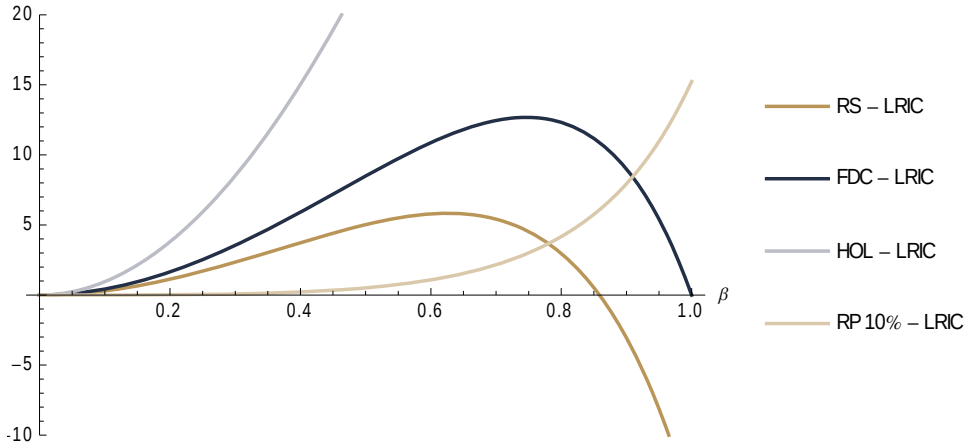
FDC yields higher expected consumer surplus than LRIC (and Regulatory Holiday). The incumbent is ensured that investment costs will be shared not only in the case of success but also in the case of failure. Here, the positive effects from higher investments dominate the fact that FDC results in lower competitive intensity than LRIC if the investment fails. By the same token, FDC tends to induce more consumer surplus than a Risk-Premium, again, because of the latter's attribute of stimulating NGA investments if and only if the probability of success is already high.

However, LRIC leads to a better outcome for consumers than Regulatory Holiday. Regulatory Holiday provides strong investment incentives but driven by the prospect of higher market power ex-post. From the consumers' perspective the positive effects of high investment do not make up for the negative effects caused by the investor dominating the new technology.

1.4.3 Investor surplus

Figure 4 below displays expected investor surplus, again, as increment relative to the LRIC counterfactual.

Figure 4: Investor surplus: RS, FDC, HOL and RP compared to the LRIC counterfactual



Source: ESMT CA model, A=100, c=20, y=5.

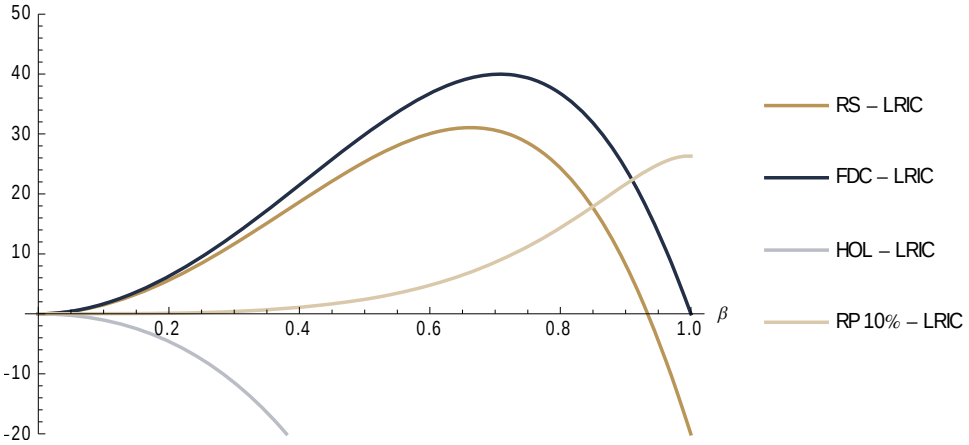
Figure 4 reveals, not too surprisingly, that Regulatory Holiday is most profitable for the investor. A regime of FDC ranks second for two reasons. First, it benefits the investor because it ensures investment cost recovery both in the success and non-success case. By the same token, second, FDC relaxes product market competition relative to Risk-Sharing and LRIC. If the NGA success probability is sufficiently low, Risk-Sharing yields the third-best outcome for the investor. This result is driven by the fact that it allows for optimised investments including the interests of both the investor and non-investor (in contrast to all other regimes). However, at the same time, relatively intensive product market competition also limits the investor's surplus (relative to FDC). Risk-Premium ranks fourth. As explained above, on the one hand, Risk-Premium cannot entirely dissolve distortions in the investor's investment rationale for it only becomes effective if the probability of success is high (in contrast to FDC and Risk-Sharing). On the other hand, Risk-Premium still makes the investor strictly better off than under LIRC if there is at least some (positive) probability of NGA success.[21]

1.4.4 Total surplus

Figure 5 displays the levels of total surplus that are obtained under the various regulatory regimes. Total surplus is the sum of consumer surplus, investor surplus and non-investor surplus.

[21] The ranking of the Risk-Premium regime is not robust with respect to all possible degrees of a Risk-Premium. See the appendix for additional calculations.

Figure 5: Total surplus: RS, FDC, HOL and RP compared to the LRIC counterfactual



Source: ESMT CA model, A=100, c=20, y=5.

The graph suggests that total surplus is highest under the FDC regime. As shown above the FDC regime seems to benefit both consumers and firms. Risk-Sharing ranks second, being most beneficial to consumers and still a good option for the investor. The regime of a Risk-Premium and LRIC are third and fourth, respectively. Most profitable for the investor, Regulatory Holiday ranks lowest in total surplus as it is disproportionately worse for consumers and non-investors.

2. Extensions of the basic model

2.1 Introduction and summary

The previous section has presented the ranking of different regulatory regimes based on the basic model.[22] As highlighted above the basic model was defined by i) including only two firms (investor and non-investor), ii) symmetry between the investor and non-investor, iii) no ex post (margin squeeze) regulation and iv) a specific Risk-Sharing regime without any wholesale price arrangements between the Risk-Sharing parties.

While our basic scenario was helpful in order to develop a first understanding of important effects and results, as well as for the underlying formal tractability, the basic scenario may often jar with the real world environment. This section therefore separately relaxes each of our previous assumptions. This means we relax one assumption at a time. The main results can be summarised as follows:

- **Multiple firms.** We consider additional firms in that we assume additional non-investors in regimes LRIC, FDC, Risk-Premium and Regulatory Holiday whilst we assume additional partners in a Risk-Sharing regime.[23] With more competitors in the product market, profits deteriorate and so do investments if they cannot be allocated to firms' (marginal) cost bases. This effect tends to reduce investment incentives, consumer surplus and investor surplus primarily in the basic Risk-Sharing scenario because under this regime investors cannot at all allocate their investment costs to their (marginal) cost

[22] In addition to the analysis contained in Nitsche and Wiethaus (2009), the previous section covered an additional regulatory setting, Risk-Premium, and an assessment of investor surplus and total surplus.

[23] This is consistent to the base case in that a Risk-Sharing scenario includes the entire industry. Section 3 provides a more flexible framework, differentiating between insiders and outsiders.

base. The same holds true for LRIC, albeit to a lesser extent, as investment costs can only be allocated to the (marginal) cost base if NGA is successful. Under the FDC regime, in contrast, investments increase in the number firms because investment costs will, in any event, increase firms' (marginal) cost base. Not only does this increase investment incentives directly, but also does any additional € spent on NGA lessen the intensity of product market competition, thereby increasing investment incentives indirectly. By the same token, the FDC regime leads to highest consumer surplus and investor surplus. Again, it should be highlighted that these changes depend on the specific form of basic Risk-Sharing considered here.

- **Market share asymmetry between the investor and non-investor.** We consider a case in which the investor has about ¾ market share (prior and after the investment). The main insight from this variation is that Risk-Sharing becomes less important the higher the investor's market share. To see this one should note that Risk-Sharing functions by aligning the incentives between the investor and the non-investor. Therefore, this device becomes less powerful if the investor captures the largest share of the market anyway. In such cases Risk-Sharing may induce fewer investments than regimes with a Risk-Premium and even LRIC as well as lower consumer surplus than a FDC regime. Notably, Risk-Sharing may lead to lower investor surplus than all other regimes, including LRIC. However, it is important to note that this logic only applies if the pre-supposed asymmetry in market-shares extends to the new NGA based services as well. Otherwise, if market shares for new NGA based products can be expected to be symmetric, the results from the basic model apply.
- **Non-margin squeeze obligation.** Our results indicate that investors may easily find themselves in a situation in which they (formally) squeeze non-investors' margins. This results from uncertainty about NGA success. In particular, investors may sink substantial amounts of money before it turns out that NGA is not as successful as expected. In such a situation the optimal retail price for NGA based products can be shown to lie below a wholesale price that recovers investment costs. Indeed, regulatory tools that are aimed at stimulating NGA deployment, such as Fully Distributed Costs (FDC) and Risk-Premium, are particularly prone to such obstacles. By example of a FDC regime, we explore what happens if the investor anticipates that he must avoid a formal margin squeeze: investments and consumer surplus will be reduced substantially. Traditional formal margin-squeeze tests might therefore be ill-suited in the context of new infrastructure developments.
- **Risk-Sharing under alternative wholesale price arrangements.** Next to basic Risk-Sharing without any wholesale transfers among partners, we consider Risk-Sharing in conjunction with three types of wholesale transfers: i) cost based, ii) surplus value based and iii) agreed to maximise joint profits. We find that NGA investments tend to increase if partners charge each other wholesale prices (however there seems to be no clear and robust ranking of

the different types). Consumer surplus tends to decrease the higher the reciprocal retail price among (two) Risk-Sharing partners. However, this relies on the assumption that there are only two firms in the industry. With more firms, and hence more intensive product market competition, higher wholesale prices safeguard investment incentives and, as a matter of degree, consumer surplus. The surplus of Risk-Sharing increases the higher the reciprocal access price. Again, this relies on the current set-up with two firms. As we find later, with outsiders to a Risk-Sharing agreement, Risk-Sharing partners do better with lower internal access prices. Total surplus results are ambiguous.

2.2 Multiple firms

2.2.1 Introduction and summary

The basic model supposes a duopoly: one investor and one non-investor. However, many markets will feature more than one non-investor.[24] This may affect our results, for example, because more firms intensify product market competition, which may affect regulatory regimes differently. This section provides a comparison of regulatory regimes on the basis of a single investor and n=3 non-investors (with one exception: in the Risk-Sharing regime all four firms engage in Risk-Sharing). The appendix contains a more comprehensive assessment of how the number of non-investors affects investments and surplus results for different regulatory regimes.

Table 2 below summarises the ranking of regulatory regimes if we suppose n=3 non-investors rather than a single non-investor (in brackets).

[24] Section 3 also considers more than a single investor in the context of alternative Risk-Sharing scenarios.

Table 2: Ranking of regulatory regimes with n=3 non-investors

	NGA investments	Consumer surplus	Investor surplus	Total surplus
LRIC	5 (--)	4 (--)	5 (--)	4 (--)
Risk-Sharing (RS) – all four firms	3 (--)	2 (1)	3 (--)	2 (--)
Fully distributed costs (FDC)	1 (--)	1 (2)	2 (--)	1 (--)
Risk-Premium (RP 10%)	4 (--)	3 (--)	4 (--)	3 (--)
Holiday (HOL)	2 (--)	5 (--)	1 (--)	5 (--)

Source: ESMT CA model, compressed view, consult graphs for details. The notation "- -" indicates that the position in the ranking does not differ in the basic model with a single non-investor.

The main effects from an increase in the number of firms can be summarised as follows:

- **NGA investment levels** tend to decrease, comparatively,[25] in regulatory regimes where investment costs are not allocated to wholesale prices (i.e. basic Risk-Sharing and partly LRIC, Risk-Premium); in contrast, investments tend to increase if costs can be fully (and certainly) distributed across all firms (i.e. FDC).
- **Consumer surplus:** Regimes in which additional firms adversely affect NGA investments (i.e. basic Risk-Sharing) may perform comparatively worse than regimes in which more firms stimulate NGA investments (i.e. FDC).
- **Investor surplus** decreases in the number of firms. Again, investor surplus is more (less) sensitive to additional firms, the less (more) of the investment costs can be allocated to wholesale prices.
- **Total surplus:** Regimes in which additional firms adversely affect NGA investments (i.e. basic Risk-Sharing) may perform comparatively worse than regimes in which more firms stimulate NGA investments (i.e. FDC).

The analysis provides the following intuition: With more competition in the post-investment stage, regulatory regimes where investment costs are allocated to wholesale prices (i.e. FDC) become relatively more attractive, both in terms of investments levels and investor surplus. In the n=3 case presented here, the resulting positive effect on investment lifts FDC up to the best regulatory regime in terms of consumer surplus.[26]

[25] We refer to how more firms tend to affect the ranking of regulatory regimes in comparison to each other.

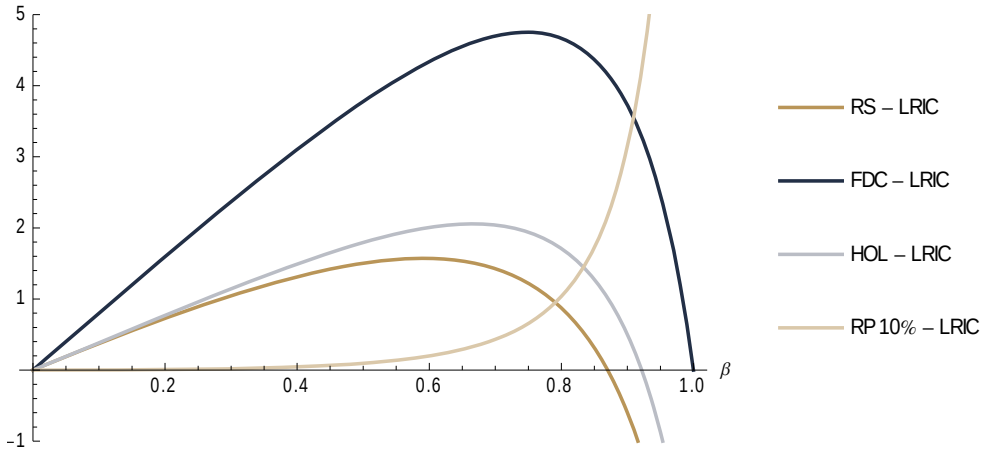
[26] When interpreting the results notice that under Risk-Sharing the combined assumptions of total industry participation and zero internal access costs drive the effect on relative ranking.

The reminder of this section reports our analytical results in more detail.

2.2.2 Investments and welfare results

Figure 6 below compares NGA investment levels in the case of a single investor and three non-investors. That said the Risk-Sharing regime includes all four firms of the industry. This way the extension presented here is consistent with our base case: Risk-Sharing is always assumed to involve the entire industry (in the basic model with two firms both firms engage in Risk-Sharing).[27]

Figure 6: NGA investments: RS, FDC, HOL and RP compared to the LRIC counterfactual with n=3 non-investors



Source: ESMT CA model, A=100, c=20, y=5, n=3.

The graph suggests no qualitative changes of the ranking, relative to the base scenario. However, this relies on the specific example. Further sensitivity checks contained in the appendix suggest the following regularities.

- Under a **LRIC** regime, an increasing number of non-investors decrease (increase) NGA investments if the probability of success is low (high).
- Under **basic Risk-Sharing**, an increasing number of non-investors (which all engage in Risk-Sharing) decrease NGA investments.[28]
- Under a **FDC** regime, an increasing number of outsiders increase investments.

Hence an increasing number of non-investors alter investment incentives quite differently, depending on the regulatory regime, and there exist critical levels which would change the comparative ranking among them.

[27] We relax this assumption in Section 3 where we consider Risk-Sharing insiders and outsiders.

[28] When interpreting the results note that under the Risk-Sharing regime the combined assumptions that all firms participate in the Risk-Sharing and all Risk-Sharing partners get access to the network at zero marginal cost both contribute to the effect on relative ranking.

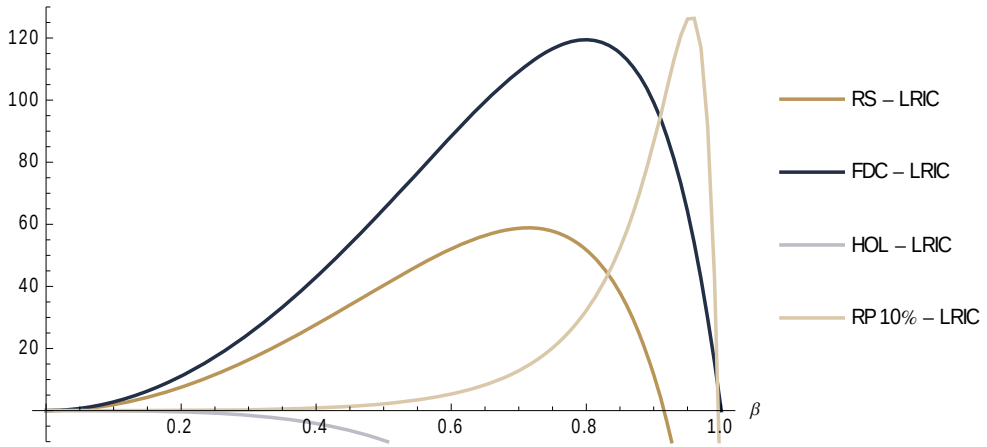
These outcomes can be understood through a combination of two effects. On the one hand increasing the number of firms increases competitive intensity and thereby reduces profits that can be earned through NGA investments. In particular, this discourages investments under a basic Risk-Sharing regime where investment costs are sunk once firms compete for end-customers and, at the same time, more firms reduce profits from product market competition. In the extreme with n=1,000, for example, firms anticipate that there are no profits to be earned from NGA investments due to perfect product market competition. Accordingly, no investments would occur.

On the other hand, with an increasing number of firms, investments might be spread over more firms, making each firm's individual investment contribution smaller. Because of this, investments increase in the number of firms under a FDC regime. The investor is ensured that investments are being split, regardless of whether NGA is successful or not.[29]

Finally, the effects driving investments under the LRIC case[30] can be thought of as a combination of what has been said for the Risk-Sharing and FDC case, respectively. As for low probabilities of success, a larger number of firms reduce investments because NGA investments costs can likely not be allocated to the firms' cost bases when they compete for end-customers. For high probabilities of success, however, investment costs will more likely be allocated to wholesale prices; the LRIC case essentially resembles the FDC case and investments increase if the number of non-investors increases.

Figure 7 presents results with respect to consumer surplus.

Figure 7: Consumer surplus: RS, FDC, HOL and RP compared to the LRIC counterfactual with n=3 non-investors



Source: ESMT CA model, A=100, c=20, y=5, n=3.

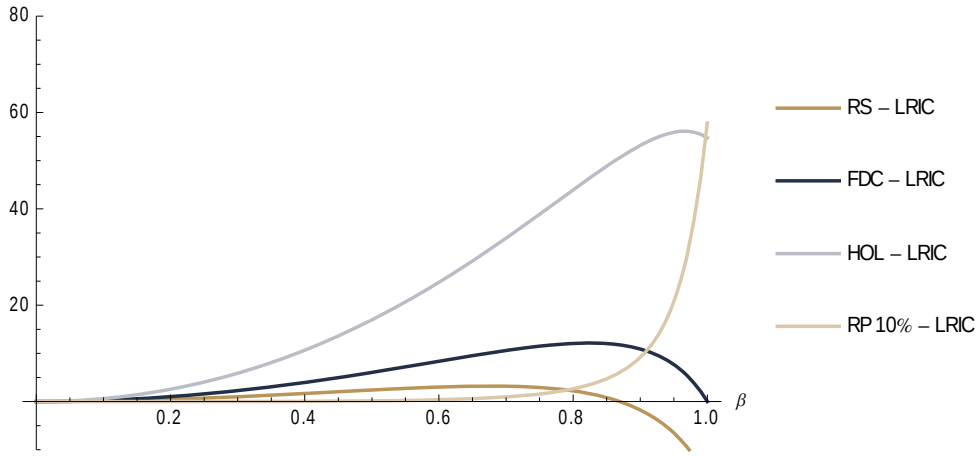
[29] Under Risk-Sharing firms can also share investments costs (with certainty). However, only the FDC regime allocates investments to firms' cost bases when they compete for end-customers, thereby reducing competitive intensity.

[30] The same is true for the Risk-Premium case which resembles the LRIC case but for higher access prices.

According to Figure 7 (and Figure 3), increasing the number of non-investors up to three, already changes the ranking of regulatory regimes in that FDC induces higher consumer surplus than Risk-Sharing. As explained above NGA investments increase under FDC and decrease under basic Risk-Sharing; hence the change in consumer surplus. This finding reveals that our initial ranking of regulatory regimes is sensitive to a varying number of non-investors or competitive intensity in the product market. At the same time one must bear in mind that the analysis, at this stage, assumes a very specific form of (basic) Risk-Sharing that does not allow for any wholesale price compensation among partners within the venture.[31]

Next, Figure 8 below shows the ranking of investor surplus, given that the investor faces three competitors.

Figure 8: Investor surplus: RS, FDC, HOL and RP compared to the LRIC counterfactual with n=3 non-investors



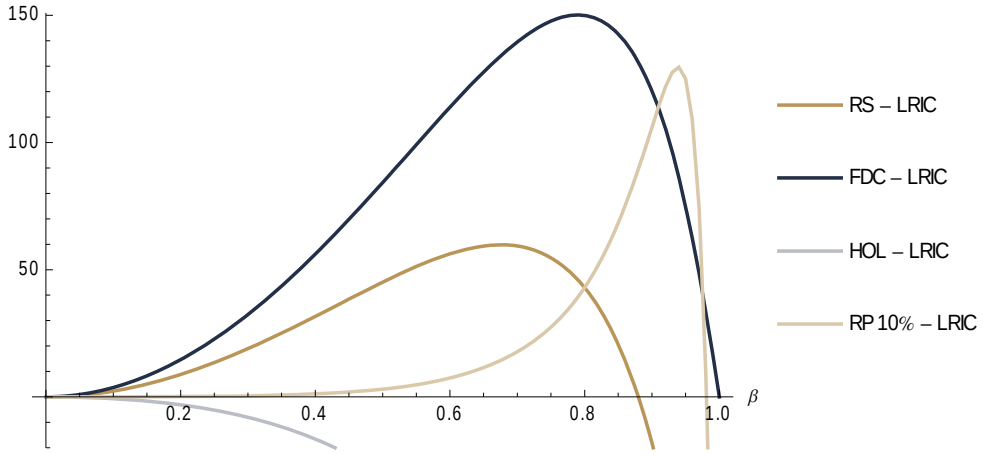
Source: ESMT CA model, A=100, c=20, y=5, n=3.

As for investor surplus, the above figure suggests no qualitative differences to the base case. Indeed, as one would expect, investor surplus decreases under all regimes if the number of firms increases. However, it should be noted that investor surplus dissolves more rapidly under the basic Risk-Sharing scenario than under LRIC and FDC; that is the ranking of investor surplus may not generally be robust with respect to a change in the number of firms.

As a final check we present results with regard to total surplus. Total surplus sums consumer surplus and investor and non-investors' profits.

[31] The fact that there is no wholesale price compensation among partners leads to relatively high competitive intensity and therefore renders the Risk-Sharing case so sensitive to variations in the number of firms. As we point out in Section 0 and 3 alternative modes of Risk-Sharing may well involve wholesale price arrangements among partners. Such forms of Risk-Sharing would be less sensitive to a varying number of firms; albeit such forms of Risk-Sharing might also create less consumer surplus with a limited number of firms exactly because competitive intensity is reduced.

Figure 9: Total surplus: RS, FDC, HOL and RP compared to the LRIC counterfactual with n=3 non-investors



Source: ESMT CA model, A=100, c=20, y=5, n=3.

The example presented by Figure 9 above suggests no change in the ranking of regulatory regimes; but this may again not hold for any given number of firms. As shown in the appendix, in a FDC regime, total surplus unambiguously increases in the number of firms. Under LRIC and Risk-Sharing, the effect of additional firms depends on the probability of success.

2.3 Asymmetries: Investor has higher market share (74%)

2.3.1 Introduction and summary

The basic model assumes that both firms have symmetric market shares. In reality, the investor will often have a larger market share than the non-investor.

In particular, we present an example in which the investor has a market share of 74%[32] before NGA is deployed. It is important to note that, by modelling implications, this assumption carries over to the post investment stage. This means we consider a situation where the investor has a higher market share before the investment (e.g. broadband access) and also expects to capture a somewhat higher market share for NGA based services (e.g. high speed internet). One justification for this assumption is that a large existing customer base likely facilitates the distribution of the new services.[33] However, as we explain below, if

[32] We impose an exogenous asymmetry on the investor and the non-investor by assuming a prohibitive price of A = 130 and A = 100 for the non-investor and the investor, respectively. If we calculate pre-investment equilibrium quantities according to these modifications, we derive at market shares of 74% and 26%, respectively. Due to the underlying model structure, post-investment, the market shares are likely to change slightly towards the smaller firm.

[33] However, this seems not inevitable. If the new services constitute totally different product markets, e.g. TV and gaming rather internet services, then existing market shares might not be a good predictor for new market shares.

the supposed link between ex ante and ex post market share is broken, the results and conclusions presented here become invalid.[34]

Table 3 below summarises the results of this model variation in comparison to the symmetric base case (in brackets).

Table 3: Ranking of regulatory regimes if the investor has a 74% market share

	NGA investments	Consumer surplus	Investor surplus	Total surplus
LRIC	4, 5 (5)	3, 4 (4)	4 (5)	3, 4, 5 (4)
Risk-Sharing (RS)	3, 4, 5 (3)	2, 3, 4 (1)	5 (3)	2, 3, 4 (2)
Fully distributed costs (FDC)	1 (--)	1 (2)	2 (2)	1 (1)
Risk-Premium (RP 10%)	3, 4 (4)	1, 2 (3)	3 (4)	1, 2, 3 (3)
Holiday (HOL)	2 (--)	5 (--)	1 (1)	1, 2, 3 (5)

Source: ESMT CA model, compressed view, consult graphs for details.

As summarised in Table 3 above, the assumption if asymmetric market shares changes the qualitative results of the model. In particular, the Risk-Sharing regime performs comparatively poorer if the investor has a high market share:

- **NGA investments:** In general, the higher an investor's (expected) share of the market for NGA based services, the less important becomes Risk-Sharing as a devise to stimulate additional investments compared to the alternative regimes LRIC counterpart (and vice verse). With a high market share the investor uses most NGAs anyway; non-investors' free-riding becomes less of an issue. However, it appears that within relevant parameter range (uncertainty of success) Risk-Sharing still induces more investments compared to LRIC. Section 3, involving a flexible number of Risk-Sharing insiders and outsiders further substantiates this claim.
- **Consumer surplus:** Because Risk-Sharing induces comparatively less additional investments if the investor has a high market share, Risk-Sharing also tends to induce comparatively lower additional consumer surplus. Again, as for NGA investments, Risk-Sharing seems to induce more consumer surplus than the LRIC counterfactual within the relevant parameter range (again, see Section 3). In the present example, FDC would be first and Risk-Sharing second-best for consumers.

[34] In fact, if there is no structural reason (customer preference, switching costs, efficiency, etc.) that induces asymmetric market shares for the new NGA based products, the basic model set-up is relevant.

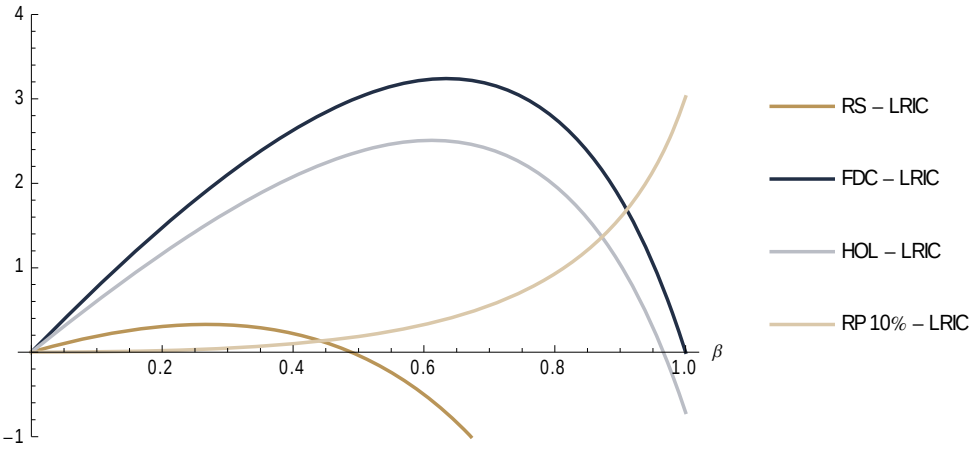
- **Investor surplus:** Again, the higher an investor's market share, the less he needs Risk-Sharing to overcome a free-rider problem. At the same time basic Risk-Sharing comes at a cost of intensive product market competition. The combination of little gain and apparent costs means that basic Risk-Sharing may lead to the worst surplus scenario for an investor with high market-share.
- **Total surplus:** Again, because Risk-Sharing creates relatively little additional investments if the investor has a high market share, this regime creates comparatively lower total surplus as compared to the base case.

The next section presents and explains our analytical results in more detail.

2.3.2 NGA investments and welfare results

Figure 10 below displays NGA investment levels if the investor has a 74% market share (and the single non-investor 26%).

Figure 10: NGA investments if the investor has 74% market share ex ante: RS, FDC, HOL and RP compared to the LRIC counterfactual



Source: ESMT CA model, A(investor)=130, A(non-investor)=100, c=20, y=5.

Notice, first, that Risk-Sharing induces comparatively lower NGA investments, if the investor has a relatively high market share (ex-ante and ex-post). The reason for this result is subtle and requires a few steps to be explained. It follows from the logic why Risk-Sharing stimulated investments in the first place (i.e. in the case of symmetric market shares).

To see this, recall that in the LRIC counterfactual the risk taken by the investor has a positive and free effect on non-investors (i.e. a positive externality): if NGA is successful, the non-investor contributes according to costs; however, if it is not

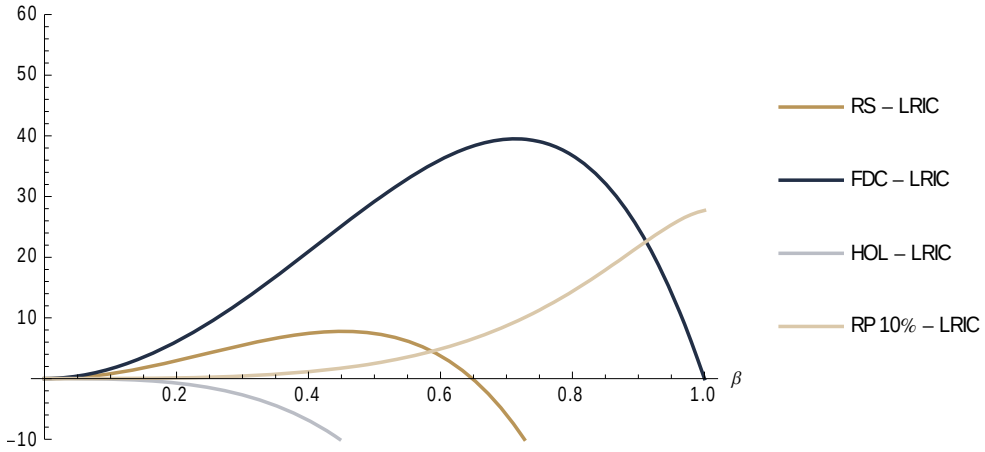
successful, trying NGA was for free. The investor, of course, has little incentive to let non-investors (i.e. competitors) free-riding on its own risk-taking. That is why LRIC induces comparatively low investments.

Under Risk-Sharing the risk taken by the investor is no longer a free-ride for the other firm. Rather, the other firm contributes in the form of up-front payments or by taking some risk in return. For example, firm A may consider that, if it deploys NGA in cities 1, 2, and 3, then, due to the partner's investment, it also has access to cities 4, 5, and 6. The Risk-Sharing mechanism removes free-riding and, upon some form of compensation, the investor deploys NGA to benefit both its own business and its partner's business.

Now, if an investor's market share is higher, so is the extent to which risk-taking benefits its own business rather than a non-investing competitor's business. This means if the investor has a larger market share, free-riding becomes less of an issue and Risk-Sharing has a weaker leverage in stimulating investments vis á vis other alternatives, notably LRIC.[35] The appendix illustrates that exactly the opposite is true if the investor has a low market share: Risk-Sharing is then the regulatory regime that induces most investments.

The other results can now be deduced from the above logic. Figure 11 regards consumer surplus.

Figure 11: Consumer surplus if the investor has 74% market share ex ante: RS, FDC, HOL and RP compared to the LRIC counterfactual



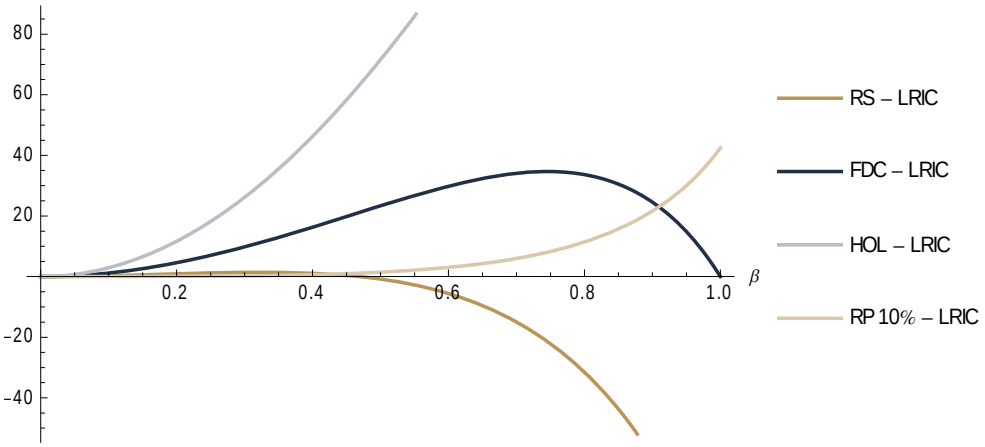
Source: ESMT CA model, A(investor)=130, A(non-investor)=100, c=20, y=5.

As explained earlier, the Risk-Sharing regime creates comparably lower consumer surplus because it induces lower investments. Yet, as long as the probability of success is relatively low, Risk-Sharing still performs second.

[35] It should be emphasised again, that the logic described here only holds if the investor expects high market shares after NGA deployment. In contrast, if market shares were (expectedly) equal after NGA deployment, free-riding effects were again stronger and Risk-Sharing would perform comparably better.

Figure 12 reports the results with respect to investor surplus.

Figure 12: Investor surplus if the investor has 74% market share ex ante: RS, FDC, HOL and RP compared to the LRIC counterfactual

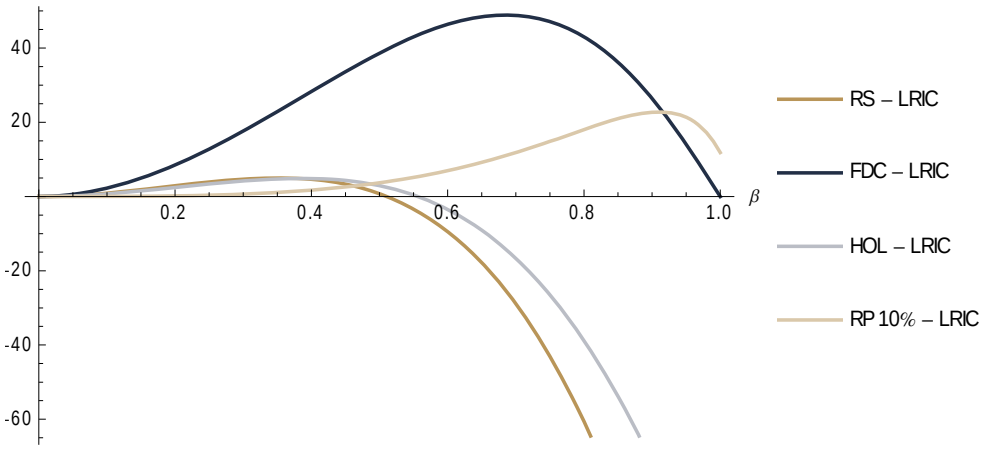


Source: ESMT CA model, A(investor)=130, A(non-investor)=100, c=20, y=5.

As regards investor surplus, our example suggests that Risk-Sharing may even become less profitable than LRIC. As explained, if the investor has a high market share it may not need Risk-Sharing to resolve the free-rider problem. By the same token, again, Risk-Sharing may have no strong positive effect on investor surplus. However, because basic Risk-Sharing (without any wholesale compensation) also intensifies retail competition, it may reduce surplus. Of course, this finding may change, if one considers Risk-Sharing modes with some form of ex-post transfer payments.

Figure 13 displays the results for total surplus as a function of consumer surplus, investor surplus and non-investor surplus.

Figure 13: Total surplus if the investor has 74% market share ex ante: RS, FDC, HOL and RP compared to the LRIC counterfactual



Source: ESMT CA model, A(investor)=130, A(non-investor)=100, c=20, y=5.

2.4 Non-margin squeeze obligation

2.4.1 Introduction and summary

The basic model focuses on the effects that various regimes of ex ante regulation have on firms' incentives to invest in NGA; but it disregards that the investor is also prone to ex-post regulation, notably in the form of non-margin squeeze obligations. As we will point out in this section, non margin-squeeze obligations can substantially distort investment decisions and harm consumers, if they are applied in the context of uncertain investments in NGA. Such concerns are particularly relevant, but by no means limited, to regulatory regimes of Risk-Premium and fully distributed costs. In either case, problems occur because, with some probability, consumers' willingness to pay might be lower than expected and, naturally, the investor would be inclined (but forbidden) to reduce its retail price for NGA based services as a consequence.

Consider first a Risk-Premium. The investor deploys NGA to maximise expected profits. This means the investor deploys NGA according to an average of various possible scenarios; in the simplest case, the investor averages a single success case and a single non-success case. This yields an average of large and small investments, respectively. After the investment, when NGA based products can first be offered to the market, the investor will learn whether it finds itself in a success case or non-success case and has actually under- or over-invested, respectively.[36]

[36] Of course, with more states of the nature the investor might also find himself in a situation in which he has invested optimally. For example, an investor averages investments according to a success and non-success case, yielding medium investments. It may turn out that NGA is not highly successful, nor a complete failure, but a 'medium' success. The investor has invested optimally. It is important to note, however, that this only occurs by pure chance and more often than not, the investor will over- or under-invest somewhat.

In the success case, there are no concerns: consumers' willingness to pay is high and the investor has an incentive to set high enough retail prices, leaving a margin to a cost-based wholesale price, even if the latter is subject to a Risk-Premium. However, in the non-success case consumers' willingness to pay might be very low and the investor must grant substantial discounts in order to at least utilise some NGAs. In such a situation, the optimal retail price may well be below a cost-based wholesale price (subject to a price-premium).[37]

Consider now a regime of fully distributed costs. This means NGA investment costs are allocated to the wholesale price, regardless of whether the NGA based services are a success or not. Again, if NGA services are no success, optimal retail prices for NGA services may well lie below a wholesale price that fully distributes investment costs.

This section first illustrates the above described intuition in the context of the existing model. More importantly it then incorporates a non-margin squeeze restriction into the model and explores how it affects investment incentives and surplus results. To that end, we use the case of fully distributed costs subject to a non-margin squeeze obligation.[38] Table 4 summarises the results.

Table 4: Ranking of regulatory regimes – including a non-margin squeeze obligation (results from the basic model in brackets)

	NGA investments	Consumer surplus	Investor surplus	Total surplus
LRIC	5 (--)	3 (4)	5 (--)	4 (4)
Risk-Sharing (RS)	3 (--)	1 (1)	3 (--)	2 (2)
Fully distributed costs (FDC)	1 (--)	2 (2)	2 (--)	1 (1)
Fully distributed costs with non-margin squeeze obligation (MS)	4 (1 FDC)	4 (2 FDC)	4 (2 FDC)	3 (1 FDC)
Holiday (HOL)	2 (--)	5 (5)	1 (--)	5 (5)

Source: ESMT CA model, compressed view, consult graphs for details.

The analyses reveal that a non-margin squeeze obligation has adverse effects on NGA investments, consumer surplus, investor-surplus and total surplus:

[37] The optimal retail price may also be well below a cost-based wholesale price without a Risk-Premium. It is only that a Risk-Premium reinforces the problem. Recall that the cost-based wholesale price spreads investment costs over retail quantities.

[38] Similar examples could be constructed for regimes of Risk-Premium and even LRIC. However, that would require a few additional assumptions in terms of a realistic premium and (for the LRIC case) another probability distribution of NGA success and non-success. The FDC regime, in contrast, readily lends itself to an introduction of a non-margin squeeze obligation.

- **NGA investments** decrease (substantially) if the investor anticipates that, with some probability, he will not have the flexibility to determine its retail prices optimally. Specifically, the risk that, upon NGA failure, the retail price has to be set above its optimal level discourages investments.
- **Consumer surplus** decreases because i) the non-margin squeeze obligations reduces NGA investments and ii) with some probability, retail prices are higher than they would be without a non-margin squeeze obligation.
- **Investor surplus** decreases as price inflexibility distorts investments and reduces profits.
- **Total surplus** decreases because consumer surplus and investor surplus decrease; albeit non-investors are better off.

The results suggest that non-margin squeeze obligations may harm consumers in the context of new and uncertain infrastructure investments. Indeed, within the modelling framework, regulators should simply refrain from a non-margin squeeze obligation. To the extent that NGA might not be successful, a non-margin squeeze obligation is likely harmful; if NGA is successful, the investor has an incentive to set its retail price high enough, not squeezing competitors' margins. However, we analyse a simple and static model. The model does not capture a possible incentive to margin squeeze in order to force an entrant out of the market and to more than recoup the temporary losses thereafter.

In particular, the results obtained here do not imply that any observed margin-squeeze situation related to new infrastructure is certainly pro-competitive. One cannot exclude the possibility that NGA is a success and the investor engages in an anti-competitive margin squeeze to promote non-investor's exit or non-entry. However, just observing a formal margin squeeze, the regulator would not know whether the margin squeeze is pro-competitive (i.e. case of NGA failure) or whether the margin squeeze is anti-competitive (i.e. case of NGA success but foreclosing behaviour of the incumbent). Optimal margin squeeze tests would have to cater for this problem.

The rest of this section first explains how (pro-competitive) margin squeezes may emerge naturally if the returns on investment are uncertain. Then we explore what happens if, in such situations, regulators impose a non-margin squeeze obligation on the investor.

2.4.2 Emergence of margin squeezes if NGA is not successful under a regime of Fully Distributed Costs

This section explains in more detail how investors may run into margin squeeze situations if NGA investments are not successful and how such a situation can be incorporated in the present framework so as to analyse the effects of non-margin

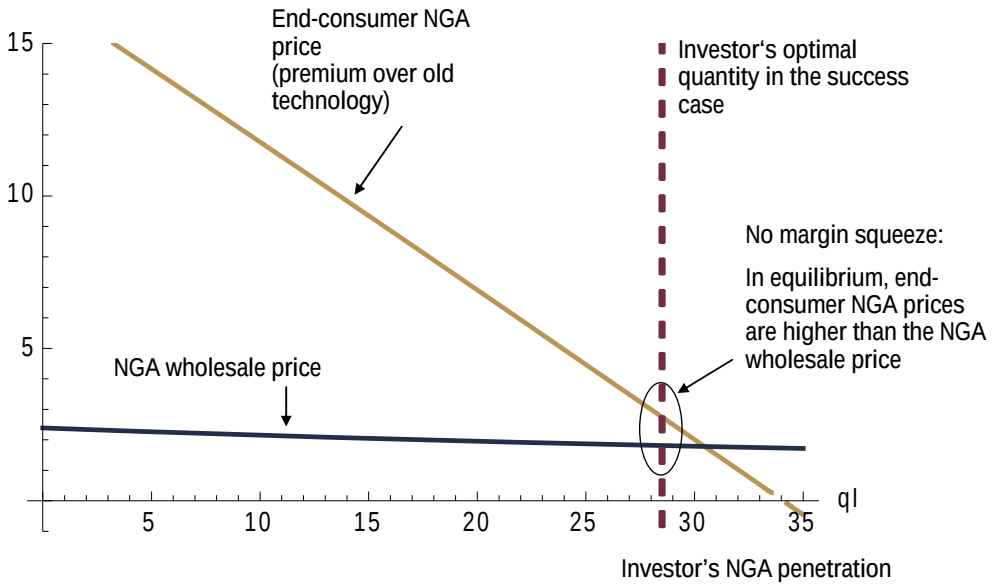
squeeze obligations. As a reference, we first illustrate the investor's pricing in the success case that does not lead to a margin squeeze situation. Then we move on to illustrate how the situation changes if NGA is not successful.

To illustrate the success case, we observe three variables.

- First, we have **the NGA wholesale price** based on the fully distributed cost principle and on firms' penetration strategies. Recall that the FDC regime distributes NGA investment costs across output quantities so that the unit wholesale price decreases the more firms penetrate the market with NGA based services.
- Second, we need to observe the **NGA retail price uplift**, again as a function of firms' penetration strategy. The uplift is the difference between the retail price with NGA deployment and without NGA deployment.[39]
- Third, we calculate the investor's optimal penetration strategy; that is its **output quantity** in the Cournot Nash equilibrium. Figure14 below pictures these three variables.

[39] As an artifact of the underlying Cournot model it is not sensible to look at the total retail price that also incorporates consumers' willingness to pay for existing products. The simple Cournot set-up then implies that there is already a margin between the retail price for the existing product and marginal costs. Looking at total retail prices, wholesale prices and marginal costs we would then account for an additional margin that can actually not be attributed NGA. In reality such an additional margin might actually not exist if competition for the existing (e.g. copper based) based product is functioning. Looking at NGA retail and wholesale price increments also resembles a cost squeeze test. This means that an access seeker would have to earn a sufficient margin for any increment of a value chain, so as to ensure that they are not discouraged from competing in certain segments. For example, if there was a sufficient margin to offer non NGA based services whilst upgrading for NGA based services implied that the additional costs exceeded the additional revenues (vis a vis non NGA based services), then access seekers might have little incentive to offer NGA based services, raising concerns by regulators and competition authorities.

Figure 14: Fully distributed costs: NGA wholesale price uplift and optimal retail price uplift in the success case: no margin squeeze

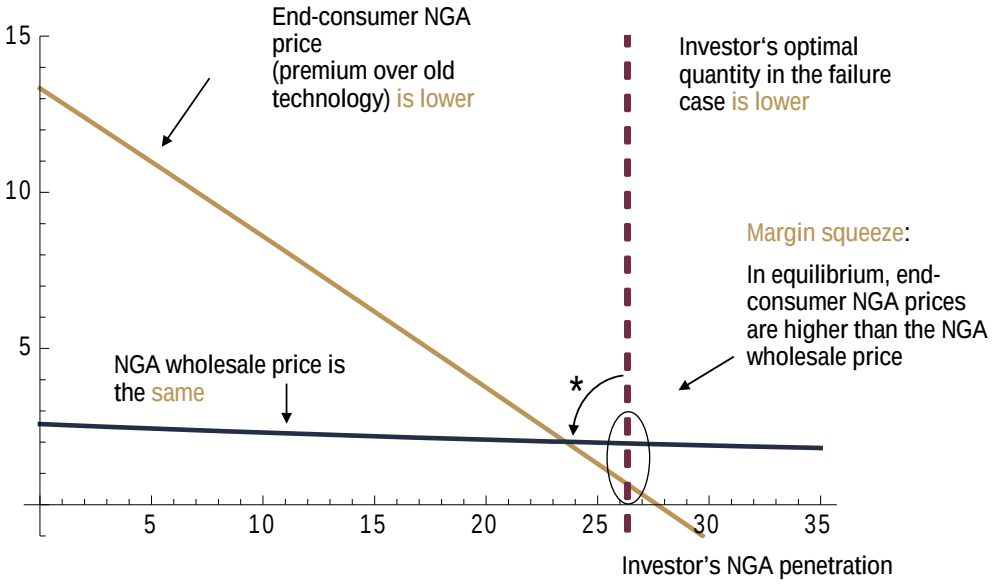


Source: ESMT CA model, A=100, c=20, y=5, beta=0.7, investments xI=6.42 (optimal for beta=0.7), demand shift xI=6.42 (success case).

The dark grey line depicts the NGA wholesale price as a function of the investor's NGA penetration (qI) and (implicitly) the non-investor's best-response penetration. As can be seen, the more the investor penetrates the market the lower per unit investment costs and the lower the wholesale price. The beige line represents the retail price uplift for NGA services, again as a function of the investor's penetration (qI) and (implicitly) the non-investor's best-response penetration. The retail price (uplift) decreases the more the investor penetrates the market. It can be shown, however, that under the firms' optimal output quantities (vertical red dotted line) the retail price will exceed the wholesale price, allowing access seekers a positive margin.

However, this may change if the NGA is not successful and consumers are not willing to pay more for NGA based services. Figure 15 below illustrates this situation.

Figure 15: Fully distributed costs: NGA wholesale price uplift and optimal retail price uplift in the non-success case would lead to a margin squeeze



Source: ESMT CA model, A=100, c=20, y=5, beta=0.7, investments xI=6.42 (optimal for beta=0.7), demand shift xI=0 (non-success case).

The figure resembles Figure 14 above, but for a lower price level (beige line) that results from consumers' lower willingness to pay and a lower optimal penetration (red dotted line), firms' best response to consumers' lower willingness to pay. As can be seen, lower penetration notwithstanding, the investor's optimal penetration does not allow for a positive margin between the retail price (uplift) and the NGA wholesale price. The non-success case results in a margin squeeze situation.[40]

Now, the interesting question is what happens if we impose a non-margin squeeze obligation on the investor. In the context of figure 14 above this requires the investor to restrict its output quantity to the point where the (beige) retail price line intersects with the (grey) wholesale price line. If such an obligation is in place, the investor anticipates that, in the non-success case, it will not be able to penetrate the market optimally (at the level of the red line) but only up to a lower level that allows for a positive margin. Below we calculate investment levels and welfare results, given that the investor has to restrict itself to the indicated penetration amount (retail price equals wholesale price) in the non-success case.[41]

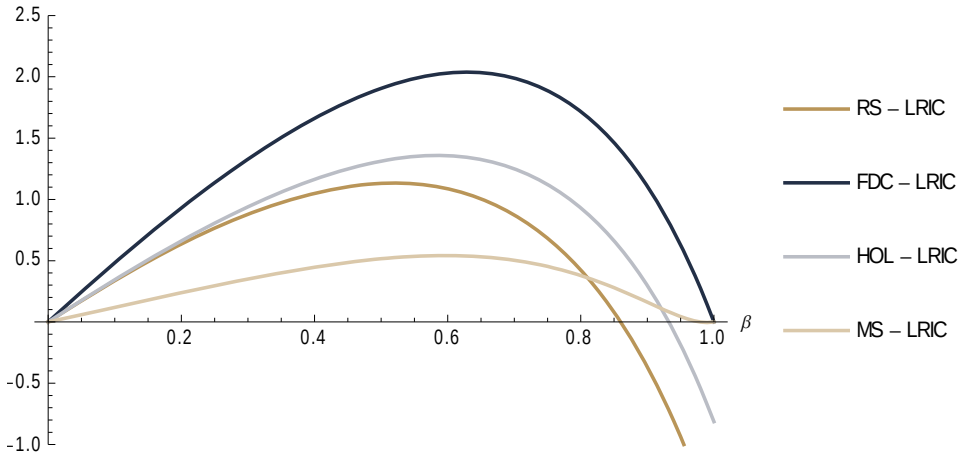
[40] 0 contains an example based on a Risk-Premium scenario where NGA is neither a complete success nor a total failure. The example illustrates that a 'medium' success case may also lead to a (pro-competitive) margin squeeze.

[41] We have checked that this is indeed the relevant constraint: it is more profitable for the investor to restrict output than to lower the wholesale price.

2.4.3 Investments and welfare results under a non margin-squeeze obligation (fully distributed costs)

Figure 16 below displays investment levels in the familiar fashion. Next to the known unrestricted FDC case the figure also includes the investment levels we obtain for the FDC case with a non-margin squeeze obligation (labelled MS).

Figure 16: NGA investments: Inclusion of a FDC non-margin squeeze scenario

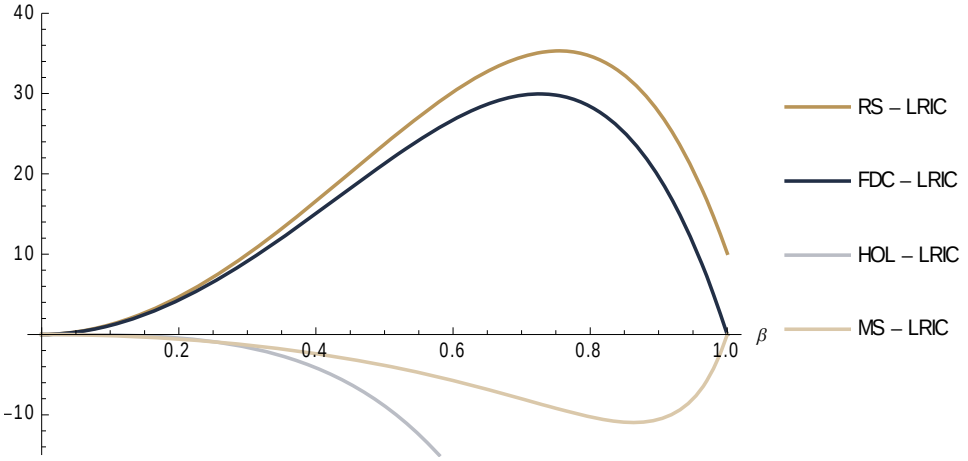


Source: ESMT CA model, A=100, c=20, y=5.

The main result coming out of Figure 16 is that, with a non-margin squeeze obligation, NGA investments are significantly reduced. This can be seen by comparing investments levels under FDC scenario (grey line) with the FDC but MS restricted scenario (light beige) line. As discussed above the investor will reduce NGA investments in light of its limited pricing flexibility should NGA turn out to be a failure. Yet, investments are still higher than under a LRIC regime, as the MS—LRIC line is still above zero.

Figure 17 below regards consumer surplus.

Figure 17: Consumer surplus: Inclusion of a FDC non-margin squeeze scenario



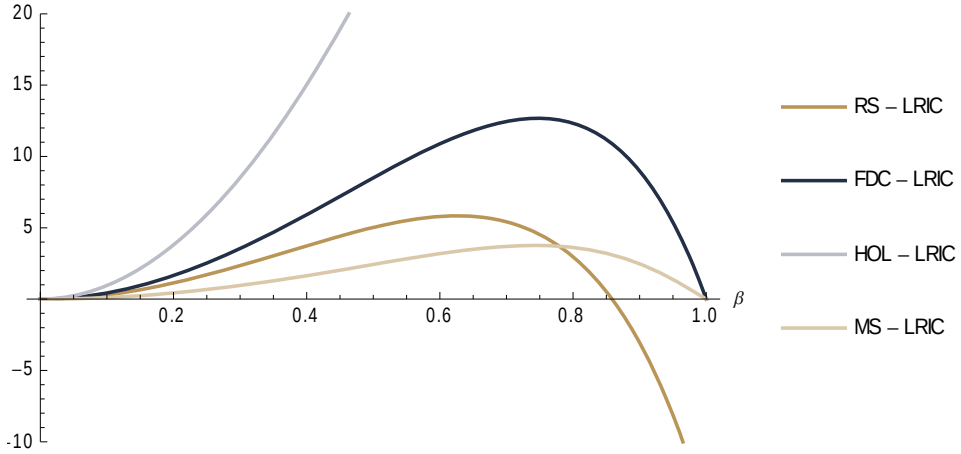
Source: ESMT CA model, A=100, c=20, y=5.

The effect of a non-margin squeeze obligation on consumer surplus appears even more severe than on investment levels. This follows because consumers are harmed for two reasons.

- First, as explained, investments are reduced relative to a level without the margin squeezes regime. For example, fewer regions might be upgraded, fibre might not be deployed to the home, or investments might simply be delayed.
- Second, for what is still being deployed, consumers are harmed as the non-margin squeeze obligation requires the incumbent to increase the retail price above the optimal level so as to exceed the wholesale price.

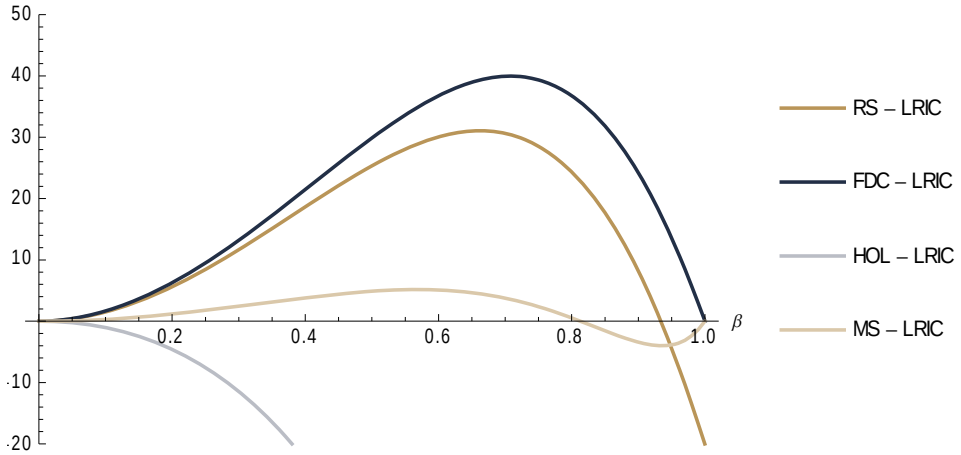
Figure 18 and Figure 19 below regard the results investor surplus and total surplus respectively. As one would expect, a non-margin squeeze obligation reduces the investor's surplus (compare FDC and MS case), albeit the investor might still be better off than under LRIC. Total surplus, taking into account the combined effects of consumer surplus, investor and non-investor surplus will also be lower under a non-margin squeeze obligation than without such a restriction (again comparing the FDC and MS case).

Figure 18: Investor surplus: Inclusion of a FDC non-margin squeeze scenario



Source: ESMT CA model, A=100, c=20, y=5.

Figure 19: Total surplus: Inclusion of a FDC non-margin squeeze scenario



Source: ESMT CA model, A=100, c=20, y=5.

2.5 Risk-Sharing under alternative wholesale price arrangements

2.5.1 Introduction and summary

Thus far we have considered a specific form of Risk-Sharing. To recap, we have referred to basic Risk-Sharing if partners agree on some joint infrastructure deployment ex ante whilst, once the new infrastructure is laid out, partners share their NGAs without any further transfer payments. For example, one firm may deploy NGA in city A, another deploys city B. Afterwards both firms compete for end-customers in both cities and whoever wins an end-customer may use the NGA regardless of the area and without wholesale transfers. Alternatively, one firm may physically deploy NGA in both city A and city B, while the other firm commits itself financially prior to the investment. Again, there would be no transfer payments among firms, once they compete for end-customers.

We have argued above that this form of Risk-Sharing may lead to rather aggressive product market competition because the absence of transfer payments lowers firms' (marginal) cost base and thereby tends to reduce retail prices. In the simple case involving only two firms, basic Risk-Sharing induces reasonable investments, high consumer surplus and high (investor) surplus. However, we also obtained that, if the number of firms increases and product market competition becomes more intense, then basic Risk-Sharing may only induce limited investments, comparatively lower consumer surplus and (investor) surplus. As we pointed out, this follows from the lack of wholesale transfers among Risk-Sharing partners.

Indeed, alternative forms of Risk-Sharing appear feasible. In particular, Risk-Sharing partners may grant each other access at cost or may otherwise agree on wholesale prices for each others' NGAs. This section explores the effects of different wholesale price arrangements among Risk-Sharing partners. In particular, we consider the simple case with two firms, where one firm explores city A and the other city B, and firms grant each other access at the following conditions:

- **Basic, B:** This is the existing benchmark without wholesale price arrangements among partners. That is the absence of transfer payments implies a low (marginal) cost base.
- **Cost based, JV:** Under this form partners grant each other access at (unit) investment costs.[42] Thus, all other things equal, higher quantities reduce the access price.

[42] The allocation mechanism where each firm bears investment costs according to market share is the same as under LRIC (in the success case) or FDC.

- **Surplus value based, S:** Firms grant each other access at a wholesale price that equals the retail price increase of NGA based products relative to the copper based products.
- **Agreed, A:** Firms set an access price to maximise their joint profits. In the present case with no outsiders, it turns out that firms would set each other foreclosing wholesale prices so that each one can monopolise its own area. As we show in Section 3.3, this result hinges on there being no competitive pressure from outsiders. It should therefore be regarded as another benchmark case, underpinning the logic and functioning of the model.

It should be noted that the above list reflects the ascending order of the magnitude of wholesale transfers (up to the reciprocally foreclosing wholesale price under scenario A). Again, in this section, we leave all other assumptions of Nitsche and Wiethaus (2009) unchanged so as to gain a better understanding of the pure impact that various wholesale prices arrangements may have on investments and surplus measures (In Section 3 we will flex additional assumptions, notably with respect to the number of Risk-Sharing insiders and outsiders). Table 5 below reports the results of this section.

Table 5: Ranking of different Risk-Sharing regimes and the LRIC counterfactual

	NGA investments	Consumer surplus	Joint surplus	Total surplus
LRIC	5	4	5	4
RS, basic (B)	4	1	4	2
RS, cost-based (JV)	1, 2	2	3	1
RS, surplus value based (S)	1, 2	3	2	3
RS, agreed wholesale price (A)	1, 2	5	1	5

Source: ESMT CA model, compressed view, consult graphs for details. The first column does not show the third rank as two regimes may be equally ranked.

The main findings of this section can be summarised as follows:

- **NGA investments** are higher if partners charge each other wholesale prices (compared to basic Risk-Sharing). However, there does not seem to be a clear ranking with respect to the above defined wholesale price regimes. This occurs, at least partly, because regimes do not simply differ by an absolute amount but also in the way they incentivise investments.

- **Consumer surplus** decreases, the higher the reciprocal wholesale price among (two) Risk-Sharing partners. As indicated above, this relies on the assumption that there are only two firms in the industry. With more firms, and hence more intensive product market competition, higher wholesale prices safeguard investment incentives and, as a matter of degree, consumer surplus.
- **Joint surplus**[43] of Risk-Sharing partners increases, the higher the reciprocal wholesale price among Risk-Sharing partners. This follows because a higher wholesale price relaxes retail competition among partners. Yet, again, this result depends on the assumption of two firms. As we will see in Section 3.3, with competitors outside the Risk-Sharing agreement, partners might well be best off granting each other free access so as to gain a competitive edge vis à vis outsiders.
- **Total surplus** results are ambiguous, being a combination of countervailing effects on consumer surplus and surplus.

The results show that absent competition from outsiders, insiders' profits (and investment levels) are higher if access prices cover at least (unit) investment costs. The increase in investment is solely due to the higher profitability caused by the price increase in the post investment stage; consumers would prefer outcomes with lower prices and lower investment. In Section 3.3 we show that the results change if there is competition from outsiders and an additional effect emerges: then insiders may gain from setting low access prices (which are the perceived marginal costs) and thereby signal aggressive pricing vis à vis outsiders.

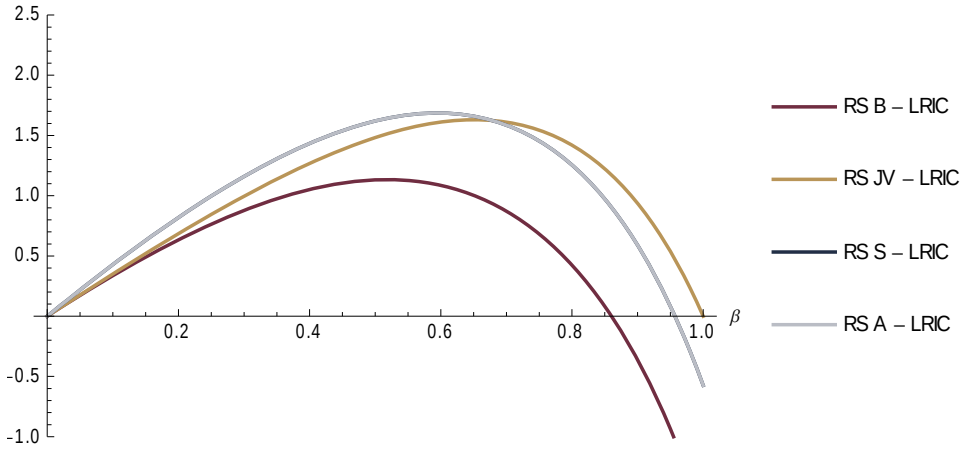
In the remainder of this subsection we briefly report the underlying analytical results from the model.

2.5.2 Investments and welfare results

Figure 20 below shows NGA investment levels for different Risk-Sharing regimes. The investment levels are again net of the investment level in the LRIC counterfactual.

[43] In this context it makes sense to look at joint surplus because we consider that one firm invests in city A and receives wholesale payments in city A while the same firm (does not deploy city B) pays for wholesale access in the other city B.

Figure 20: NGA investments: Comparison of different Risk-Sharing regimes and the LRIC counterfactual

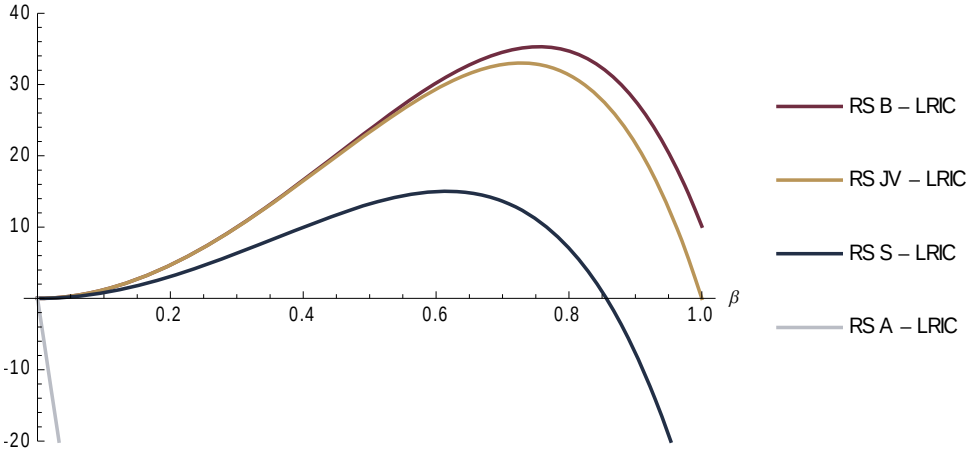


Source: ESMT CA model, A=100, c=20, y=5, B ~ no wholesale prices, JV ~ wholesale access at cost, S ~ wholesale access at the value of the retail price surplus, A ~ wholesale access for reciprocal foreclosure.

Figure 20 indicates that regimes in which Risk-Sharing partners charge each other wholesale prices yield higher investments than the basic Risk-Sharing regime (notice that regimes S and A lead to the same investment levels and S does appear explicitly). A higher (reciprocal) wholesale price relaxes retail competition. This increases the returns on the investment and hence stimulates investment incentives.

Figure 21 displays the consumer surplus increments that various Risk-Sharing regimes induce over the LRIC counterfactual.

Figure 21: Consumer surplus: Comparison of different Risk-Sharing regimes and the LRIC counterfactual



Source: ESMT CA model, A=100, c=20, y=5, B ~ no wholesale prices, JV ~ wholesale access at cost, S ~ wholesale access at the value of the retail price surplus, A ~ wholesale access for reciprocal foreclosure.

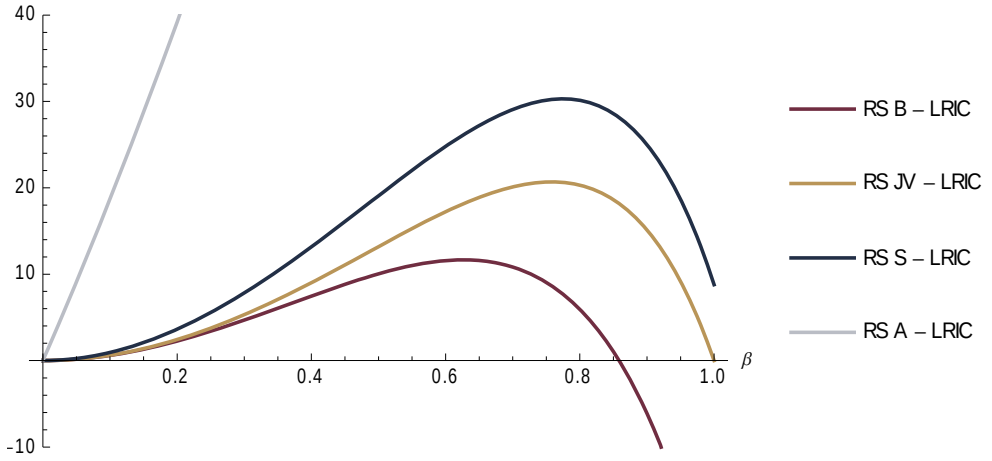
In the present model configuration, the basic Risk-Sharing regime yields highest consumer surplus, followed by a regime of cost-based access, surplus value based wholesale prices, LRIC and a regime in which the partners agree on a wholesale price that maximises their joint profits (reciprocal foreclosure). It should be noted that these findings hinge on the assumption that there are only two firms in the industry. With only two firms, the retail market is sufficiently concentrated so as to allow partners to make some profits from NGA investments even if marginal costs are low and do not incorporate any such (sunk) costs. This means, under-investment is not the prime concern. Rather, the basic Risk-Sharing mode induces strong retail competition, which benefits consumers. Cost-based (JV) and surplus based wholesale prices (S) result in lower consumer surplus because the increase firms' marginal costs by an amount equal to per unit NGA costs and per unit retail price increase. Finally, the agreed wholesale price would lead to two local monopolies and therefore results in the least desirable outcome for consumers.

Again, these results change in an environment with more firms and more intense product market competition. In such an environment the fact that wholesale prices induce more investments may well outweigh the fact that they also relax retail competition.

Figure 22 compares Risk-Sharing partners' joint surplus. We refer to joint surplus in order to account for the fact that partners may find themselves in different roles, depending on the area. Specifically, we have in mind a situation in which

firm 1 deploys city A and firm 2 deploys city B. This means firm 1 covers investment costs and receives wholesale revenues in city A but pays wholesale prices in city B. Yet, for computational reasons, we then focus on a single city A, but add profits of firm 1 and 2. Of course, this resembles adding up firm 1's profit in city A and B. In order to ensure comparability, we double profits in the LRIC counterfactual; that is a counterfactual in which firm A would unilaterally deploy NGA in cities A and B, subject to LRIC regulation.

Figure 22: Joint surplus: Comparison of deploying two cities jointly (under different Risk-Sharing regimes) and deploying two cities in the LRIC counterfactual

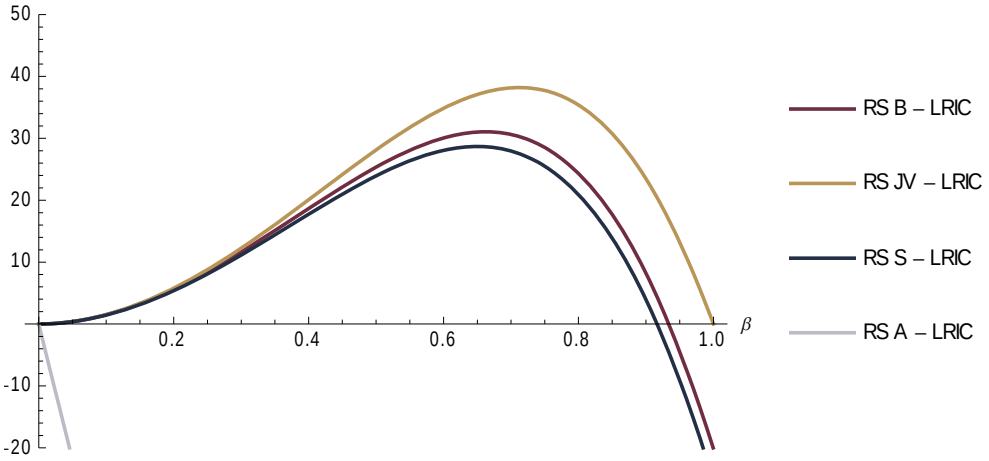


Source: ESMT CA model, A=100, c=20, y=5, B ~ no wholesale prices, JV ~ wholesale access at cost, S ~ wholesale access at the value of the retail price surplus, A ~ wholesale access for reciprocal foreclosure.

Figure 22 above shows that, in the case with only two Risk-Sharing partners and no outsiders, joint profitabliy increases with the wholesale price that partners charge each other. The intution is that higher wholesale prices relax retail competition and thereby increase joint profitablity. In the extreme benchmark case where partners agree on a profit maximising wholesale price (A), indeed, partners best foreclose each other in city A and B, respectively, and earn regional monopolistic rents. We note again, that this finding vanishes once we introduce outsiders. When outsiders exert competitive pressure on Risk-Sharing partners then the latter may well maximise their own profits in chargin each other minimal wholesale prices.

Figure 23 compares results in terms of total surplus; that is the sum of consumer surplus and joint surplus (investor and non-investor surplus in the LRIC counterfactual).

Figure 23: Total surplus: Comparison of different Risk-Sharing regimes and the LRIC counterfactual



Source: ESMT CA model, A=100, c=20, y=5, B ~ no wholesale prices, JV ~ wholesale access at cost, S ~ wholesale access at the value of the retail price surplus, A ~ wholesale access for reciprocal foreclosure.

The figure suggests, that Risk-Sharing with cost-based access (JV) induces highest total surplus, followed by basic Risk-Sharing and the value based form of Risk-Sharing (S) in which firms charge each other a wholesale price equal to the NGA associated retail price increase. Not surprisingly, the extreme benchmark case (A), where firms monopolise their own region, leads to lowest total surplus.

3. Alternative Risk-Sharing approaches

3.1 Introduction and summary

In the basic model we considered a single specific form of Risk-Sharing. First, we assumed that Risk-Sharing partners settle all compensations prior to the investment. For example, a situation where partners deploy different areas and then grant each other free access just as financial commitments fall under this category. However, Risk-Sharing partners may consider charging each other wholesale prices. Second, we supposed that a Risk-Sharing consortium involved the entire industry. Of course, in reality there might also outsiders. Third, by implication, the analyses were silent on whether outsiders should have access to NGAs or not. Again, in reality access conditions, if any, for outsiders will shape investment incentives for insiders, consumer surplus and investors' surplus.

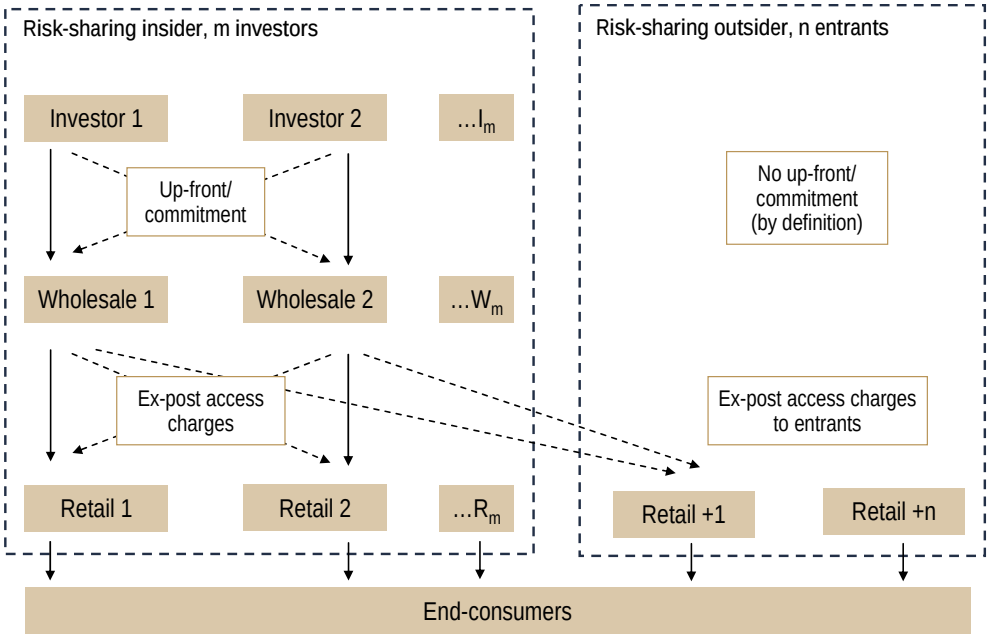
Before we move on, a few clarifications and definition seem helpful:

- **Investors (Insider):** all firms in a Risk-Sharing consortium. If not stated otherwise, we assume that all insiders are symmetric (e.g. in terms of market share) and share the risk symmetrically (see Section 3.7 for an extension towards asymmetry). However, this does not necessarily imply physical investment by all insiders; a symmetric financial up-front contribution is economically equivalent.

- **Non-investors (Outsider):** all firms who do not take any up-front risk. If not otherwise stated, we assume no outsider access (see Section 3.6 for a discussion).
- **Distribution of risk:** as stated above, in general, we assume a symmetric distribution of risk among Risk-Sharing insiders.
- **Risk-Sharing contracts implicitly assumed by the current modelling:** practically, Risk-Sharing can be implemented by various means. The forms covered by the model are i) commitment to minimum quantities (economically similar to up-front payments but for the risk of bankruptcy of committed Risk-Sharing partners), ii) up-front payments and iii) build and share (city A and B) models. However, additional forms of Risk-Sharing are possible, in particular contract durations and various lot sizes.

In the previous section we already relaxed the first restriction and allowed positive reciprocal access charges for Risk-Sharing partners. This section extends the analysis further with respect to all the aforementioned dimensions. Figure 24 below illustrates them.

Figure 24: Important dimensions of Risk-Sharing



Source: ESMT CA.

Figure 24 illustrates a stylised telecommunication industry with the supply chain on the vertical dimension and the players on the horizontal dimension. The left dotted box indicates the sphere of a number of m Risk-Sharing insiders. At the

top level insiders agree to jointly deploy NGA in a single or in various areas. At this level insiders may (or may not) negotiate up-front contributions to the Risk-Sharing consortiums. Such contributions may, for example, take the form of physical deployment of a certain area or some financial commitment. In any event, such contributions are defined ex ante and are hence not tied to partners' success at the retail stage. However, partners may also decide to compensate one's other investment efforts through wholesale payments further down the value chain. For example, if one insider deploys area 1 and another area 2, absent any up-front commitment, partners charge each other wholesale price on a per unit basis. Partners could negotiate such wholesale prices or just base them on average investment costs. Finally firms compete for end-consumers in the retail stage. As indicated by the right dotted box, retail competition will most likely involve a number of n outsiders, who, by definition, have not contributed to NGA deployment. Outsiders compete either on the basis of the old infrastructure or they obtain access to NGA infrastructure as well.

In this section we analyse the outcomes of three distinct forms Risk-Sharing. First, in the basic Risk-Sharing model, insiders compensate each other entirely by means up-front payments, e.g. build and share or commitment models (this form of Risk-Sharing has been assumed in the basic model). Second, under wholesale Risk-Sharing, insiders agree to deploy NGA jointly (e.g. in cities A and B, respectively) and grant each other access at an optimal internal wholesale price (this resembles the Agreed (A) case in Section 2.5, but within a framework). In distinction to the subsequent model, the wholesale price is set so as to maximise surplus within the Risk-Sharing consortium. Third, with JV Risk-Sharing, partners grant each other access subject to per unit wholesale payments. In contrast to the wholesale model, however, the wholesale price is based on average investment costs. This can also be interpreted in terms of an infrastructure JV (see JV case in Section 2.5).[44]

We first analyse these settings under the assumption that outsiders have no access to NGA. Thus, outsiders solely act as a competitive restraint in the post investment stage as they continue to provide copper based services. In a second step we derive some conditions that must hold for outsider access (if any) not to decrease investments and consumer surplus relative to a scenario where outsiders have no access. The main findings can be summarised as follows:

- **Basic Risk-Sharing:** NGA investments depend on the ratio between insiders and outsiders. In particular, more insiders lead to higher investments if insiders' share does not exceed (roughly) 50% of the market (and decrease thereafter). The number of insiders that maximise consumer surplus is slightly higher and the number that maximises insider surplus is slightly smaller.

[44] Section 0 also contained a Surplus (S) case. In that section the surplus case was interesting because the Agreed (A) case led to extreme and unrealistic outcomes. In this section the extreme results vanish due to the presence of outsiders and Wholesale Risk-Sharing (i.e. the Agreed case) appears more realistic.

- **Wholesale Risk-Sharing:** The profit-maximising wholesale price decreases in the number of outsiders and increases in the number of insiders. However, as long as there are not too many insiders (e.g. roughly 50% of the market), insiders are best-off by not charging each other any wholesale prices. To that end the basic Risk-Sharing model is best for insiders. If insiders exceed about 50% they optimally charge each other wholesale prices. Wholesale prices then function so as to restore NGA investment incentives. Again, the number of insiders to maximise consumer surplus is slightly higher and the number to maximise insider surplus is slightly smaller (than the number to maximise NGA investments).

- **JV Risk-Sharing:** Compared to the previous models, this form can accommodate more insiders without reducing NGA investment incentives (e.g. more than 50% but still less than 100%) because cost-based wholesale prices ensure that insiders can recoup investment costs (in the success case). Consumer surplus unambiguously increases in the number of insiders. Insider surplus is maximised, if insiders account for about 50% of the market.

- **Comparative assessment:** Our results suggest that basic and wholesale Risk-Sharing models, involving about 50% of the industry, create most investments in NGA, largest consumer surplus and highest insider surplus. It appears that a JV Risk-Sharing model involving the entire industry creates highest total surplus, followed by basic and wholesale Risk-Sharing involving about 50% of the industry. All forms of Risk-Sharing result in higher NGA investments, larger consumer surplus, higher insider surplus and larger total surplus than the LRIC counterfactual.

- **Outsider access:** Risk-Sharing without outsider access induces larger consumer surplus than the LRIC counterfactual. Against this background we argue that outsider access to NGA, if any, should i) not undermine that firms participate in Risk-Sharing in the first place and ii) make consumers better off than without outsider access. In particular, the first condition requires that non-participation does not lead to systematically higher expected pay-offs than participation. In turn, this implies that outsiders cannot have equal access conditions as insiders, once the risk is substantially reduced ex post. Indeed the underlying economic principles suggest outsider access, if any, subject to a Risk-Premium. The second condition means, for example, that outsider access must not result in tight (i.e. traditional) non-margin-squeeze obligations for investors.

The remainder of this section is organised as follows. We explore the three Risk-Sharing models separately and in somewhat more depths. In particular, the analysis offers some guidance as how to optimally design a given Risk-Sharing model from consumers' and insiders' perspectives. Then we compare the outcome of different Risk-Sharing models among each other and to the LRIC counterfactual. The section helps to decide what kind of a Risk-Sharing model to

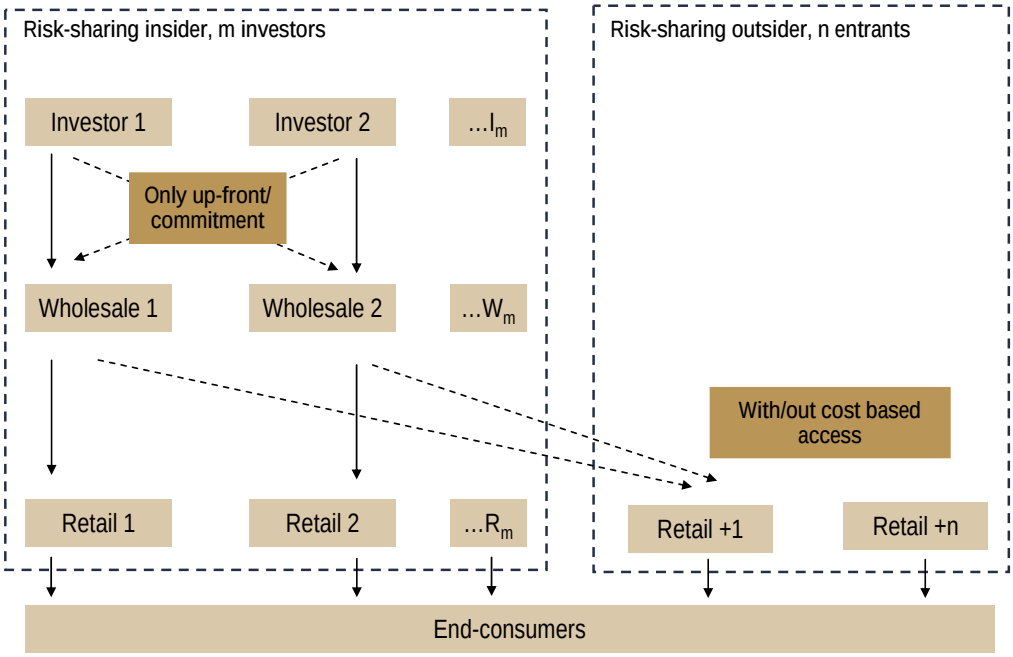
install in the first place. As the just mentioned assessments suppose no outsider access, the final section developments some principles for outsider access.

3.2 Some economics of basic Risk-Sharing

3.2.1 Introduction

Figure 25 below replicates our stylised industry model but highlights the essential elements of the basic-Risk-Sharing model.

Figure 25: Basic Risk-Sharing scenario



Source: ESMT CA.

As illustrated by Figure 25, in the basic Risk-Sharing scenario insiders settle all contributions prior to the investment and retail competition. By definition, there are no further wholesale payments (on a per unit basis), once firms compete in the retail stage.

This principle may be applied in two ways. First, in a build and share type of basic Risk-Sharing, partners may deploy different geographical areas (possibly subject to side payments) and then grant each other access to the infrastructure. Partners' right of access to one's infrastructure is compensated by the reciprocal

access rights. Practically, the firm that first wins a customer in the retail stage may use the corresponding NGA within the scope of the Risk-Sharing consortium. Second, in the commitment type basic Risk-Sharing, a single or a few insiders will physically deploy NGA whilst others commit financially. For example, such a commitment may simply involve direct investment contributions or specify a certain price and quantity of NGAs to be used in the subsequent retail stage. The relevant economic principle is always the same: insiders settle contributions ex ante and the usage of NGAs (in the retail stage) is not subject to further wholesale transfers.[45]

Below we explain how NGA investments and welfare results change if we consider a varying number of insiders and outsiders. In so doing we suppose that outsiders will have no access to NGAs.

3.2.2 Summary of main findings

As explained above, the main feature of the basic Risk-Sharing model is (by definition) the absence of any wholesale transfers once firms compete for end-customers in the retail stage. Rather, insiders cooperate in deploying different areas or through an ex-ante financial commitment. Because the costs for NGA are then sunk when firms offer NGA to end-customers, product market competition is relatively intense. This effect determines how investment incentives change if the number of insiders and outsiders to a Risk-Sharing consortium change.

As regards investment incentives, it can be shown[46] that more Risk-Sharing insiders increase the total amount of NGA deployment only if there are at least as many outsiders.[47] Noteworthy, this result supposes symmetric, i.e. equally strong insiders and outsiders. If there are, for example, substantially smaller outsiders, more insiders may increase NGA deployment only if the number of insiders is substantially smaller than the number of outsiders. For example, even two partners with substantial market share (e.g. more than 50%) might lead to maximum NGA deployment in regions with a fringe of numerous but small other firms.[48]

The underlying economic logic follows from two effects. First, as we have already encountered and explained in Section 2.3, a Risk-Sharing agreement must involve sufficient incremental market share so as to become effective. Only if sufficient firms commit financially or deploy NGA themselves, will Risk-Sharing

[45] Notice that the basic model of Nitsche and Wiethaus (2009) assumes this form of Risk-Sharing.

[46] The basic Risk-Sharing case (without outsider access) is analytically rather simple and we can therefore derive explicit solutions that warrant a higher degree of generality.

[47] This statement is true for a *given number of outsiders*. Hence, if there are three outsiders and three insiders, an additional insider increases investments. If there are three outsiders and four insiders, an additional insider decreases investments. Notice that this differs from increasing the number of insiders for a *given number of total firms*. That is we do not state whether, for a seven-firm industry, increasing the number of insiders from three to four increases investments. The latter statement would imply that, by increasing the number of insiders, we decrease the number of outsiders at the same time. Depending on more parameters, the mathematical expression for such a statement is more complex but bears little extra information.

[48] It might be worthwhile trying to extend the model even further in this respect, so that one can determine how much market (rather than the number of firms) should be involved in a Risk-Sharing consortium.

induce substantial extra deployment of NGA.[49] Second, however, the basic Risk-Sharing mode leads to intensive product market competition. Therefore, if too many firms get involved and have access to the new technology, the profits from NGA will deteriorate and so will investments.

These considerations have two important implications. First, as for basic Risk-Sharing, a general (regulatory) rule for a Risk-Sharing consortium to involve as many insiders as possible appears unfounded and may actually discourage NGA investments. For example, if a region exhibits two or three strong players and a competitive fringe, then two or three Risk-Sharing partners may well maximise NGA investments. Indeed, second, the optimal size of a Risk-Sharing consortium depends on the region(s) in question. Regions with fewer (strong) players should feature a smaller absolute number of insiders (if the objective is to maximise investments).

Intuitively, consumer surplus is driven by the amount of NGA investments and the intensity of product market competition. Building on our results from above, more insiders may (or may not) increase NGA investments but will certainly stimulate product market competition. It can then be said that more insiders will certainly increase consumer surplus for as long as they increase NGA investments (see results above); indeed, the number of insiders that maximises consumer surplus tends to exceed the number that maximises NGA investments (compare also Figure 53 and Figure 54 in the appendix). That said, it follows again that a general claim for a basic Risk-Sharing agreement to include as many insiders as possible could not be supported: too many insiders may decrease consumer surplus as they discourage investments in NGA.[50]

Next, we consider average insider surplus. We have to look at average insider surplus because, for a given single location, insiders have different roles: one firm may deploy NGA physically whilst others obtain free wholesale access. Of course, the investor is worse-off than the non-investors for this location. However, Risk-Sharing partners will fulfil their part of the deal at another location so that, across all locations, all insiders expect similar profits. Again, our results suggest an interior solution with respect to the optimal number of Risk-Sharing insiders. For example, Figure 55 in the appendix suggests that, in a seven-firm industry, a Risk-Sharing consortium with three insiders leads to higher surplus than both one with two and one with four insiders. The results indicate that investors tend to prefer a smaller number of insiders (i.e. three) than the regulator (i.e. four to maximise consumer surplus).

The results on total surplus mirror our previous observations. For example, in a seven-firm industry total surplus is highest with four insiders (see Figure 56 in the appendix).

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[49] One intuitive way to motivate this rationale is as follows: a firm might have a higher incentive to deploy NGA in a certain area, if it obtains access in two more areas (Risk-Sharing with three partners) rather than in one more area (Risk-Sharing with two partners).

[50] For a seven-firm industry, Figure 54 indicates that four insiders create more consumer surplus than three insiders; but seven insiders create substantially lower consumer surplus than four insiders. Again, these results suppose symmetric market shares. We would expect that if insiders had higher market shares, the consumer surplus maximising number of insiders would be lower.

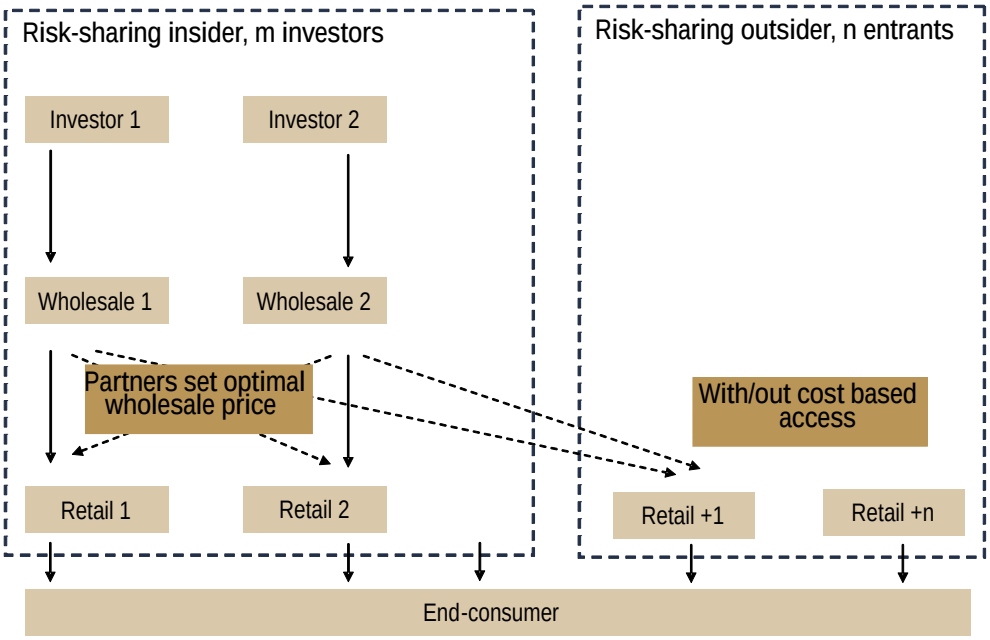
In conclusion the analyses suggest that from both investors' and consumers' perspectives the basic Risk-Sharing agreements should not involve the entire industry. Indeed, our results indicate that basic Risk-Sharing agreements involving about half of the industry (in terms of equally strong players or market shares) tend to benefit investors and consumers alike (albeit investor tend prefer less insider than consumers).

3.3
Some economics of the wholesale Risk-Sharing model

3.3.1 Introduction

Figure 26 below replicates our stylised industry model but highlights the essential elements of the wholesale Risk-Sharing model.

Figure 26: Wholesale Risk-Sharing scenario



Source: ESMT CA.

Figure 26 illustrates that, in contrast to basic Risk-Sharing model, the wholesale model allows Risk-Sharing partners to charge each other wholesale prices for the usage of each others' NGAs'. For example, if firm A may deploys city 1 and firm B deploys city 2, then A and B commercially negotiate the wholesale price that A pays B in order to offer NGA based services in 2 and B pays A in order to offer NGA based services in 1, respectively.

It is indeed important to note that the wholesale price is negotiated among Risk-Sharing partners, taking into account the mutual costs and benefits of higher or lower wholesale prices. As such a negotiated wholesale price may well result in a zero wholesale price where partners acknowledge each others' investment contributions in terms of Risk-Sharing and realise that further wholesale prices were to their mutual disadvantage.[51] In contrast, if insiders were to set their own wholesale prices unilaterally, other wholesale prices might occur.[52]

The negotiated wholesale price only applies to the Risk-Sharing Parties for them having taken the risk of NGA failure. Again, at this stage, we suppose that outsiders have no access to NGAs.

3.3.2 Summary of main findings

As discussed above, if partners set a zero wholesale price, the outcome would resemble the basic Risk-Sharing model. However, Section 2.5 indicated that Risk-Sharing partners might have an incentive to set high internal wholesale prices so as to relax product market competition among each other. Yet that analysis ignored outsiders. This section investigates the optimal wholesale price set by insiders if these face competitive pressure from outsiders.

The optimal wholesale price results from a trade-off between two effects. Indeed, as argued in Section 2.5, there is an incentive to set a high wholesale price so as to relax competition among insiders. However, insiders also have an incentive to reduce the internal wholesale price so as to keep a competitive edge vis à vis outsiders.

As a result of the above explained trade-off, one can show that the optimal wholesale price increases in the number of insiders whereas it decreases in the number of outsiders. In particular, it can also be shown that insiders (optimally) do not charge each other wholesale prices at all for as long as their number does not exceed the number of outsiders by too much.[53] It can be shown, moreover, that the insider/outsider ratio to induce no wholesale transfers corresponds to the insider/outsider ratio up to which more insiders induce more NGA investments in the basic Risk-Sharing model (see Section3.2.).

These findings have some interesting practical implications. First of all, insiders may prefer not to charge each other wholesale prices. According to our model the wholesale price is non-positive as long as there are more outsiders than

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51 In such a case one had simply shown that basic Risk-Sharing is the profit-maximizing model for insiders.

52 That is an agreed wholesale price allows insiders to pay each other by virtue of reciprocal access rather than a per unit monetary transfer. Without such an agreement, each firm would probably have an incentive to set a higher wholesale price.

53 The model suggests the profit-maximising wholesale price is weakly negative if and only if the number of insiders, m, is weakly smaller than the number of outsiders + 1, i.e. n+1. Indeed, algebraically the optimal wholesale price is negative as long as the number of insiders does not exceed the number of outsiders. This suggests insiders had an incentive to subsidise each other so as to create a tough commitment against outsiders. However, we consider such practice infeasible in practice and assume that the wholesale price will not fall below zero.

insiders.[54] Hence, partners (endogenously) choose basic Risk-Sharing; the results and conclusions of the previous section being valid. However, if there are more insiders than outsiders or (possibly) if insiders capture a larger market share than outsiders,[55] then insiders start charging each other positive wholesale prices (the higher, the more insider or the larger their market share). Interestingly, the model reveals that the optimal wholesale price is then set such that NGA investments remain constant in the number of (increasing) insiders.

The effects of an increasing number of insiders on NGA investments in a wholesale Risk-Sharing model can be broadly summarised as follows. More insiders tend to increase NGA investments as long as the number of insiders does not exceed the number of outsiders, the internal wholesale price being zero. If the number of insiders starts to exceed the number of outsiders (or, possibly, insiders' market share exceeds 50%), insiders start to charge each other wholesale prices, relaxing retail competition among insiders and re-enforcing NGA investment incentives. Indeed, beyond the 'critical' number of insiders, the optimal wholesale price ensures that NGA investment levels remain constant if the number of insiders increases further. This is the crucial difference to the basic Risk-Sharing model where, beyond the 'critical' number of insiders, more insiders would reduce NGA investments.

As regards consumer surplus the outcomes for wholesale Risk-Sharing appear similar to those of basic Risk-Sharing: consumer surplus increases up to a number of four insiders (in a seven-firm industry). One difference between the two models is that any wholesale Risk-Sharing model that involves all firms in the industry yields the worst outcome for consumers (and the best for firms) because firms would use the wholesale price as a means to segment regional markets among each other (see also Section 2.5). However, in this extreme form, the result appears of little practical relevance at best.

Again, similar to the case of basic Risk-Sharing, wholesale Risk-Sharing tends to increase up to a number of three insiders (in a seven-firm industry). An additional fourth insider reduces insider surplus. However, a wholesale Risk-Sharing among all firms (seven, here) is most profitable due to the, unrealistic, cartelisation effect of a large wholesale price.

Total surplus increases in the number of insiders up to four (in a seven-firm industry). Due to the practically unrealistic cartelisation effect, total surplus is lowest in a set-up involving the entire industry.

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[54] The exact condition is slightly less restrictive and stated in footnote 53. Notice also, again, that these ratios imply symmetry between insiders and outsiders. If insiders are larger than outsiders, then two or three insiders may already have an incentive to charge each other positive wholesale prices, notwithstanding a fringe of numerous, albeit smaller, outsiders.

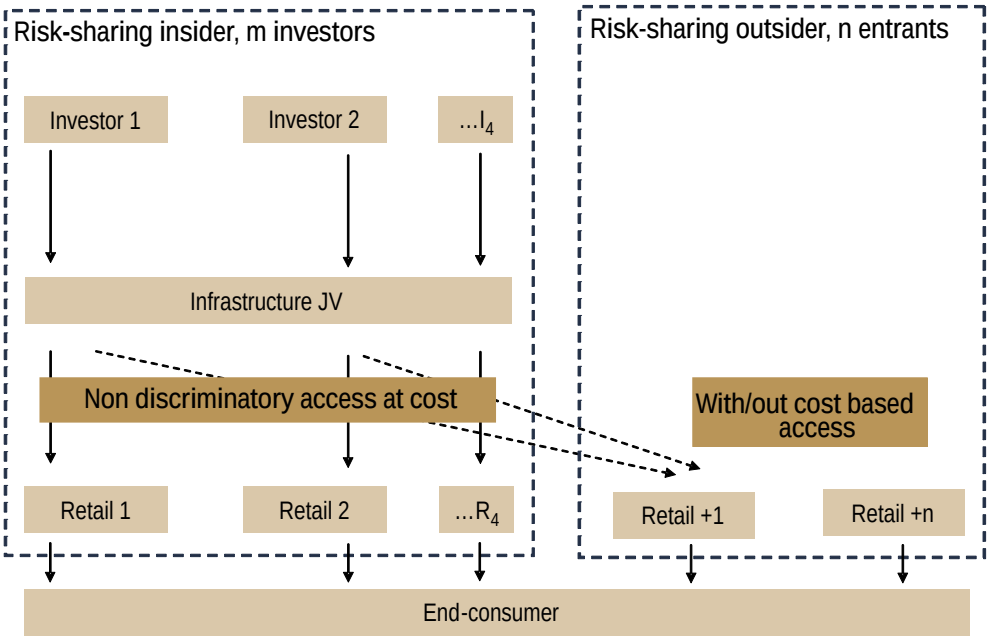
[55] Again, we try to convey the idea rather than the precise mathematical condition (see footnote 53). The statement with respect to market share is an inference; we have not modelled that explicitly.

3.4
Some economics of the JV Risk-Sharing model

3.4.1 Introduction

Figure 27 below replicates our stylised industry model but highlights the essential elements of the JV Risk-Sharing model.

Figure 27: JV Risk-Sharing scenario



Source: ESMT CA.

Essentially the JV model is a special form of a wholesale model, namely one where the internal wholesale price equals unit investment costs. This model can hence be applied if investors deploy different areas and grant each other (wholesale) access according to unit investment costs. Alternatively, investors may form and fund an infrastructure joint venture (JV) that deploys NGA in a certain geographic area. In the subsequent retail stage insiders purchase wholesale NGA from the JV whereby the wholesale price equals unit investment costs. The JV's profits are distributed among insiders.

The cost-based wholesale price only applies to Risk-Sharing insiders for them having taken the risk of NGA failure. We suppose that outsiders have no access to NGAs.

3.4.2 Summary of main findings

In the JV model the economic outcome implies that partners are committed to compensate each at a given (cost-based) wholesale price.[56] In contrast to the previous models, basic and wholesale Risk-Sharing, the current form enforces higher (internal) wholesale prices.[57] As a consequence, changing the number of insiders affects JV Risk-Sharing in a (slightly) different way than the previous modes.

First, our analysis suggests that NGA investments in a JV model are slightly more robust with respect to an increase in the number of insiders than the basic model. For instance, investments still increase in the number of insiders even if the latter already exceed half of the industry.[58] That is, even though internal competition increases and retail profits dissolve, investment incentives remain intact because investments increase wholesale prices, hence marginal retail costs and, in turn, retail prices. Yet, as we report below, the basic and the wholesale model still tend to induce more NGA investments in most insider/outsider configurations.

Second, by the mechanism described above, we have that consumer surplus unambiguously increases in the number of insiders (e.g. from two to seven in a seven-firm industry). As explained above, the main effect arising from more insiders in a JV model is more intense retail competition; there is only a small, if any, effect discouraging investments.

Third, we find that insiders' profits tend to remain more stable even if the number of insiders exceeds 50% of the market. That said insider surplus does evaporate eventually, if the number of insiders increases too much (e.g. up to 100%, see Figure 71 in the appendix).

Finally, driven by increasing consumer surplus, we find that total surplus increases in the number of insiders.

3.5 Comparative assessment of Risk-Sharing models

The previous three subsections considered each of the proposed Risk-Sharing models separately, in particular focusing on the effects arising from a varying number of insiders. As such the analyses provided some guidance on how to design a given model of Risk-Sharing. The question of what model is best in the first place has not yet been addressed.

This section moves on to compare Risk-Sharing models among each other. In so doing we consider a seven-firm industry and the same given number of insiders

[56] A cost-based wholesale price is of course not entirely 'given' but depends on firms' penetration strategies: a more aggressive penetration reduces the unit wholesale price.

[57] With respect to the wholesale model, this can be said at least for as long as insiders are not in the majority (or have the highest market share).

[58] NGA investment incentives may be reduced eventually, if the number of insiders increases from four to seven. See Figure 54 in the appendix).

and outsiders for each model.[59] In addition we also report the counterfactual outcome of a LRIC regime in a seven firm industry. The tables below summarise the findings in form of a ranking of i) NGA investment incentives, ii) consumer surplus, iii) insider surplus and iv) total surplus.

Table 6 below reports the NGA investment ranking of different Risk-Sharing modes and the LRIC counterfactual (vertical dimension) for a given number of two to seven insiders (horizontal dimension).

Table 6: Ranking of NGA investments for different Risk-Sharing models and the LRIC counterfactual, two to seven insiders

	Seven firms, two insider (72)	Seven firms, three insider (73)	Seven firms, four insider (74)	Seven firms, seven insider (77)
Basic RS no outsider access	1	1	1	3
Wholesale RS no outsider access	1	1	1	1
JV RS no outsider access	3	3	3	2
LRIC counterfactual	4	4	4	4

Source: ESMT CA model, compressed view, consult graphs for details.

According to Table 6 the basic and the wholesale Risk-Sharing model induce most NGA investments if the number of insiders does not exceed four. Indeed, Figure 73 to Figure 75 in the appendix show that basic and wholesale Risk-Sharing lead to exactly the same investment levels. This is not surprising, as we have seen that Risk-Sharing partners set a zero wholesale price if the number of insiders is not too large relative to the number of outsiders; that is the wholesale model resembles the basic model. The JV Risk-Sharing model induces lower investments than the aforementioned models. In the JV model, an additional € spent on NGA, increases insiders' marginal costs in the retail stage. This positions insiders comparatively (to zero internal wholesale prices) weaker vis à vis outsiders and hence insiders reduce investments (compared to the basic and wholesale model). Of course this logic only holds if there are enough outsiders to impose a severe competitive constraint on insiders. In contrast, if there are no outsiders (e.g.

[59] This shall assure we are comparing like for like. However, different models could generally also be tight to given and differing numbers of insiders.

seven insiders), the JV model induces more investments than the basic model.[60] All models, in all configurations yield more NGA investments than LRIC.

Drawing also on results from the previous sections, in summary, we find that basic and wholesale Risk-Sharing models, involving about 50% of the industry,[61] create most investments in NGA.

Table 7 below compares the levels of consumer surplus.

Table 7: Ranking of consumer surplus for different Risk-Sharing models and the LRIC counterfactual, two to seven insiders

	Seven firms, two insider (72)	Seven firms, three insider (73)	Seven firms, four insider (74)	Seven firms, seven insider (77)
Basic RS no outsider access	1	1	1	2
Wholesale RS no outsider access	1	1	1	4
JV RS no outsider access	3	3	3	1
LRIC counterfactual	4	4	4	3

Source: ESMT CA model, compressed view, consult graphs for details.

If the number of Risk-Sharing insiders does not exceed four, the consumer surplus ranking mirrors the ranking on NGA investments. In particular, inducing most NGA investments and keeping retail competition intense, basic and wholesale Risk-Sharing induce highest consumer surplus. With both lower NGA investments and less intensive retail competition, the JV Risk-Sharing model ranks third. The LRIC counterfactual ranks fourth. Things change slightly if insiders exceed 50% of the industry. For example, if all firms take part in Risk-Sharing, then the JV model restores investment incentives relative to the basic model and, consequently, yields a larger consumer surplus. Again, covering 100% of the market, the wholesale model implies monopolization and results in the worst outcome for consumers. This exception aside, however, all forms of Risk-Sharing make consumers better off than LRIC.

[60] With no outsiders the wholesale model induces even more investments than the JV model. As we explained earlier, this result relies on the rather unrealistic implication that partners use the wholesale price to create e.g. local monopolies.

[61] his has been tested in terms of the number of symmetric insiders. We suspect that the qualitative result would by and large carry over to market share in general (e.g. in terms of fewer insiders, yet capturing up to about 50% of the market).

Drawing also on results from the previous sections, in summary, we find that basic and wholesale Risk-Sharing models, involving about 50% of the industry,[62] create the largest consumer surplus.

Table 8 below regards average insider surplus.

Table 8: Ranking of average insider surplus for different Risk-Sharing models and the LRIC counterfactual, two to seven insiders

	Seven firms, two insider (72)	Seven firms, three insider (73)	Seven firms, four insider (74)	Seven firms, seven insider (77)
Basic RS no outsider access	1	1	1	3
Wholesale RS no outsider access	1	1	1	1
JV RS no outsider access	2	2	2	2
LRIC counterfactual	3	3	3	4

Source: ESMT CA model, compressed view, consult graphs for details.

Table 8 reveals that the basic and wholesale Risk-Sharing model lead to the highest expected surplus for Risk-Sharing insiders. Again, the basic and the wholesale model are in fact equal if they involve up to a good 50% of the market (four firms in our seven-firm model) because the profit-maximising wholesale price in the wholesale model is zero and hence resembles the basic model. Only if the number of insiders exceeds this critical level, the basic and the wholesale model depart from each other. In the wholesale model insiders can countervail too intensive (internal) competition by means of higher wholesale prices, thereby restoring investment incentives and keeping profits stable. The JV Risk-Sharing model ranks after the two aforementioned models. All models improve investors' surplus relative to the LRIC counterfactual.

Again, combining the different strands of our analyses, we find that basic and wholesale Risk-Sharing models, involving about 50% of the industry,[63] lead to the largest insider surplus.

Table 9 below displays the ranking with respect to total surplus.

[62] This has been tested in terms of the number of symmetric insiders. We suspect that the qualitative result would by and large carry over to market share in general (e.g. in terms of fewer insiders, yet capturing up to about 50% of the market).

[63] This has been tested in terms of the number of symmetric insiders. We suspect that the qualitative result would by and large carry over to market share in general (e.g. in terms of fewer insiders, yet capturing up to about 50% of the market).

Table 9: Ranking of total surplus for different Risk-Sharing models and the LRIC counterfactual, two to seven insiders

	Seven firms, two insider (72)	Seven firms, three insider (73)	Seven firms, four insider (74)	Seven firms, seven insider (77)
Basic RS no outsider access	3	1	1	2
Wholesale RS no outsider access	3	1	1	4
JV RS no outsider access	2	3	3	1
LRIC counterfactual	1	4	4	3

Source: ESMT CA model, compressed view, consult graphs for details.

As regards total surplus the ranking of Risk-Sharing regimes is more sensitive to its specification. If Risk-Sharing involves about 50% of the market (e.g. three to four firms in our example), then the basic and (implicitly equal) wholesale model lead to largest total surplus, followed by JV Risk-Sharing and the LRIC case, respectively. This result is driven by the large investments, a good deal for consumers and high insider surplus. In contrast, if a Risk-Sharing regime only involves a minority of the industry (e.g. two firms in our seven-firm example), LRIC might create largest total surplus. To understand this, recall that LRIC is a comparatively good regime for non-investors. With only few Risk-Sharing insiders, low surplus of outsiders weighs high, driving down the total surplus results under Risk-Sharing. Of the latter, the JV model performs better than the basic and the wholesale models, because the JV model induces insiders to compete less aggressively vis à vis outsiders (and internally). On the other hand, if Risk-Sharing covers for example all players (seven firms in our case), then the JV model turns out best, followed by the basic Risk-Sharing model and the LRIC counterfactual, respectively. The wholesale model is again worst, because of the monopolisation effect explained earlier. JV Risk-Sharing involving all players performs well because i) none firm finds itself in a less-profitable outsider position and ii) the JV mechanism of allocating investment costs to firms marginal costs in the retail stage, still ensures decent investment in NGA and hence consumer surplus.

Synthesising our results on total surplus, it appears that a JV Risk-Sharing model involving the entire industry creates highest total surplus, followed by basic and wholesale Risk-Sharing involving about 50% of the industry.

3.6 Outsider access

Our analyses above have supposed that outsiders had no access to NGA. Still, all modes of Risk-Sharing—basic, wholesale and JV—tend to induce more NGA investments and more consumer surplus than the LRIC counterfactual. This means, consumers and regulators should prefer Risk-Sharing without outsider access at least over the LRIC counterfactual. However, the question remains under what conditions outsider access may benefit consumers. This question has various important dimensions. For example, should insiders be allowed to agree on the access condition for outsiders? Or should insiders refrain from any explicit agreement with respect to outsider access, leaving access conditions to wholesale competition? Finally, under what conditions, if any, should regulators enforce outsider access? However, an explicit extension of our model is not subject of this study.[64]

That said one can derive a few important insights without analysing the formal model. These considerations are based on two propositions:

- **Risk-Sharing participation must be incentive compatible.** By this we mean that a firm's expected surplus from not participating must not be higher than a firm's expected surplus from participating in a Risk-Sharing agreement. If firms would be systematically better-off by staying out, then no Risk-Sharing agreements would come along. Likely, firms might then find themselves in the LRIC counterfactual, which has been shown to induce less investment and lower consumer surplus than Risk-Sharing.
- **Risk-Sharing with outsider access should not harm consumers.** Outsider access should not be a means to its own end but benefit consumers. We therefore propose that access conditions should ensure that consumers are better off with outsider access than without such access.

Below we discuss a few implications of these requirements.

3.6.1 Incentive compatibility

First, we consider whether equal access could be incentive compatible. Under equal access outsiders obtain NGA wholesale access subject to the same conditions that are valid for insiders. As regards basic, wholesale and JV Risk-Sharing, equal access means that outsiders obtain access for free, at the internal wholesale price and at unit investment costs, respectively. However, equal access is clearly not incentive compatible. If, after the investment stage, non risk-taking non-investors and risk-taking investors obtain equal access rights then non-investors' expected profits exceed investors' expected profits by the possible loss of investment costs in the case of NGA failure. Firms prefer the non-investor role and Risk-Sharing agreements will hardly emerge.

[64] Indeed such an extension increases the complexity of the formal model substantially and computational power has thus far been insufficient to compute the corresponding second-stage Nash equilibrium.

We have established that equal access conditions are not incentive compatible. This means that non-investing outsiders should have somewhat higher wholesale prices than insiders. For the JV model, outsiders must hence pay a wholesale price above unit investment costs. However, for the basic and the wholesale Risk-Sharing model, a claim for a higher outsider access price is not very powerful as these models tend to have zero access prices in the firs place.

In a second step, we therefore ask whether an outsider access price equal to unit investment costs might be incentive compatible. For the JV Risk-Sharing model it is easy to see that a cost-based outsider access price is not incentive compatible. Indeed, for this case, cost-based access implied equal access which we have argued is not incentive compatible. Hence, outsiders must have a higher than cost-based access price in the JV model.

For the basic and the wholesale model things are more complex. First of all it can still be said that a cost based access price advantages outsiders because they cover investment costs if and only if NGA is successful. The risk of failure is still borne by insiders. However, insiders might have a strategic advantage vis à vis outsiders, depending on wholesale revenues are distributed among them.

Consider first a situation in which insiders do not distribute wholesale revenues among each other. For example, the investor 1 in city A keeps its wholesale revenues in city A and investor 2 keeps its wholesale revenues in city B and so forth. Insiders' obtain NGA wholesale access at zero (marginal) costs and those insiders who have not invested in a particular city (e.g. 1 in city B) also have no opportunity cost of using NGA in that particular city.[65] This means insiders are (on average) committed to compete more aggressively than outsiders and are likely to grasp a higher market share. Without further analysis it can hence not be said whether a cost-based outsider access price would be incentive compatible or not.

Second, consider a situation where insiders re-distribute wholesale revenues among each other. For example, notwithstanding there are only wholesale revenues in A, these will be shared between investor 1 (of A) and 2 (of B). With such a re-distribution mechanism in place, investors commonly internalise the opportunity cost of using NGA rather than to wholesale them. This means insiders loose their strategic advantage over outsiders and do not systematically grasp higher market shares than outsiders. Accordingly insiders are just left with the disadvantage of bearing investment costs if NGA is not successful. Hence, again cost-based access regulation would not be incentive compatible.

As a final step, we consider wholesale competition among insiders. Generally, all our Risk-Sharing models can be combined with wholesale competition. In the basic model, insiders deploy NGA jointly, do not charge each other internal

[65] In fact, with cost based outsider access, the marginal cost of the regional investor is not zero because the outsider wholesale price constitutes an opportunity cost for the regional investor. However, all other insiders obtain truly costless access in that region and benefit from lower marginal costs. With the regional investor being a regional non-investor in another region, on average, insiders have lower marginal costs than outsiders and hence a strategic advantage in the retail stage.

wholesale prices, but have the right to use NGA both in the wholesale market and in the retail market on a first come first serve basis. In the wholesale model insiders may charge each other internal wholesale prices and then have the right to both wholesale and retail NGA. Finally, in a JV model insiders would purchase NGA form the JV on the basis of unit investment costs and then be allowed to either wholesale or retail the NGA.

3.6.2 Outsider access should not harm consumers

There is also a special rule for the wholesale model of Risk-Sharing. To that end we argue that the outsider access price should not be tied to insiders' wholesale prices. For example, regulators should not impose any rules according to which the external wholesale price should equal the internal wholesale price nor the internal wholesale price plus a given percentage or amount. With such a tie, insiders had an incentive to increase (internal) wholesale prices to the detriment of consumers.[66] Therefore, outsiders' wholesale prices (if any) should not be referenced to insiders' wholesale prices. For example, unit investments costs plus x, appear as a better, less distorting, base.

In any event the result that there should be no undifferentiated non-margin squeeze obligation also holds in this environment (see Section 2.4).

3.7 Asymmetric Risk-Sharing

The modelling results reported thus far presumed symmetric firms and symmetric Risk-Sharing. Specifically, each insider had the same market share and takes the same risk with respect to up-front contributions, may it be in terms of a proportionate share, 1/(m = number of insiders), of physical deployment or by means of a proportionate up-front payment or commitment, again 1/m. However, in practice many Risk-Sharing regimes will be asymmetric. One motivation for asymmetric Risk-Sharing is an expected asymmetric market structure for NGA based services. Small entrants with a small customer base, for example, will unlikely be prepared to take the same risk as an incumbent with an expected higher market share for NGA based services (see also Section 2.3.). Unfortunately, asymmetries render the underlying mathematical model largely intractable.[67] This section offers a brief qualitative assessment of the main possible changes arising from asymmetries.

We first discuss two forms of asymmetries separately. Acknowledging that, in practice, combinations thereof are possible we then provide an example with combined asymmetries.

[66] From a formal point of view, if there were no outside options based on the legacy network, insiders would simply re-install the foreclosing wholesale price.

[67] In particular, the reference scenarios of LRIC and FDC cause problems.

- First, we consider asymmetric firms (e.g. in terms of market share) but who commit fully in proportion to their market share.
- Second, we will discuss the possibility of symmetric firms who, e.g. due to different attitudes towards risk, commit asymmetrically.
- Third, we provide an example of combined asymmetries in terms of market share and commitment.

3.7.1 Asymmetric firms but full commitment

We have already encountered the effect of firm size asymmetries in Section 2.3. We derived that Risk-Sharing with a smaller firm tends to induce comparably lower additional NGA investments and consumer surplus because a lower risk increment taken by another firm means that Risk-Sharing becomes less relevant for an investor as compared to a high risk increment taken by another firm. We would expect that this qualitative result carries over to the case with multiple insiders and outsiders. Consider the case of a large incumbent (say 40% market share), two relatively large competitors (say 20% market share, each) and a fringe of small firms (10% together). If previous market shares are a good predictor for NGA based market shares, then Risk-Sharing among the incumbent and one large competitor tends to induce more NGA investments as compared to Risk-Sharing between the incumbent and one of the fringe operators. In the extreme, if a Risk-Sharing partner takes only marginal (e.g. almost zero) risk, Risk-Sharing will hardly generate additional investments, or may even lower investments, depending on the benchmark scenario.

At the same time, the results in this section also showed that, if a consortium involves more than about half of symmetric firms in the industry, further insiders tend to reduce investments. Again, this result can be used to infer the effect of additional (asymmetric) insider increments to Risk-Sharing agreements. As argued above, we would expect that more market share increases NGA investments in Risk-Sharing consortia up to a certain degree, but will discourage investments eventually.

While we believe that 50% of market share remains to be a workable rough indication as for the critical amount of market share, the critical level may also be sensitive to market share distributions or, more precisely, the concentration within the group of insiders and outsiders (e.g. insider and outsider HHI). Again, this follows from the underlying logic driving our results, where, on the one hand, more insiders and more risk spread encourages NGA investments and, on the other hand, more insiders also increase internal competition and hence discourage investments. The latter discouraging effect, for example, becomes weaker if a given market share of insiders becomes more concentrated (e.g. insiders have 50% of the entire market but insider HHI increases). Hence, we

would expect that the critical number or market share of insiders tends to increase if insiders are concentrated relative to outsiders. This seems to be of rather strong practical relevance as Risk-Sharing consortia may naturally tend to involve the two to four strongest players, facing a rather fragmented group of outsiders.

3.7.2 Symmetric firms but different commitment

Asymmetric Risk-Sharing may also occur if symmetric firms agree to share the risk asymmetrically. Consider, for example, two symmetric firms could expect symmetric market shares for NGA based products, say 10,000 customers each. Yet, firm 2 is more adverse to risk than firm 1. In such a situation firm 2 could commit to 5,000 rather than 10,000 NGAs. Should firm 2 require more NGAs later on, it could be treated as an outsider for the amount of NGAs on top of its committed share. Access to these additional NGAs would then depend upon the common outsider access conditions. Of course, this is just one example and there multiple permutations, reflecting different degrees of asymmetric Risk-Sharing.

Again, the possible outcomes of such intermediate forms of Risk-Sharing can be assessed in terms of intermediate outcomes between the 'pure' results in this report. For example,

- with outsider access under LRIC, asymmetric Risk-Sharing lies in between the pure cases of symmetric Risk-Sharing (i.e. when both firms share the risk equally), as discussed in this report, and LRIC (i.e. when one firm takes the entire risk) as discussed in this report;
- with outsider access at cost plus a Risk Premium, asymmetric Risk-Sharing may lie in between the pure cases of symmetric Risk-Sharing, as discussed in this report, and the Risk-Premium regime (i.e. when one firm takes the entire risk);
- without outsider access, asymmetric Risk-Sharing lies in between the pure cases of symmetric Risk-Sharing (i.e. when both firms share the risk equally), as discussed in this report, and Regulatory Holiday (i.e. when one firm takes the entire risk), again as covered by this report.

It follows that qualitative advantages and disadvantages of intermediate forms of Risk-Sharing can be discussed in terms of the corresponding advantages and disadvantages of the underlying pure regimes. One implication of this is that the positive results (in terms of e.g. consumer surplus) that we derive for the case of Risk-Sharing, extend to these intermediate case, albeit to a lesser extent.

3.7.3 Asymmetric firms and asymmetric commitment: an example

In a final step, we combine elements of both cases discussed above by means of a simple example and some varying constitutional settings. Suppose an industry with current (and expected market shares) of 40%, 20%, 20%, 10% and 10%. The counterfactual involves NGA deployment by the 40% operator and LRIC access conditions for all other competitors. Against this counterfactual we discuss several forms of Risk-Sharing.

- 1) **LRIC counterfactual**: as explained LRIC regulation will impose the entire risk on the investing 40% operator. Having to share the gains but bearing the risk of failure alone, the investor will only deploy NGA to a small extent and consumer surplus is comparably low.
- 2) **Risk-Sharing between the 40% operator and a 20% competitor** who contributes 33% (its insider share) of total investment costs with a share of **100% up-front**, outsider access under LRIC: compared to the LRIC counterfactual defined above, first, Risk-Sharing stimulates investments. Second, the up-front payment intensifies competition, which countervails investment incentives somewhat. Third, because outsiders have to pay wholesale prices at the retail stage whilst insiders don't, more investments improve insiders' competitive position vis à vis, which stimulates investments. As an overall effect, we would expect investments and consumer surplus to increase relative to the LRIC counterfactual.
- 3) **Risk-Sharing between the 40% operator and a 20% competitor** who contributes 33% (its insider share) of total investment costs with a share of **50% up-front** and pays a reduced wholesale price, outsider access under LRIC: with some of the up-front contribution being migrated into wholesale prices, this regime should lead to an intermediate outcome of the two aforementioned ones. In particular, Risk-Sharing still stimulates investments (though to a lesser extent than scenario 2, because the up-front contribution is only half as big). Second, the up-font payment still stimulates competition (again to a lesser extent), which countervails the incentive to invest. Third, after investments are sunk, insiders are in a better competitive position than outsiders which stimulates investment incentives (to a lesser extent than under scenario 2). Overall, we would therefore expect this scenario to lie in between the two aforementioned ones in terms of investments and consumer surplus. Indeed, we would expect that investments and consumer surplus, for the given set-up (i.e. 40% plus 20%), increases in the share of the up-front contribution.
- 4) Scenarios 2) and 3) but **no outsider access**: in scenarios 2) and 3) we assumed outsider access under LRIC. Without outsider access the competitive position of insiders vis à vis outsiders improves if NGA is a success (that is in expected terms). This stimulates investments further; in both scenarios 2) and

- 3), we would expect NGA investment levels to increase. This effect also increases expected consumer surplus. However, as outsiders become a weaker competitor, there is also a countervailing effect on consumer surplus. It is not clear, a priori, which effect dominates and so is the overall effect on consumer surplus.
- 5) Scenarios 2) and 3) **but outsider access under LRIC plus a Risk Premium**: in scenarios 2) and 3) we assumed outsider access under LRIC. A Risk Premium for outsiders will stimulate investments, albeit to a lesser extent than under scenario 4) with no outsider access at all. As regards consumer surplus, we have again two countervailing effects: on the one hand a Risk-Premium tends to increase consumer surplus due to the additional investments created; on the other hand, the premium tends to lower consumer surplus as it makes outsiders a weaker competitor. Yet, based on the results we derive for the Risk-Premium scenario in 0, we would expect (non-excessive) risk-premia to increase consumer surplus in comparison to scenarios 3) and 4). Alongside, a Risk-Premium is likely necessary in order to render participation in Risk-Sharing incentive compatible: the expected outsider profits must not be higher than expected insider profits.

4. Conclusion: Economic principles and policy implications

Below we review our overall view as it is set out in the executive summary. The conclusions are derived from the formal analyses and most often reflect direct formal results. However, in order to present the conclusions in a non-technical and applicable way, formal results are simplified and complemented by our best understanding of the topic and its underlying economic principles.

4.1 Main economic principles

Our analysis reveals a number of relevant economic mechanisms that can inform management as well as policy makers.

As expected by jointly analyzing investment incentives and competition in the post-investment stage, we identify what may be called the **"profit effect"**: seen in isolation, higher prices in the product market increase the return on NGA investment, investments and investors' profits. However, our model set-up goes one step further and analyses the impact on consumers, which are interested in both NGA investments and low prices. Thus, we can analyse the positive "profit effect" but also account for the negative "**price effect.**" Our analysis clearly

shows that neither a pure focus on investment (like under Regulatory Holiday) nor a pure focus on allocative efficiency (LRIC) are optimal when risky investments are at stake. Profits need to be reasonable but not excessive.

This may already be considered as an important message for policy makers and management. Yet, our analysis reveals a number of additional effects, which show that reducing the question to a simple "trade-off" between investment and prices is short sighted. Institutional details matter as certain regulatory regimes can tackle the central investment problem more efficiently than merely incentivizing investors by "high prices." Indeed, regulators can directly address the uncertainty by improving the situation of investors in the failure state (if NGA turns out not to be a market success). This may be called the **"risk effect."** Spreading the risk benefits both investors and consumers. The FDC scenario often performs surprisingly well because it insures investors in the failure state: *all* market participants are forced to contribute to investment costs. This can be achieved by various means: either by forcing all consumers (and hence non-investors) to move from copper to NGA swiftly or by explicitly allowing investors to recoup investments through other channels than the most efficient technology (e.g. by a surcharge on copper).[68]

Related but slightly different is the **"free-rider effect."** LRIC is particularly ill suited when risky but important investments are at stake. In the success case, outsiders get access at cost whereas in the failure case outsiders are protected from any loss; they free-ride on the risk taken by the investor. This free-ride lowers the investor's profit in the success state and renders market participants better-off by non-investing. A Risk-Premium addresses this problem by limiting the free-ride in the success state. As a stand-alone measure, however, it does not perform as well as other measures given that it does not address the risk as such.

Finally, there is a **"participation effect."** Outcomes of various regulatory regimes vary depending on the number and the market share of those investing and (potentially) sharing the risks. Risk-Sharing regimes do well as they spread the risk and facilitate intensive product market competition if the investment costs are not added to the (marginal) access costs (in the subsequent wholesale stage). In situations where product market competition is expected to be intense (due to many market participants) Risk-Sharing partners should start cushioning product market competition by setting positive (internal) access charges.

Although some conflicts of interest remain, our analysis reveals a (potentially surprising) broad range of common interests of investors and regulators. Once it is accepted that neither Regulatory Holiday nor a (traditional) LRIC approach appears most efficient, investors and regulators should be interested in scenarios that (1) spread the risk and (2) balance prices and profits to ensure investment and (3) eliminate the free-rider problem. There are still differences in detail

[68] Notice that we do not advocate higher access prices for the cooper network before investments take place. Indeed, ex ante inflated prices for copper would reduce incentives to invest in fibre rather than to stimulate them.

(regulators may prefer lower prices and more Risk-Sharing insiders than investors) but the alignment of interests appears easier than traditional thinking, being either purely focused on allocative efficiency (LRIC) or on the profit effect (Regulatory Holiday), would suggest.

Indeed, taken together our analysis hints towards an optimal policy mix that involves several elements:

- Risk-Sharing can be helpful to involve several market participants and to spread the risk of investment. The appropriate internal access price should be set according to the expected number of insiders and outsiders.
- To make Risk-Sharing attractive and to eliminate the free-rider problem, investors should be protected by a Risk-Premium.
- In order to make such a Risk-Premium effective and derive beneficial effects for investors and consumers alike, it requires a more sophisticated margin-squeeze regulation. In particular, there should be no non-margin-squeeze requirement if NGA turns out to be no success.
- While the FDC regime may often be an attractive alternative to Risk-Sharing, it may also be seen as a complement. One crucial learning point from our analysis is that FDC performs well as it reduces the risk for the investor. This feature can also be utilised by means of a skilful management of the transition process. For example, as long as copper and fibre based infrastructure exist in parallel, Risk-Sharing insiders may use NGA exclusively or grant access to outsiders at a premium. However, a swift network migration may introduce a fibre-only world soon after and lay the ground for a de facto FDC regime.

These overall policy conclusions lend support to the steps initiated by the broadband action plan, initiated by the German Government. As the following more detailed discussion of the results show, our analysis can provide helpful and interesting insights as to the appropriate implementation of the general approach outlined above.

4.2 Policy implications for investors

- **Regulatory Holiday would be the first best option:** The analytical results confirm that a Regulatory Holiday would lead to the best outcome for investors. However, this option jars with consumers' interests and does not seem to be feasible in Europe.

- **Investors should try to avoid LRIC and opt for alternatives Risk-Sharing or Fully-Distributed-Costs (FDC):** If investments are risky, LRIC implies that non-investors can free-ride on investors' risk-taking. Investors are better-off if the risk is spread across all potential beneficiaries through regimes involving Risk-Sharing or Fully-Distributed-Costs. Risk-Premium regulation is still better than LRIC but generally less profitable than Risk-Sharing and Fully-Distributed-Costs.

- **Risk-Sharing is consistently better than LRIC[69] and appears like a first best alternative for investors**

  - The analytical results suggest that Risk-Sharing consortia involving just less than 50% of the industry are most profitable for Risk-Sharing insiders. In such a setting insiders should not charge each other internal wholesale prices after the investment stage so as to maintain a competitive edge vis à vis outsiders. This is consistent with basic Risk-Sharing forms such as 'build and share' or commitment models. If a Risk-Sharing consortium is deemed to involve more than 50% of the industry, insiders should charge each other wholesale prices whereby the internal wholesale price should increase, the more firms enter the consortium. The aim is to set the internal wholesale price so as to relax retail competition somewhat and, as consequence, to restore NGA investment incentives.

  - Cost-based internal access prices are never profit-maximising. As just explained, often it is best not to charge each other any wholesale price at all. If large Risk-Sharing consortia require wholesale price payments (e.g. because they become large), insiders can find better (e.g. more profitable) wholesale prices. This means that a JV type of Risk-Sharing (where insiders obtain wholesale NGA at costs) is never optimal from investors' perspectives.

  - Some investment rules can be summarised as follows. First, if a Risk-Sharing consortium becomes larger, NGA investments should increase provided the consortium involves still less than about 50% of the market. The dominating effect of additional (or larger) partners is then to spread the risk more broadly. Second, if a Risk-Sharing consortium exceeds 50% of the market and internal wholesale charges are not feasible, then NGA investments should decrease the more the consortium increases. The dominating effect of additional (or larger) partners is then intensified retail competition, making an appropriate return on investment less likely. Third, if a Risk-Sharing consortium exceeds 50% of the market and internal wholesale charges are feasible, NGA investments should not decrease substantially but insiders should countervail intensive retail competition by means of higher internal wholesale prices.

[69] An exception may occur if the incremental investment participation under Risk-Sharing is very small. Naturally, the incremental investment participation can be small, if incremental co-investors expect a small market share of NGA based retail products.

  - Investors should consider avoiding Risk-Sharing consortia in favour of a FDC regime if i) the incremental investment participation under Risk-Sharing is small, or ii) product market competition is expected to be very intense.
  - Risk-Sharing insiders' surplus is higher without outsider access than with equal or non-risk-adjusted cost-based outsider access. This means insiders are better off if they can either avoid outsider access or enforce at least higher than cost-based outsider access (for arguments see policy implications for regulators).

- **Fully-Distributed-Cost (FDC) is unambiguously better than LRIC and is another first best alternative for investors (if feasible)**
  - FDC spreads investments across all industry participants, regardless of NGA success. As such it avoids the possibility that non-investors free-ride on investors' risk-taking. It allows substantial investments in NGA, even if product market competition is intense, because wholesale prices will always recoup investment costs.
  - FDC is a viable alternative to Risk-Sharing if i) the incremental investment participation under Risk-Sharing is small, or ii) product market competition is expected to be very intense.

- **Risk-Premium is certainly better than LRIC but in most instances of risky investments less profitable than Risk-Sharing or FDC.**
  - This results because a Risk-Premium regime only becomes effective if the probability of NGA success is already high whilst Risk-Sharing and FDC regimes remedy the very problem of investing in NGA: uncertainty.
  - However, Risk-Premium regimes can be combined with other regimes. For example, combining a Risk-Premium with Risk-Sharing may be required to provide adequate incentives to participate in Risk-Sharing.

- **For any given regime[70] non-margin squeeze obligations hurt investors' expected surplus.**
  - This results because, if NGA turns out not to be successful, investors may be forced to set higher than optimal (competitive) retail prices. Consequently, investors cannot fully exploit NGA and lose market share.
  - As this would also harm consumers, we believe that there are good arguments for NGA failure cases to be excluded from non-margin squeeze obligations. In our opinion a clear distinction between (possibly anti-competitive) margin-squeeze issues in an NGA success case and pro-competitive margin-squeeze situations in the failure case, is key to such arguments (see implications for regulators). To that end investors may voluntarily want to promote transparency about whether NGA is a success or failure vis à vis regulators.

[70] If applicable; of course under Regulatory Holiday and a Risk-Sharing regime without outsider access a non-margin squeeze obligation is meaningless.

4.3 Policy implications for regulators

We suppose that the regulator aims at maximising consumer surplus.

- **No Regulatory Holiday:** notwithstanding large investments in NGA, Regulatory Holiday likely induces an asymmetric market structure, reduces competition and makes consumers worse off than under the LRIC counterfactual.
- **But options better than LRIC are available:** LRIC involves free-riding effects for non-investors and distorts investments. In the context of risky investments consumers benefit from regimes Risk-Sharing, Fully-Distributed Costs and, to a lesser extent, Risk-Premium.
- **Risk-Sharing may function as a first-best regime for consumers**
  - Risk-Sharing removes free-rider effects and restores investment incentives. At the same time Risk-Sharing may often keep retail competition rather intense if high (internal and external) wholesale prices can be avoided. That is, Risk-Sharing promotes NGA penetration. Our results suggest that Risk-Sharing is robustly better than LRIC, provided that investments are risky. We discuss possible optimisation rules below.
  - As a rule of thumb Risk-Sharing agreements should optimally involve just above 50% of the market.[71] Substantially less involvement means that there is too little competition among insiders, eventually mimicking Regulatory Holiday. In contrast, too much involvement may render competition among insiders too intensive and discourage investments. From an insider's perspective, Risk-Sharing agreements are profit-maximising, involving just below 50% of the market. This means that regulators' and investors' incentives are broadly aligned.
  - If Risk-Sharing agreements are optimal in size (e.g. involving just above 50% of the market), there should be no concern that insiders increase internal access prices as a means to relax internal competition. Commercially negotiated internal access prices remain low (often zero), provided there is enough competitive pressure from outsiders.
  - If Risk-Sharing consortia involve a very large share of the industry (e.g. towards 100%), internal access prices should be based on costs (e.g. JV model). On the one hand, no (zero) internal wholesale prices would discourage investments due to intense internal competition. On the other hand, if left to Risk-Sharing partners, wholesale prices might be set too high so as to relax retail competition by too much.
  - Access conditions for outsiders, if any, must be determined with caution. As a primer principle, the expected surplus as an outsider must not be higher than the expected surplus as an insider (incentive compatibility).

[71] We show this by means of the number of symmetric firms being involved in a Risk-Sharing consortium. We believe that results with respect to market share would remain robust in the context of asymmetric firms.

Otherwise firms have little incentive to participate in Risk-Sharing; potential investors find themselves back in the default, e.g. LRIC, mode and consumers are worse off. In particular, incentive compatibility rules out (ex-post) access equality because this would render non-participation systematically more profitable than sharing part of the risk. Further, wholesale prices for outsiders should not be determined with reference to wholesale prices that insiders might charge each other. With such a link insiders may be incentivised to increase their internal wholesale price to the ultimate detriment of consumers. Therefore, wholesale prices for outsiders should be referenced to something else, e.g. unit investments cost plus a Risk-Premium.

- If a Risk-Sharing consortium is deemed to grant access to outsiders, margin-squeeze issues may arise. Our general advice (see below) then applies: Risk-Sharing insiders should be assured (retail) pricing flexibility if NGA is not successful. Specifically, Risk-Sharing insiders should be allowed to retail NGA at a price below a risk-adjusted cost-based wholesale price to outsiders. Otherwise, a non-margin squeeze obligation would distort insiders' investment incentives and, in addition, directly harm consumers due relatively high retail prices in the failure case. Of course, non-margin squeeze obligations should remain valid if NGA is a success.

- **Fully-Distributed-Costs (FDC) regulation is another first best solution for consumers**

  - FDC functions as an insurance for the investor: if NGA fails, the investor can still distribute investment costs through wholesale prices. This stimulates investments in NGA and consequently benefits consumers; notwithstanding, full cost distribution relaxes retail competition somewhat. Noteworthy a FDC regime facilitates equal access conditions.

  - In the base case with two firms, Risk-Sharing tends to achieve higher consumer surplus than FDC. However, our extensions suggest that FDC may be a particularly good alternative if i) Risk-Sharing would have to involve many firms, ii) retail competition is very intense and iii) a Risk-Sharing consortium would only involve little more market share relative to a sole investor.

  - As we note below, a FDC regime is particularly prone to pro-competitive margin squeeze situations if NGA turns out less successful than expected: the investor might have an incentive to retail NGA below a fully cost-distributed wholesale price. It is important that such (failure) margin-squeeze cases are not scrutinised. Otherwise investments would sink and, in addition, consumers are worse off the in the failure case.

  - Within our modelling framework, an FDC regime seems comparatively easy to implement. As in all other alternatives that involve access to non-investors, one has to determine a cost-based wholesale price. However, FDC does not require specifying an appropriate Risk-Premium or any other asymmetry in ex-post access conditions on top.
  - In practice, FDC may also be seen as a complement to Risk-Sharing. One crucial learning point from our analysis is that FDC performs well as it reduces the risk for the investor. This feature can also be utilised by means of a skilful management of the transition process from copper to fibre. For example, as long as copper and fibre based infrastructure exist in parallel, Risk-Sharing insiders may use NGA exclusively or grant access to outsiders at a premium. However, a swift network migration may introduce a fibre-only world soon after and lay the ground for a de facto FDC regime.

- **Risk-Premium as a third best alternative**
  - We find that an appropriate Risk-Premium may certainly benefit consumers in comparison to the LRIC counterfactual.
  - However, seen in isolation a Risk-Premium regime does not appear as good as Risk-Sharing and FDC from a consumers' perspective. The main reason for this is that a Risk-Premium only leverages investments if the NGA success probability is rather high to start with. In contrast, Risk-Sharing and FDC become effective for lower success probabilities and yield higher expected consumer surplus.
  - Risk-Premium may complement Risk-Sharing to the extent that outsider access is considered (see above). Our results suggest it is not the best stand-alone policy, though.

- **Very cautions approach with respect to margin squeeze**
  - Risky investments may 'automatically' lead into (formal) margin-squeeze situations if NGA is less successful than anticipated. We show this by means of a FDC regime: if NGA fails investors may optimally retail NGA below cost-based wholesale prices, once investments are sunk. The same logic applies to NGA failure under a Risk-Premium regime and under Risk-Sharing with outsider access.
  - If investors anticipate that they will be scrutinized in such situations, they will reduce NGA investments to the detriment of consumers. In addition, consumers will suffer whenever NGA is not successful and a non-margin-squeeze obligation forces the investor(s) to increase retail prices above the optimal level. For that reason investors should maintain full pricing flexibility in failure cases, not being subject to margin-squeeze scrutiny.

— However, the possibility for pro-competitive margin squeezes (in the failure case) does not rule out anti-competitive margin squeezes (e.g. in the success case). Authorities should still prosecute the latter. To that end it would be helpful to identify failure and success cases, respectively. Investors' business case calculations may function as a viable source for that kind of information. In particular, if both an investor's NGA retail price and NGA penetration remains below expected levels, then this points towards a failure case.

4.4 Limitations and avenues for future research

Each approach to derive management and policy advice has its advantages and disadvantages. We believe that the model based approach presented here has decisive advantages as we attempt to take into account institutional details of different regulatory regimes that are usually not modelled in academic papers. As a result we can apply analytical rigour to settings which come close to the real world.

As our simulations show, we can identify several effects that may influence incentives of market participants and market outcomes in opposing ways. Non model based advise can only resolve such "trade-offs" intuitively. In contrast, our model based approach establishes the "net effect" after simultaneously accounting for many forces that are potentially pulling from different directions. Moreover, the model reveals the economic mechanisms at work and can therefore inform management decisions and regulatory decisions which would otherwise potentially ignore such effects.

Nevertheless, important limitations remain. Our model is not "calibrated;"[72] that is the numbers that we simulate allow conclusions regarding the ranking of different regimes within a given setting but cannot be interpreted as, for example, Euro-amounts of investment. More generally, we hesitate to give full weight to the "distance" between outcomes.

Moreover, although we do take into account many institutional details, a purely model based approach will still have to simplify matters to keep the analysis tractable.

Both limitations can affect the policy advice that we provide. To see why consider the following:

- The simulation outcomes suggest that introducing more market participants may improve consumer surplus by far more than other institutional details of the chosen regulatory settings. This result hinges, however, on interpreting

[72] Calibration often refers to determining the numerical specification of the equations, given their functional forms (e.g. determine the exact cost for deploying one additional NGA). Here we use the term more generally, also considering the testing of different functional forms. For example, provided data on past behaviour of market participants exist, the explanatory power of different structural models can be tested by trying to predict the past. If this works well, further credibility is given to using the structural model for predicting future behaviour in an amended regulatory setting.

the "distance" and we would suggest doing this with caution. Taken at face value, however, future research should endogenise entry and explore which regime stimulates entry.

- Much of the analysis supposes certain scenarios without stating the likelihood of these scenarios to emerge in the real world. For example, we raise the issue of incentive compatibility only in the context of outsider access in the most complex scenarios of Risk-Sharing (involving several insiders and outsiders). The analysis presented there shows that such arguments can be important as market participants may not be willing to participate in Risk-Sharing regimes unless the additional introduction of a Risk-Premium improves the position of an investor relative the position of a non-investor and access seeker. While we have taken such results into account on a qualitative basis, more formal and systematic research could reveal further insights.

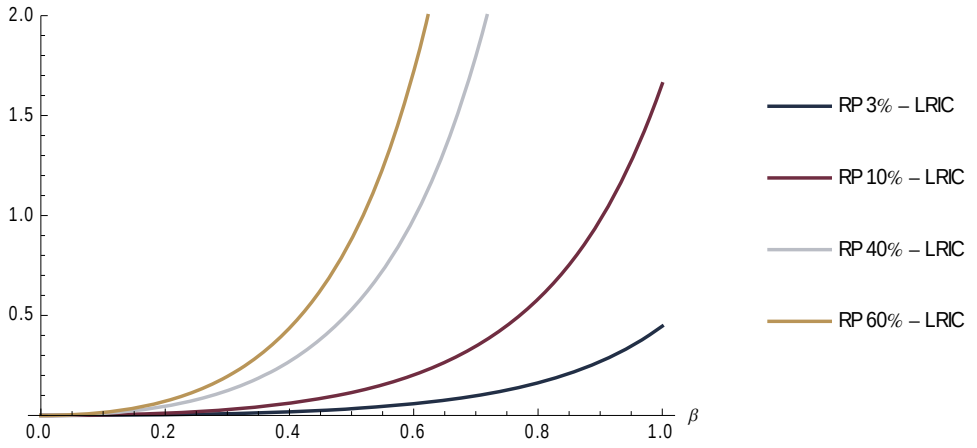
Future work could attempt to address the limitations described above. In addition and as set out to some extent in the proposed extension option, further research could be helpful. The list below may serve as a starting point for considering future work.

- Our results on settings with many insiders and outsiders are based on qualitative considerations. A refined analysis would consider outsider access under the various Risk-Sharing regimes proposed and check implications quantitatively. Other examples exist as we did not analyse all feasible permutations which can easily amount to several hundreds[73] – an uninformative mess.
- A more comprehensive analysis of all competitive effects would also have to consider more traditional elements of competition economics. This includes an analysis of the effects of different regimes on the potential to collude (e.g. due to increased transparency or more similar costs), an analysis of alternative margin-squeeze tests, a more elaborate analysis of the effects of regulatory regimes on wholesale competition and the impact of various regimes on infrastructure competition.
- As more and more regulatory approaches emerge in the real world, policy and management advice can increasingly draw on these experiences.

[73] Consider for example, three Risk-Sharing Scenarios plus one LRIC counterfactual (4), thee versions of outsider access (3, none, cost-based, and Risk-Premium), up to ten firms in the industry (9) and up to ten insiders (9): 972 permutations, not accounting for different Risk-Premia.

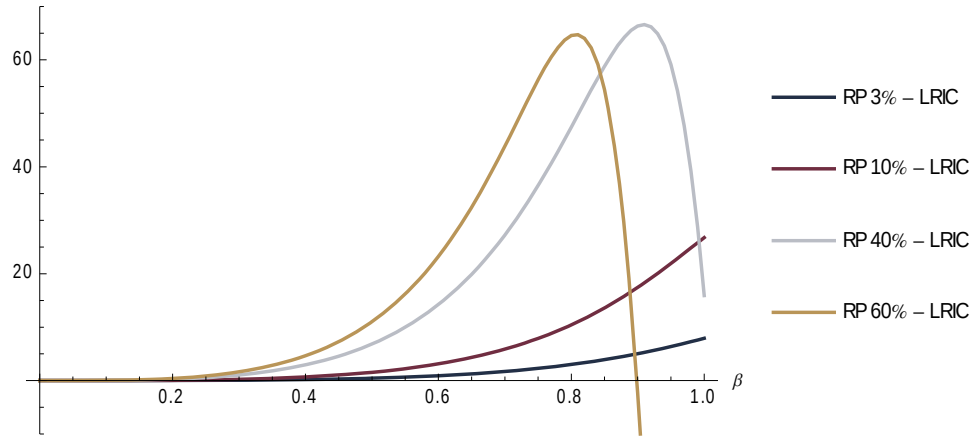
Appendix 1
Basic model, comparison of different risk-premia

Figure 28: NGA investments: Comparison of different risk-premia



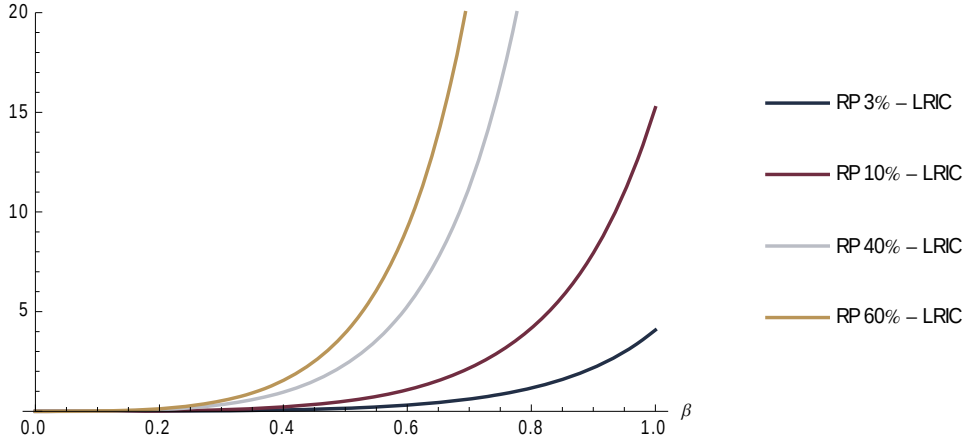
Source: ESMT CA model, A=100, c=20, y=5, p=0.03, p=0.1, p=0.4 and p=0.6.

Figure 29: Consumer surplus: Comparison of different risk-premia



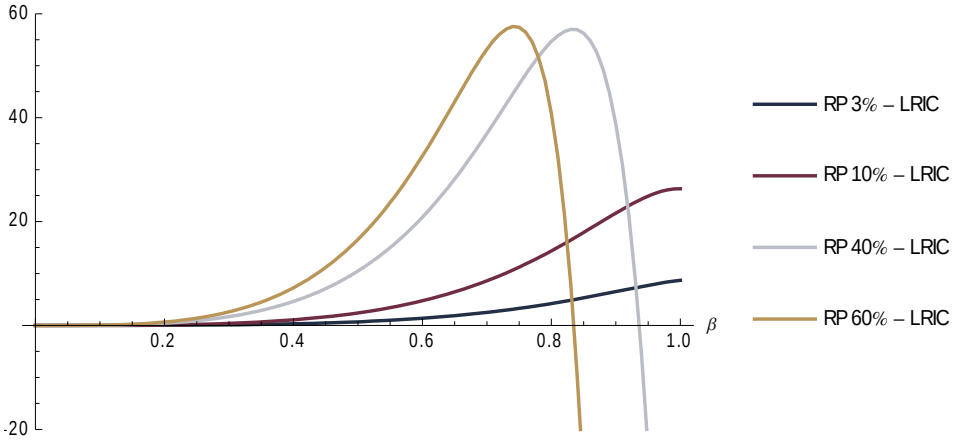
Source: ESMT CA model, A=100, c=20, y=5, p=0.03, p=0.1, p=0.4 and p=0.6.

Figure 30: Investor surplus: Comparison of different risk-premia



Source: ESMT CA model, A=100, c=20, y=5, p=0.03, p=0.1, p=0.4 and p=0.6.

Figure 31: Total surplus: Comparison of different risk-premia

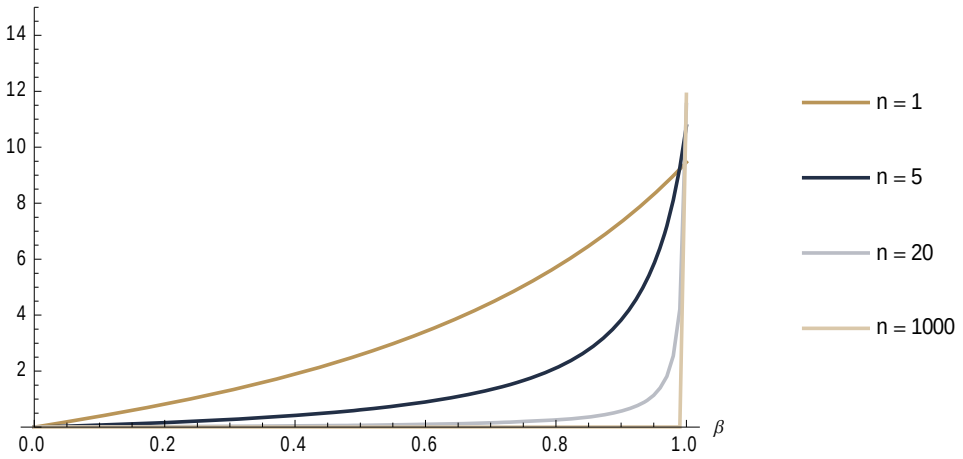


Source: ESMT CA model, A=100, c=20, y=5, p=0.03, p=0.1, p=0.4 and p=0.6.

Appendix 2
Single investor, variation of the number of non-investors

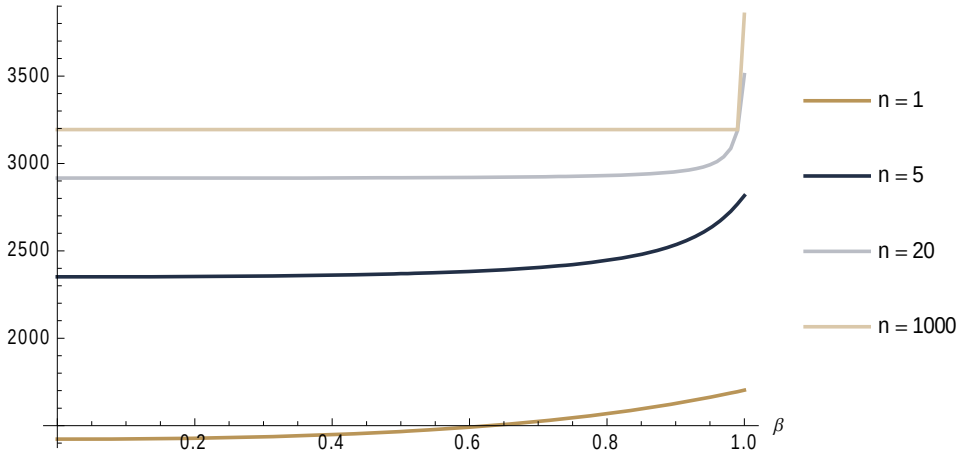
A2.1
LRIC

Figure 32: NGA investments: LRIC counterfactual, single investor and varying number of non-investors



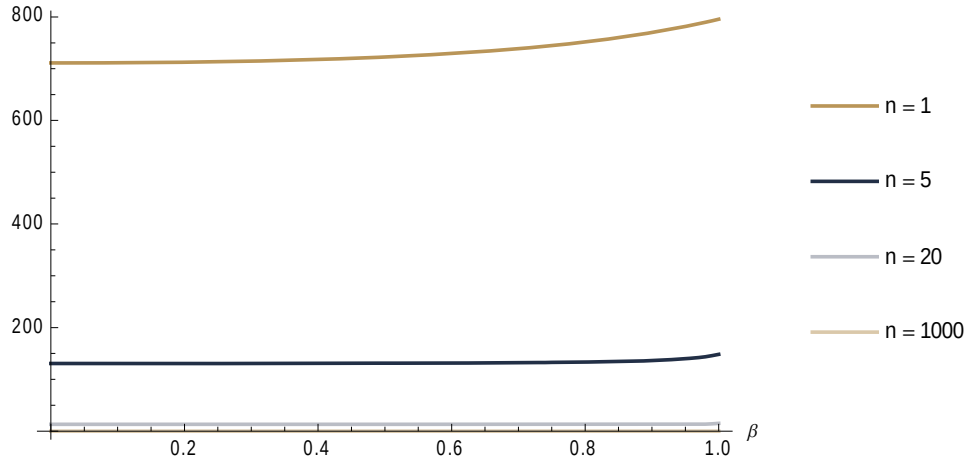
Source: ESMT CA model, A=100, c=20, y=5, n=1, n=5, n=20 and n=1,000.

Figure 33: Consumer surplus: LRIC counterfactual, single investor and varying number of non-investors



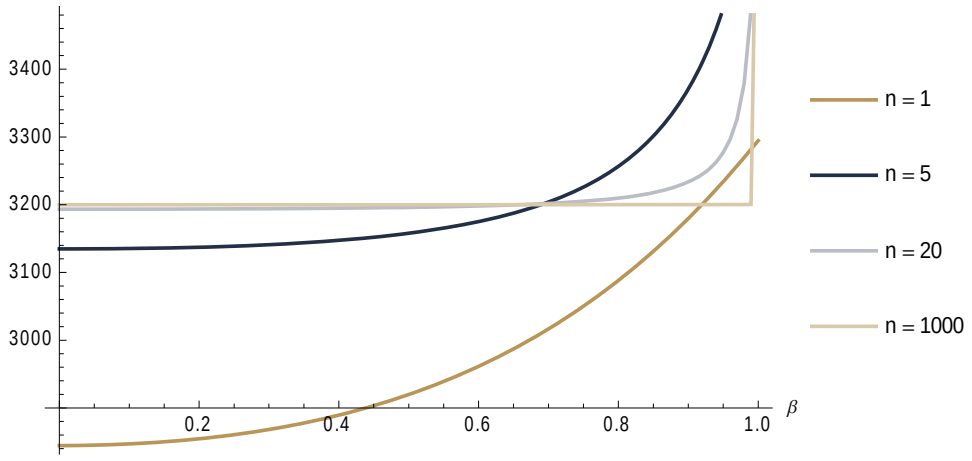
Source: ESMT CA model, A=100, c=20, y=5, n=1, n=5, n=20 and n=1,000.

Figure 34: Investor surplus: LRIC counterfactual, single investor and varying number of non-investors.



Source: ESMT CA model, A=100, c=20, y=5, n=1, n=5, n=20 and n=1,000.

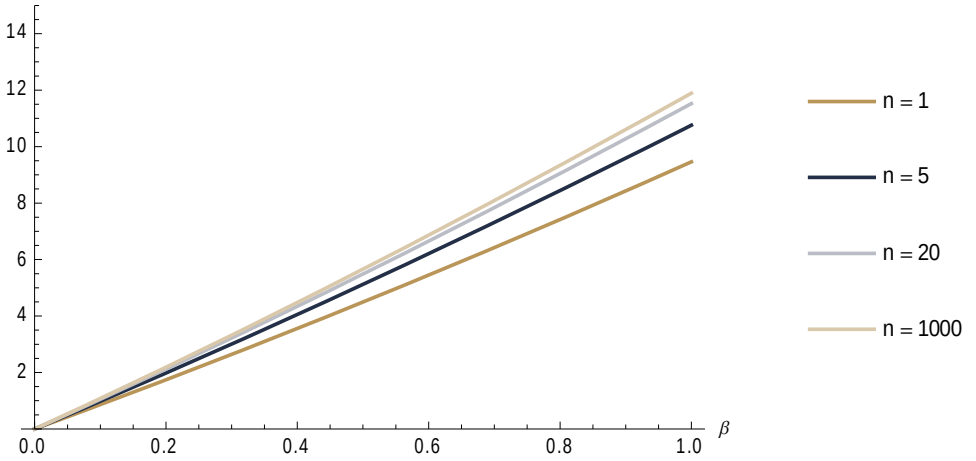
Figure 35: Total surplus: LRIC counterfactual, single investor and varying number of non-investors



Source: ESMT CA model, A=100, c=20, y=5, n=1, n=5, n=20 and n=1,000.

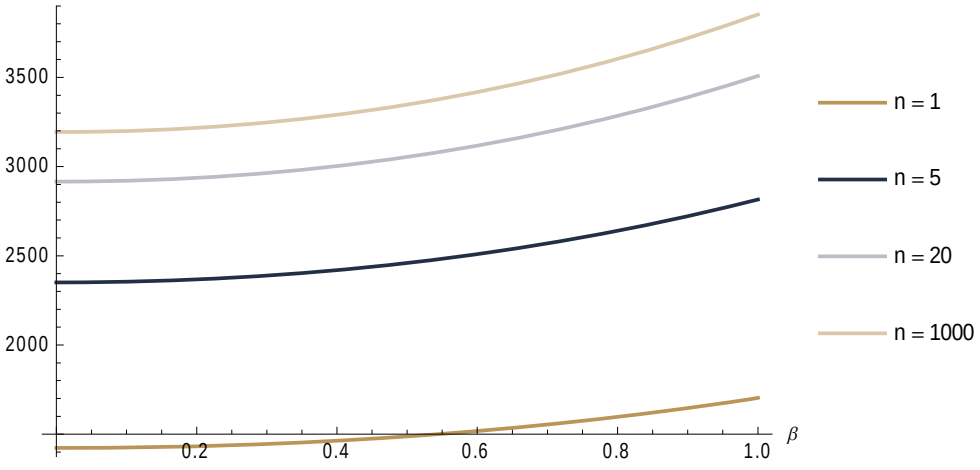
A2.2
Fully distributed costs (FDC)

Figure 36: NGA investments: FDC case, single investor and varying number of non-investors



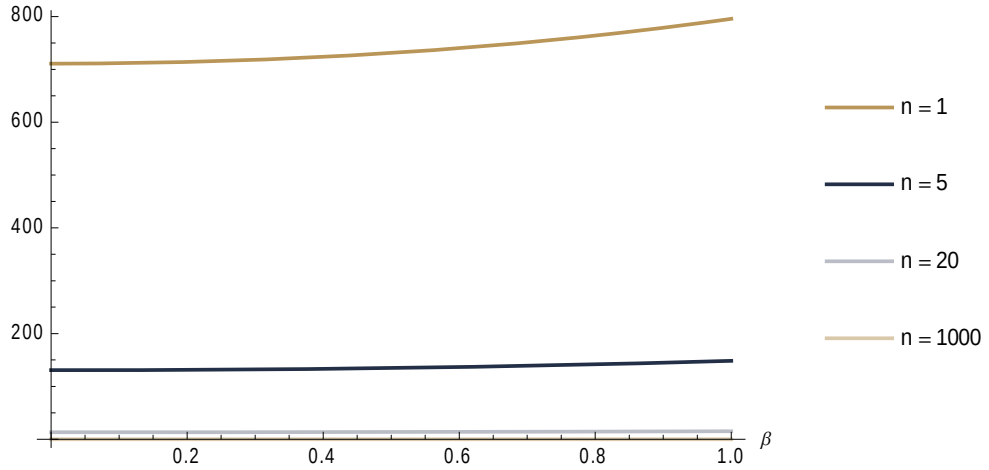
Source: ESMT CA model, A=100, c=20, y=5, n=1, n=5, n=20 and n=1,000.

Figure 37: Consumer surplus: FDC case, single investor and varying number of non-investors



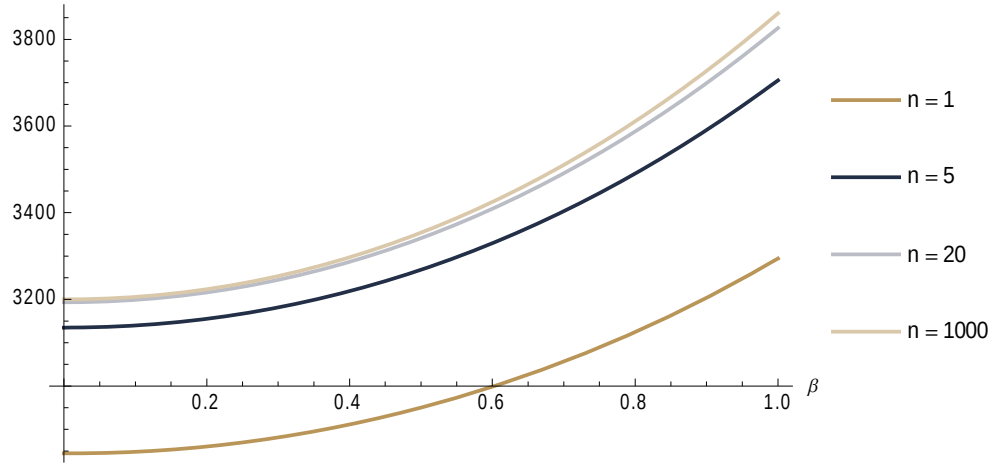
Source: ESMT CA model, A=100, c=20, y=5, n=1, n=5, n=20 and n=1,000.

Figure 38: Investor surplus: FDC case, single investor and varying number of non-investors



Source: ESMT CA model, A=100, c=20, y=5, n=1, n=5, n=20 and n=1,000.

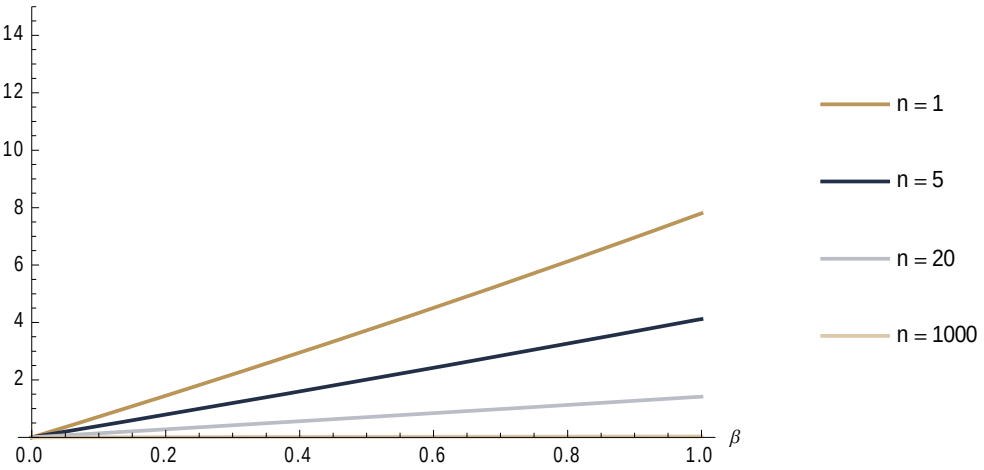
Figure 39: Total surplus: FDC case, single investor and varying number of non-investors



Source: ESMT CA model, A=100, c=20, y=5, n=1, n=5, n=20 and n=1,000.

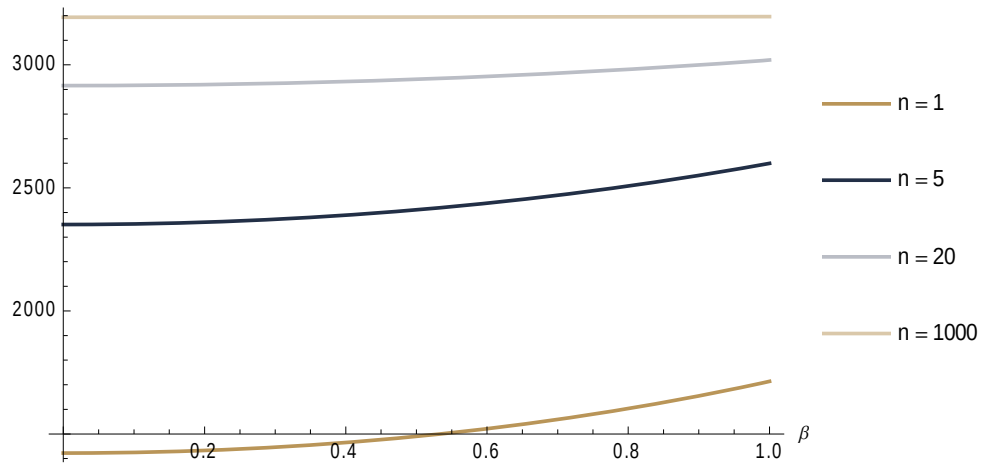
A2.3
Risk-Sharing

Figure 40: NGA investments: Risk-Sharing, single investor and varying number of non-investors



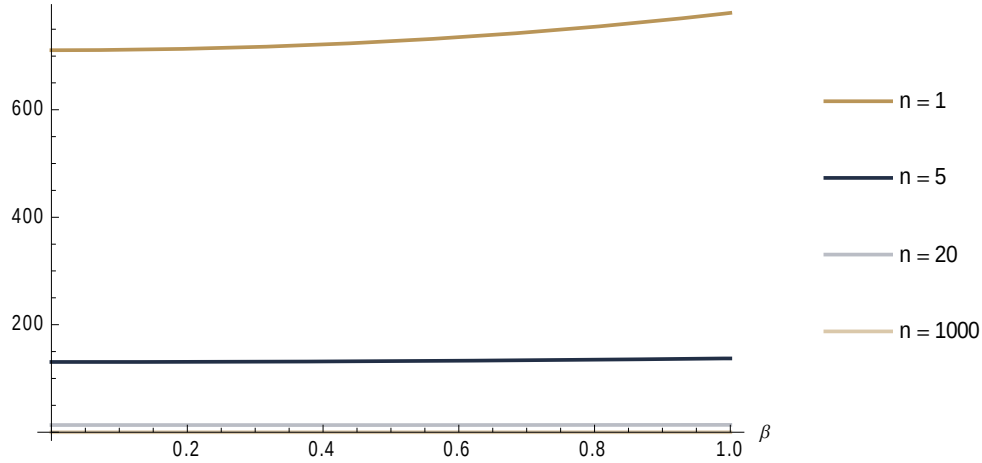
Source: ESMT CA model, A=100, c=20, y=5, n=1, n=5, n=20 and n=1,000.

Figure 41: Consumer surplus: Risk-Sharing, single investor and varying number of non-investors



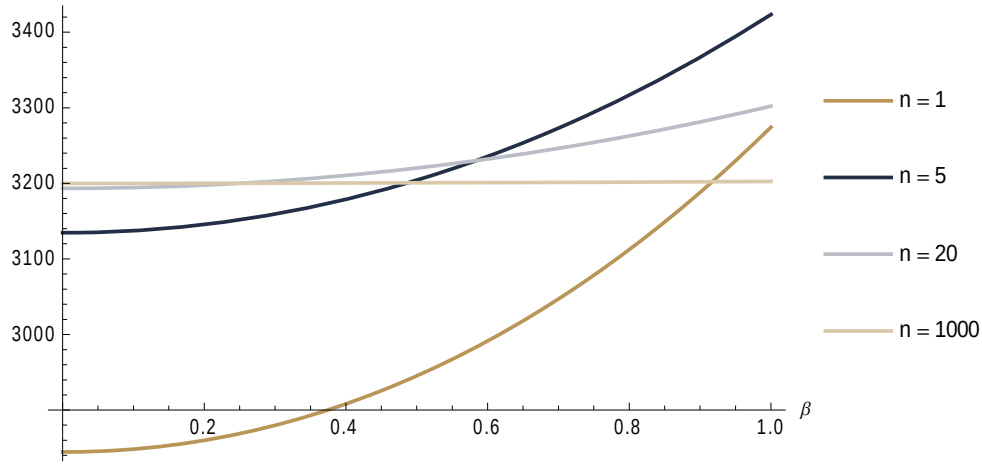
Source: ESMT CA model, A=100, c=20, y=5, n=1, n=5, n=20 and n=1,000.

Figure 42: Investor surplus: Risk-Sharing, single investor and varying number of non-investors



Source: ESMT CA model, A=100, c=20, y=5, n=1, n=5, n=20 and n=1,000.

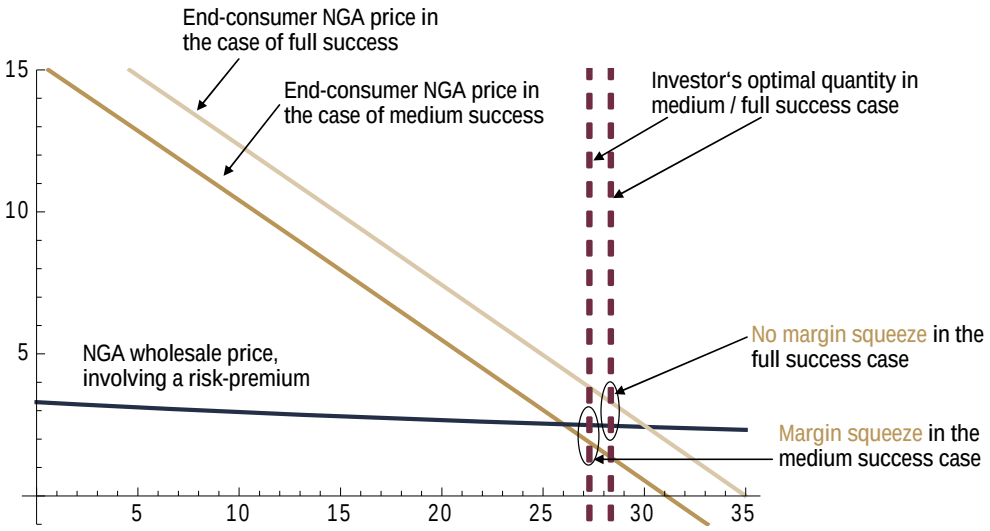
Figure 43: Total surplus: Risk-Sharing, single investor and varying number of non-investors



Source: ESMT CA model, A=100, c=20, y=5, n=1, n=5, n=20 and n=1,000.

Appendix 3
Emergence of margin squeezes under a Risk-Premium scenario

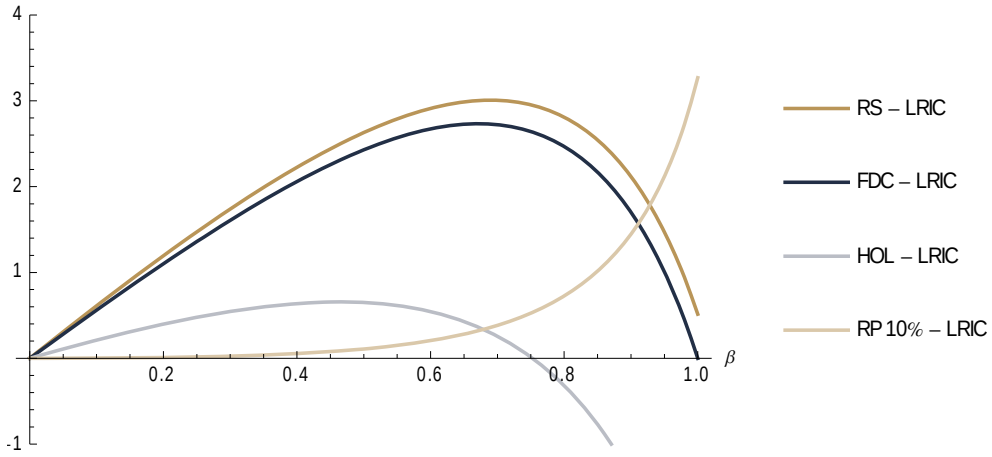
Figure 44: Risk-Premium: NGA wholesale price uplift, optimal retail price uplift and optimal output quantity (penetration) in a full success case and in a medium success case: medium success case may lead to a margin squeeze



Source: ESMT CA model, A=100, c=20, y=5, beta=0.7, Risk-Premium=0.4, xI=6.23 (optimal for beta=0.7 and Risk-Premium=0.4), demand shift by (1/2)xI=3.12 and (medium-success case) and by xI=6.23 (full-success case).

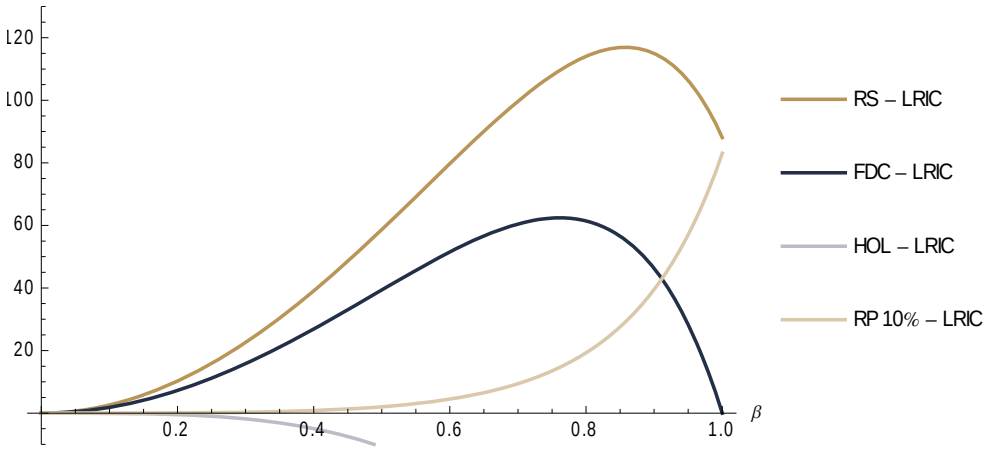
Appendix 4
Asymmetries: Investor has lower market share (26%)

Figure 45: NGA investments if the investor has 26% market share ex ante: RS, FDC, HOL and RP compared to the LRIC counterfactual



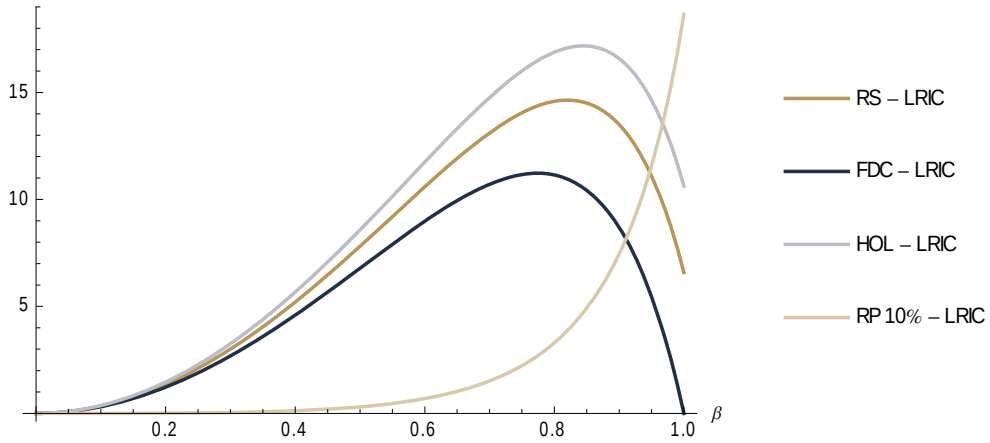
Source: ESMT CA model, A(investor)=100, A(non-investor)=130, c=20, y=5.

Figure 46: Consumer surplus if the investor has 26% market share ex ante: RS, FDC, HOL and RP compared to the LRIC counterfactual



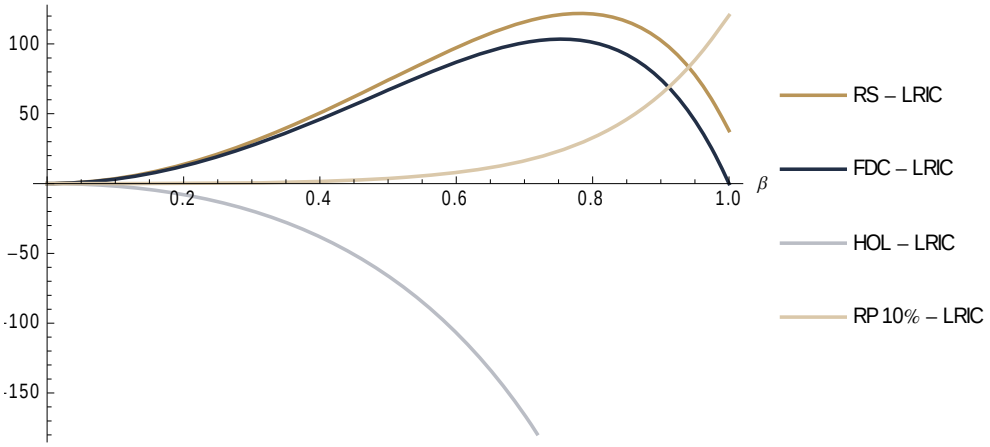
Source: ESMT CA model, A(investor)=100, A(non-investor)=130, c=20, y=5.

Figure 47: Investor surplus if the investor has 26% market share ex ante: RS, FDC, HOL and RP compared to the LRIC counterfactual



Source: ESMT CA model, A(investor)=100, A(non-investor)=130, c=20, y=5.

Figure 48: Total surplus if the investor has 26% market share ex ante: RS, FDC, HOL and RP compared to the LRIC counterfactual

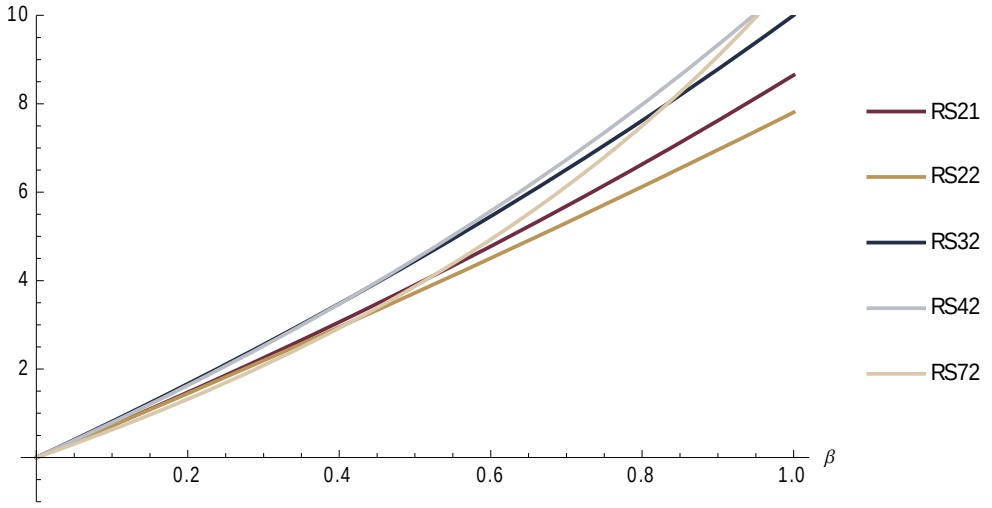


Source: ESMT CA model, A(investor)=100, A(non-investor)=130, c=20, y=5.

Appendix 5
Basic Risk-Sharing without outsider access

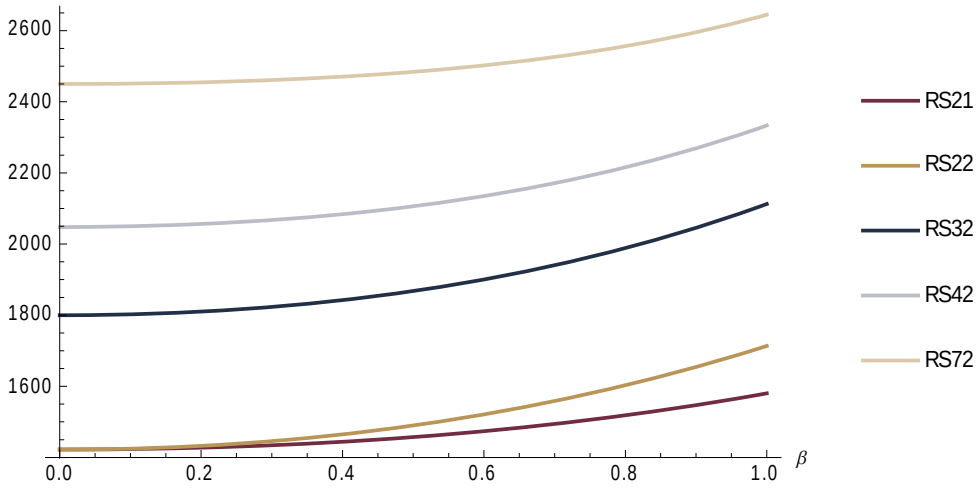
A5.1
Two Risk-Sharing partners (insiders), increasing the number of outsiders

Figure 49: Investments under basic Risk-Sharing, two insiders, varying number of outsiders



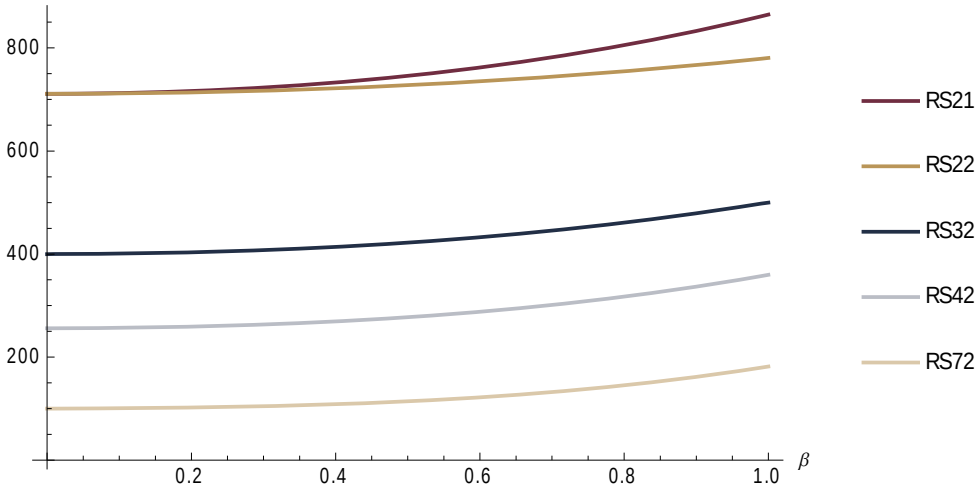
Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(42) four firms in the industry which of two are Risk-Sharing partners.

Figure 50: Consumer surplus under basic Risk-Sharing, two insiders, varying number of outsiders



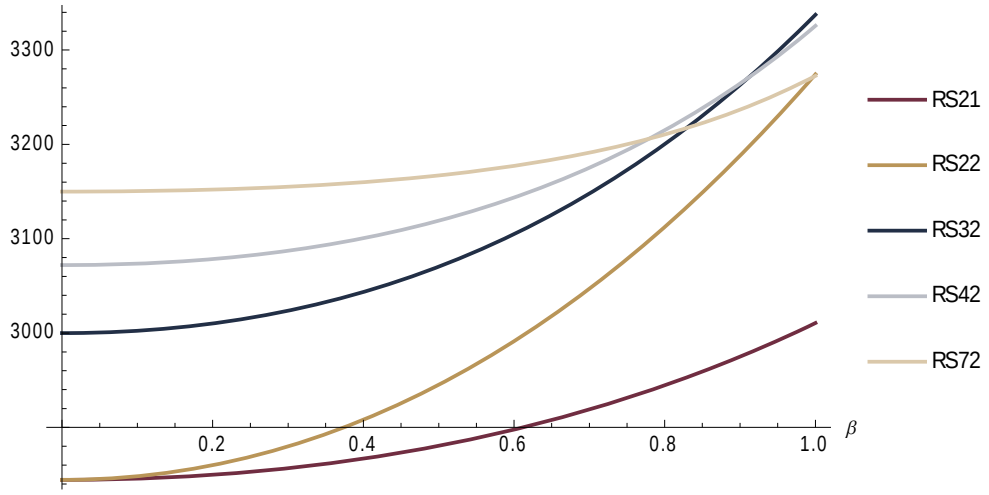
Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(42) four firms in the industry which of two are Risk-Sharing partners.

Figure 51: Average insider surplus under basic Risk-Sharing, two insiders, varying number of outsiders



Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(42) four firms in the industry which of two are Risk-Sharing partners.

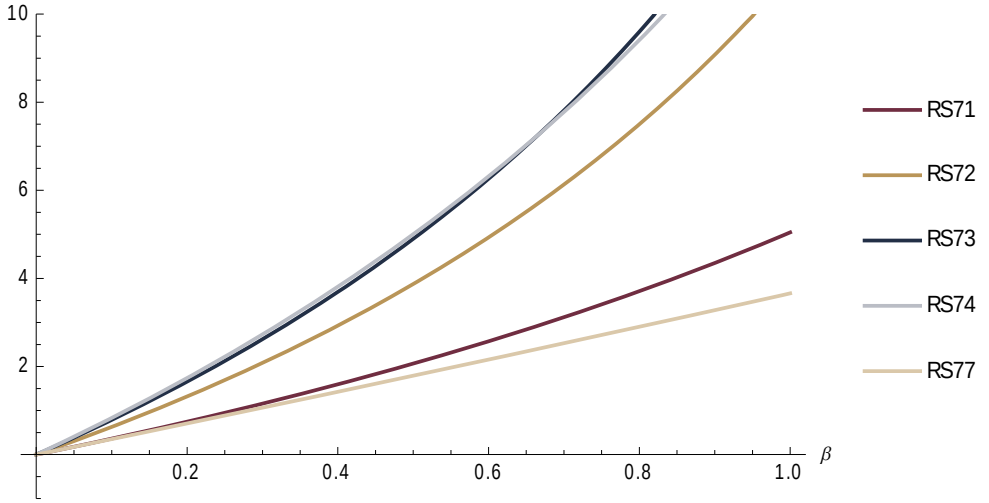
Figure 52: Total surplus under basic Risk-Sharing, two insiders, varying number of outsiders



Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(42) four firms in the industry which of two are Risk-Sharing partners.

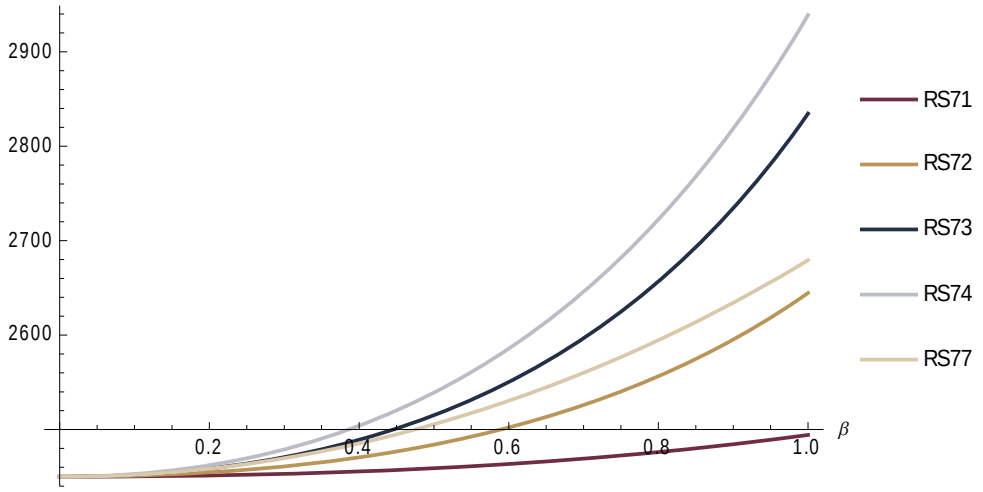
A5.2
Seven-firm industry, increasing the number of insiders

Figure 53: Investments under basic Risk-Sharing, seven-firm industry, varying the number of insiders



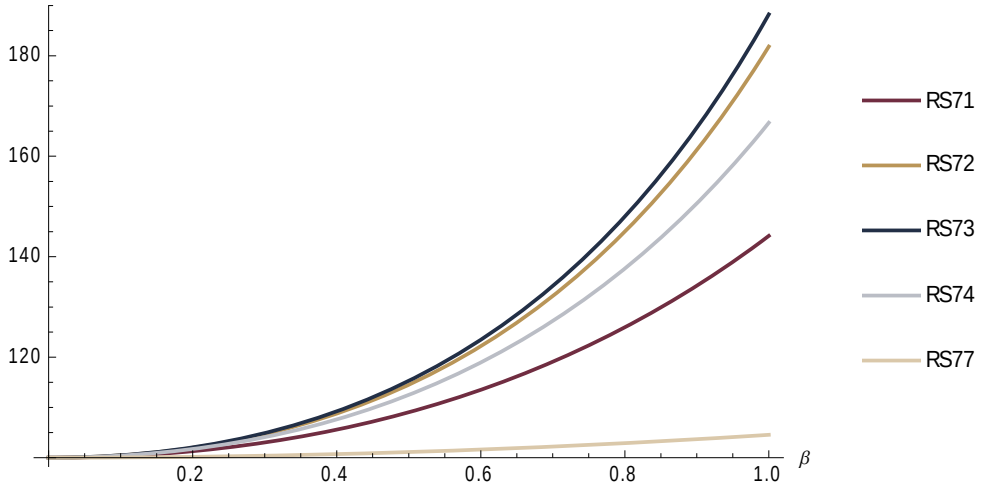
Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(74) features seven firms in the industry which of four are Risk-Sharing partners.

Figure 54: Consumer surplus under basic Risk-Sharing, seven-firm industry, varying the number of insiders



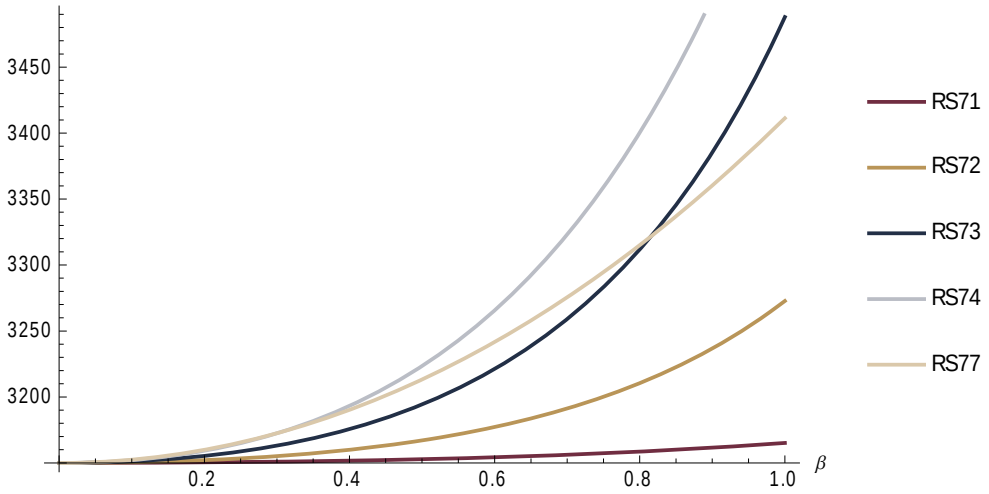
Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(74) features seven firms in the industry which of four are Risk-Sharing partners.

Figure 55: Average insider surplus under basic Risk-Sharing, seven-firm industry, varying the number of insiders



Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(74) features seven firms in the industry which of four are Risk-Sharing partners.

Figure 56: Total surplus under basic Risk-Sharing, seven-firm industry, varying the number of insiders

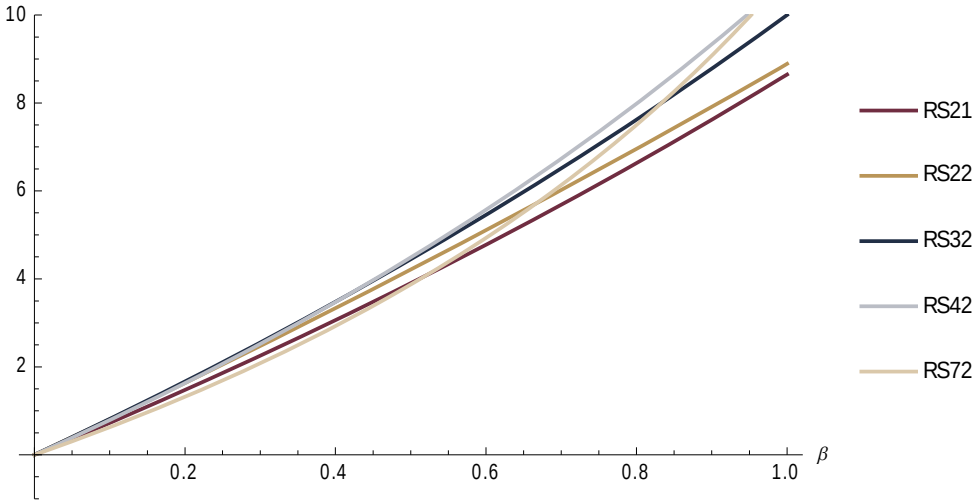


Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(74) features seven firms in the industry which of four are Risk-Sharing partners.

Appendix 6
Wholesale Risk-Sharing without outsider access

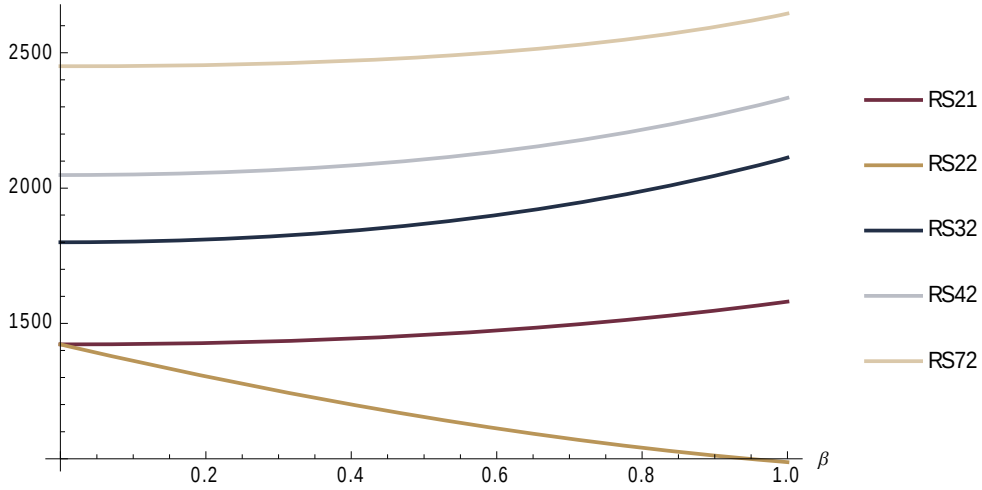
A6.1
Two Risk-Sharing partners (insiders), increasing the number of outsiders

Figure 57: Investments under wholesale Risk-Sharing, two insiders, varying number of outsiders



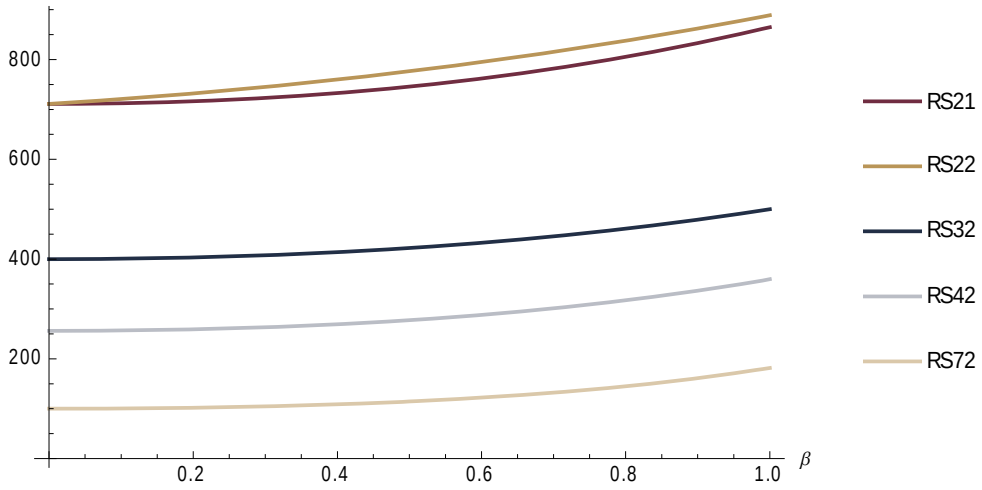
Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(42) features four firms in the industry which of two are Risk-Sharing partners.

Figure 58: Consumer surplus under wholesale Risk-Sharing, two insiders, varying number of outsiders



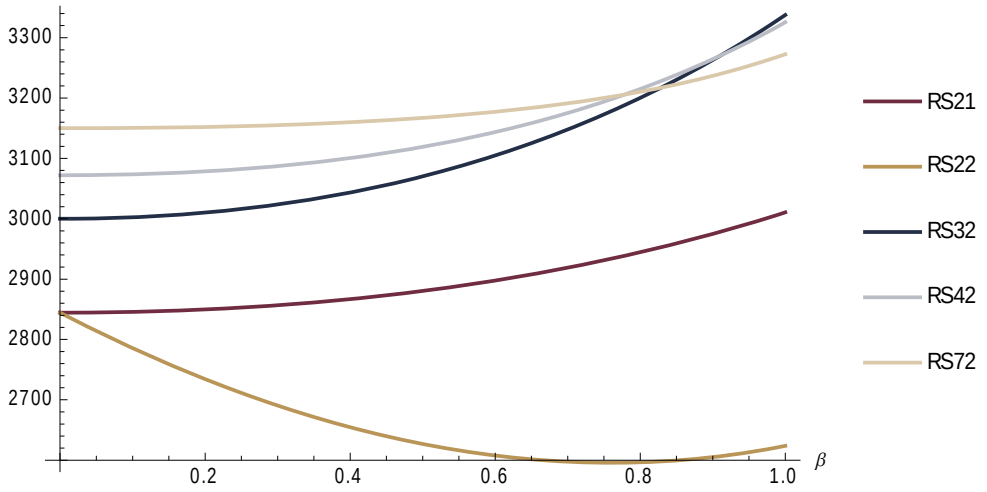
Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(42) features four firms in the industry which of two are Risk-Sharing partners.

Figure 59: Average insider surplus under wholesale Risk-Sharing, two insiders, varying number of outsiders



Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(42) features four firms in the industry which of two are Risk-Sharing partners.

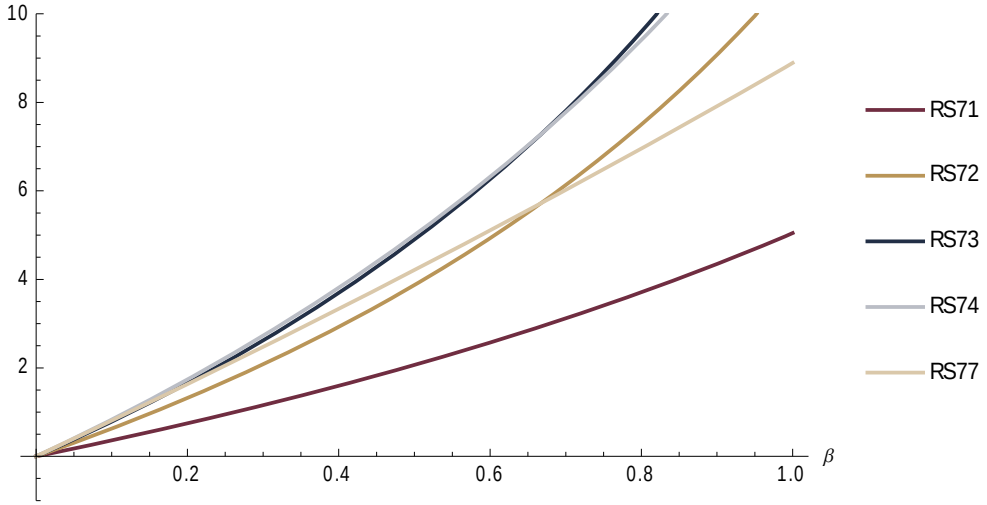
Figure 60: Total surplus under wholesale Risk-Sharing, two insiders, varying number of outsiders



Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(42) features four firms in the industry which of two are Risk-Sharing partners.

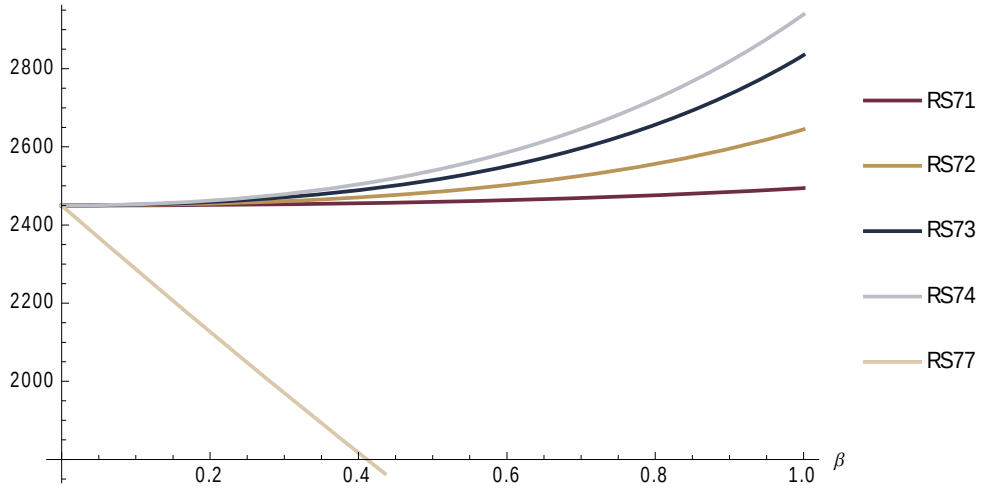
A6.2
Seven-firm industry, increasing the number of insiders

Figure 61: Investments under wholesale Risk-Sharing, seven-firm industry, varying the number of insiders



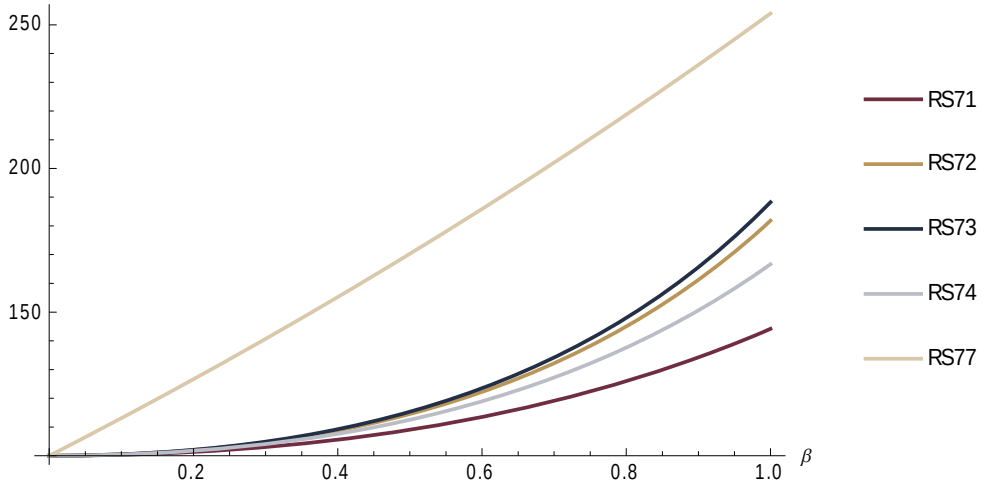
Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(74) features seven firms in the industry which of four are Risk-Sharing partners.

Figure 62: Consumer surplus under wholesale Risk-Sharing, seven-firm industry, varying the number of insiders



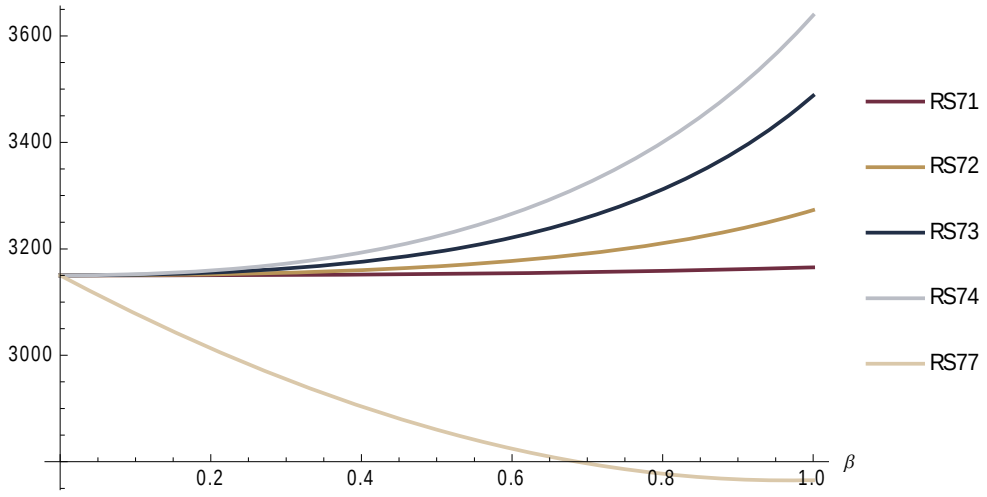
Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(74) features seven firms in the industry which of four are Risk-Sharing partners.

Figure 63: Average insider surplus under wholesale Risk-Sharing, seven-firm industry, varying the number of insiders



Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(74) features seven firms in the industry which of four are Risk-Sharing partners.

Figure 64: Total surplus under wholesale Risk-Sharing, seven-firm industry, varying the number of insiders

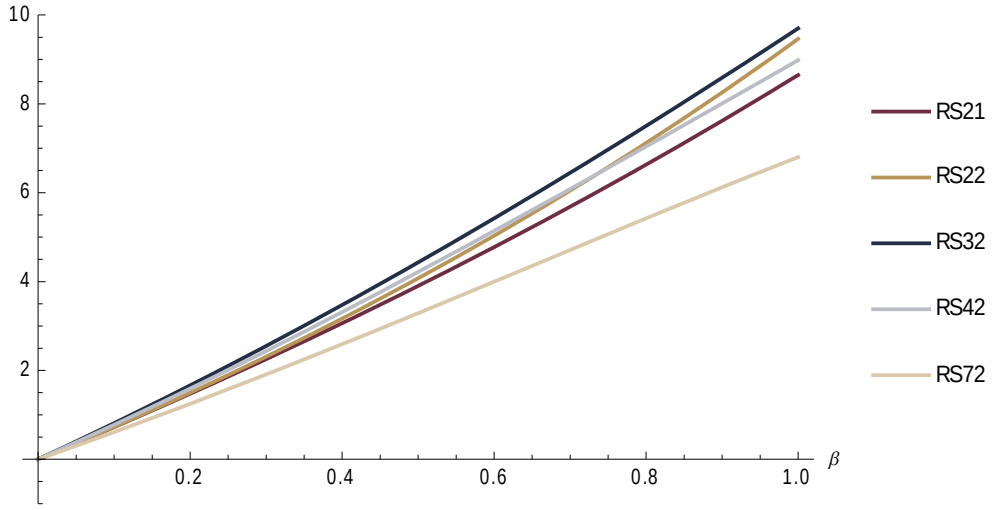


Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(74) features seven firms in the industry which of four are Risk-Sharing partners.

Appendix 7
JV Risk-Sharing without outsider access

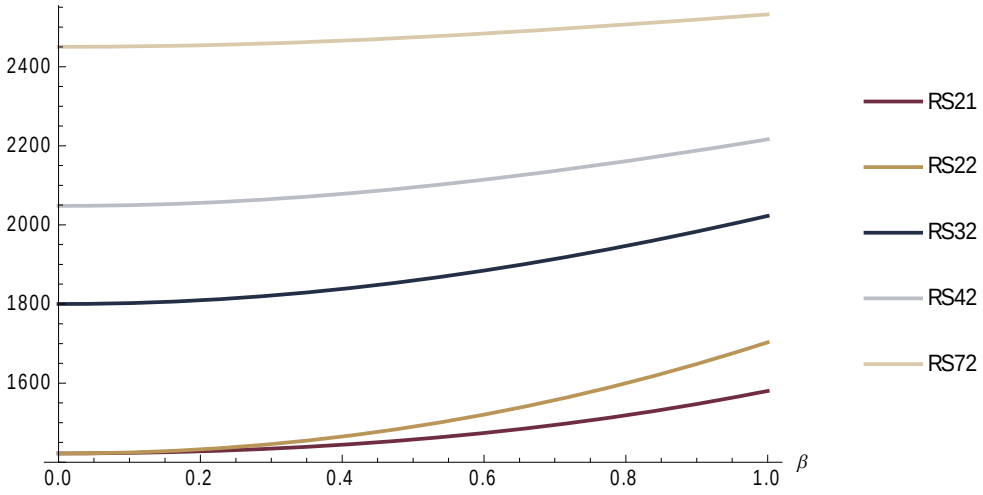
A7.1
Two Risk-Sharing partners (insiders), increasing the number of outsiders

Figure 65: Investments under JV Risk-Sharing, two insiders, varying number of outsiders



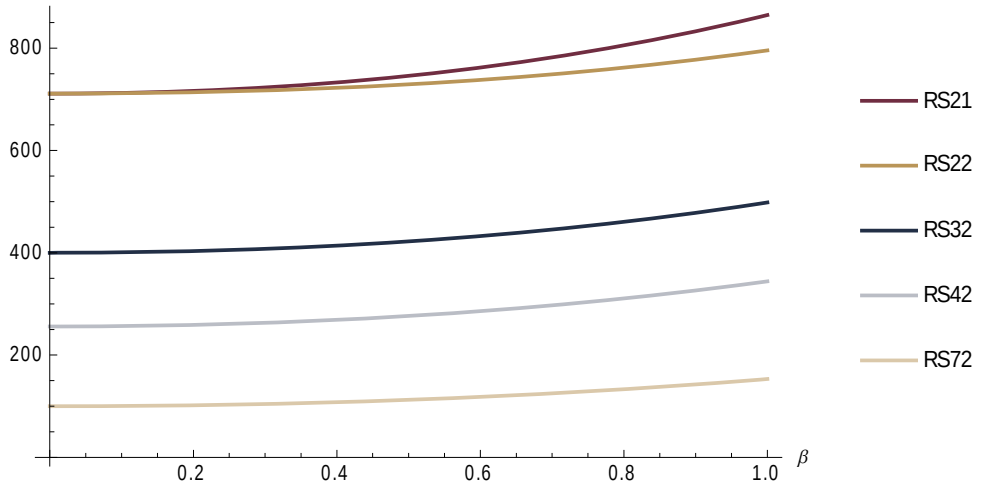
Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(42) features four firms in the industry which of two are Risk-Sharing partners.

Figure 66: Consumer surplus under JV Risk-Sharing, two insiders, varying number of outsiders



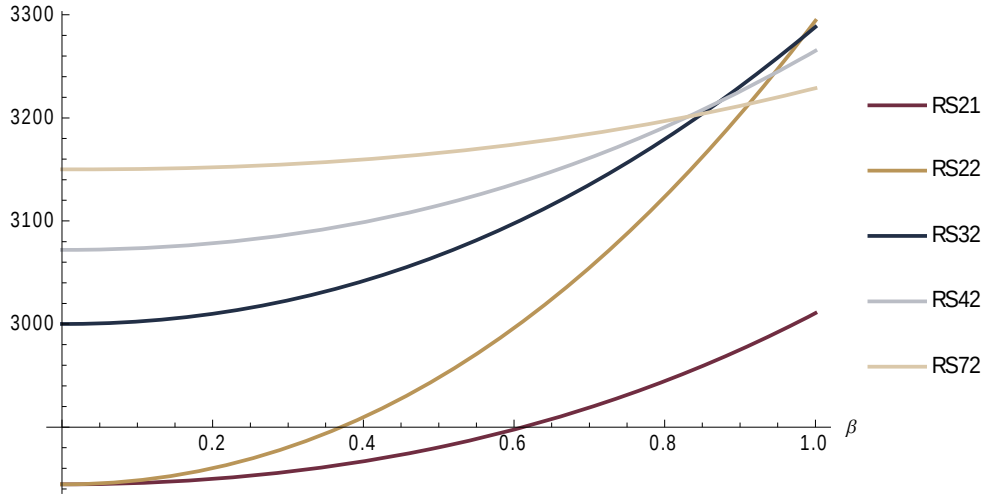
Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(42) features four firms in the industry which of two are Risk-Sharing partners.

Figure 67: Average insider surplus under JV Risk-Sharing, two insiders, varying number of outsiders



Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(42) features four firms in the industry which of two are Risk-Sharing partners.

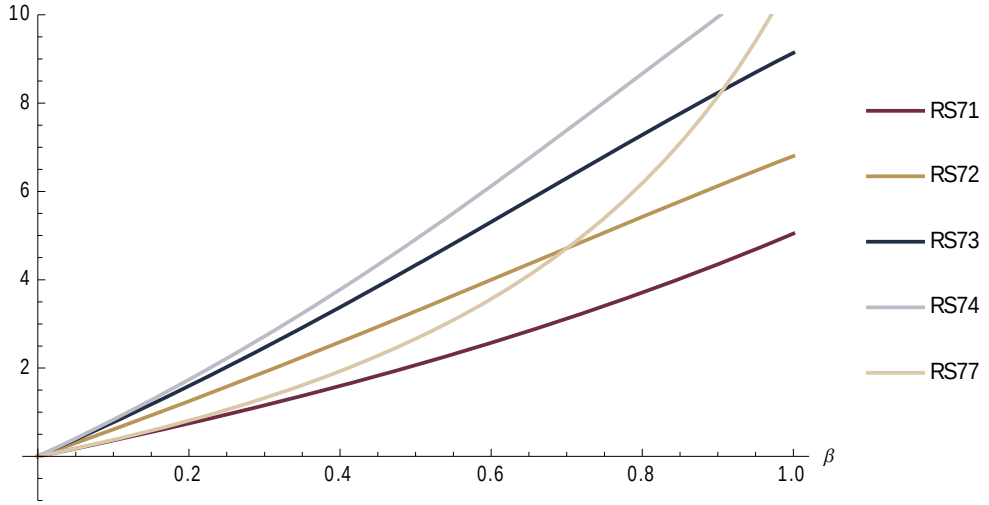
Figure 68: Total surplus under JV Risk-Sharing, two insiders, varying number of outsiders



Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(42) features four firms in the industry which of two are Risk-Sharing partners.

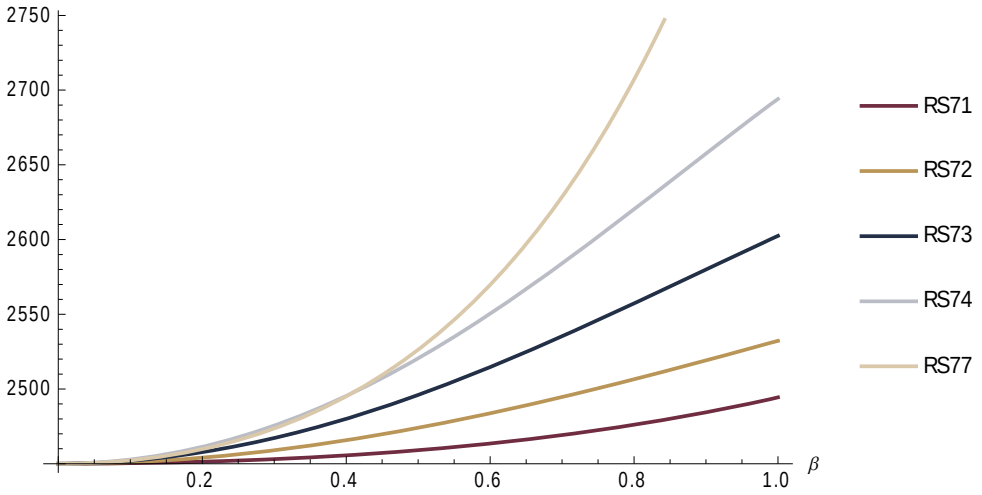
A7.2
Seven-firm industry, increasing the number of insiders

Figure 69: Investments under JV Risk-Sharing, seven-firm industry, varying the number of insiders



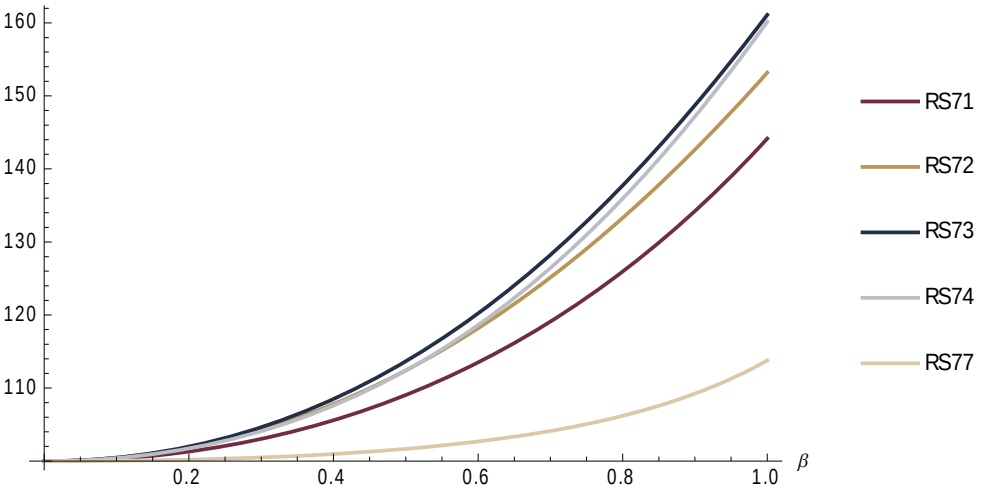
Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(74) features four firms in the industry which of two are Risk-Sharing partners.

Figure 70: Consumer surplus under JV Risk-Sharing, seven-firm industry, varying the number of insiders



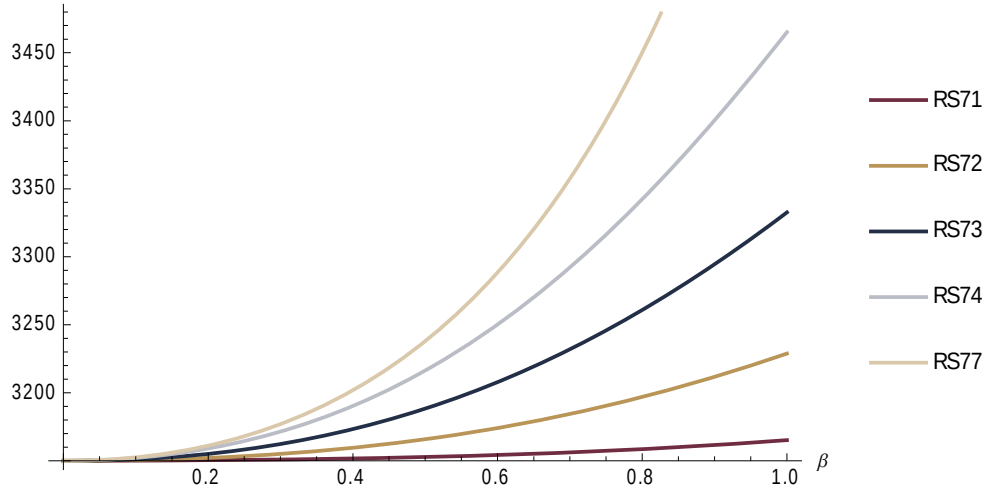
Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(74) features four firms in the industry which of two are Risk-Sharing partners.

Figure 71: Average insider surplus under JV Risk-Sharing, seven-firm industry, varying the number of insiders



Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(74) features four firms in the industry which of two are Risk-Sharing partners.

Figure 72: Total surplus under JV Risk-Sharing, seven-firm industry, varying the number of insiders

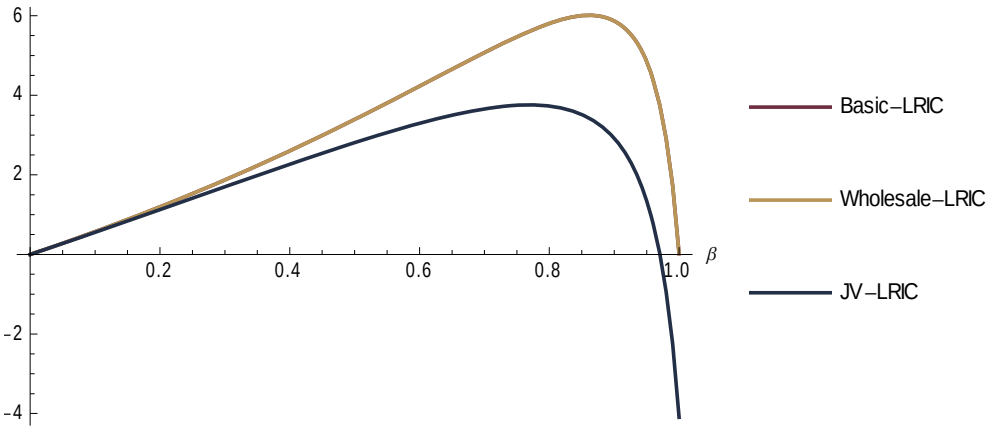


Source: ESMT CA model, A=100, c=20, y=5, RS(n+m)(m) with m insiders and n outsiders, e.g. RS(74) features four firms in the industry which of two are Risk-Sharing partners.

Appendix 8
Comparative assessment of Risk-Sharing models

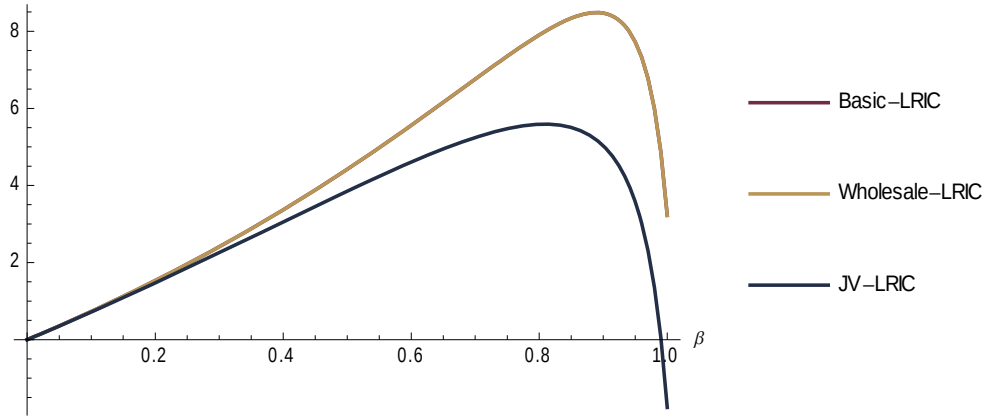
A8.1
Investments, seven-firm industry with two to seven insiders

Figure 73: Comparative RS NGA investments in a seven-firm industry with two insiders (case 72)



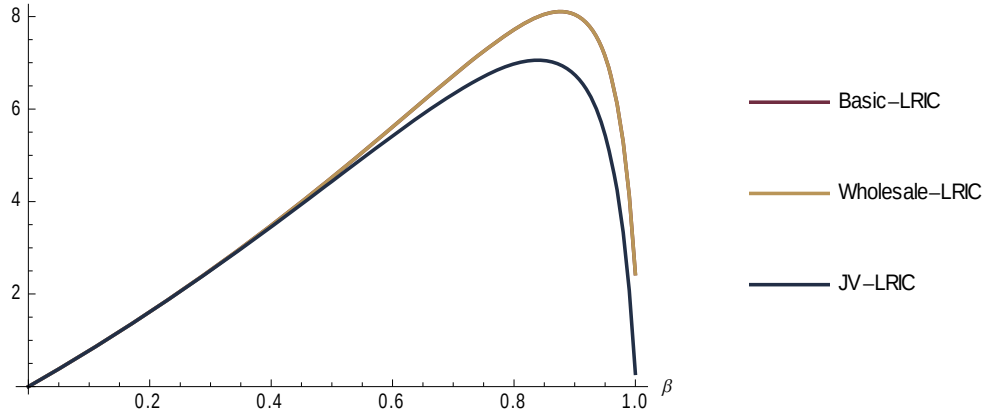
Source: ESMT CA model, A=100, c=20, y=5, n=5 outsiders, m=2 insiders.

Figure 74: Comparative RS NGA investments in a seven-firm industry with three insiders (case 73)



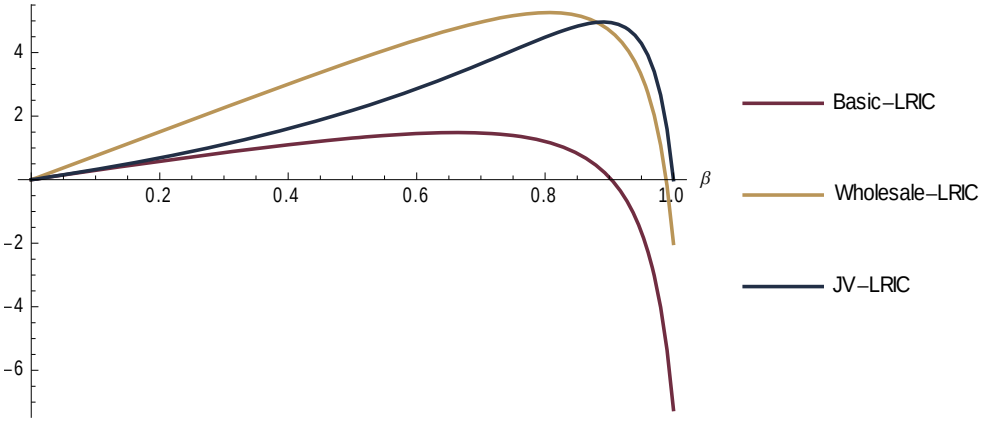
Source: ESMT CA model, A=100, c=20, y=5, n=4 outsiders, m=3 insiders.

Figure 75: Comparative RS NGA investments in a seven-firm industry with two insiders (case 74)



Source: ESMT CA model, A=100, c=20, y=5, n=3 outsiders, m=4 insiders.

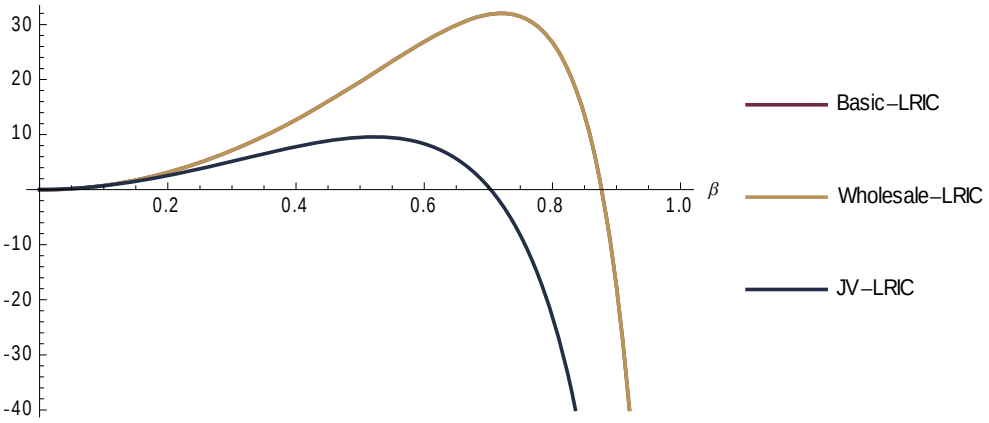
Figure 76: Comparative RS NGA investments in a seven-firm industry with two insiders (case 77)



Source: ESMT CA model, A=100, c=20, y=5, n=5 outsiders, m=7 insiders.

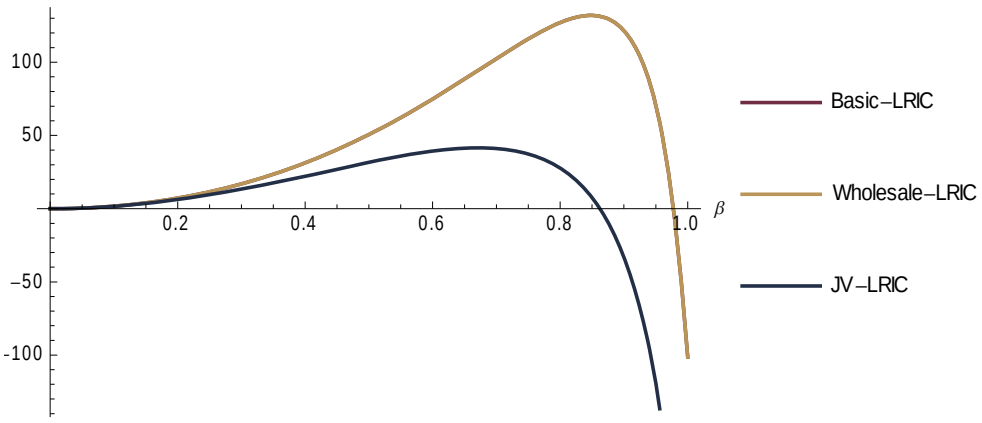
A8.2
Consumer surplus, seven-firm industry with two to seven insiders

Figure 77: Comparative RS consumer surplus in a seven-firm industry with two insiders (case 72)



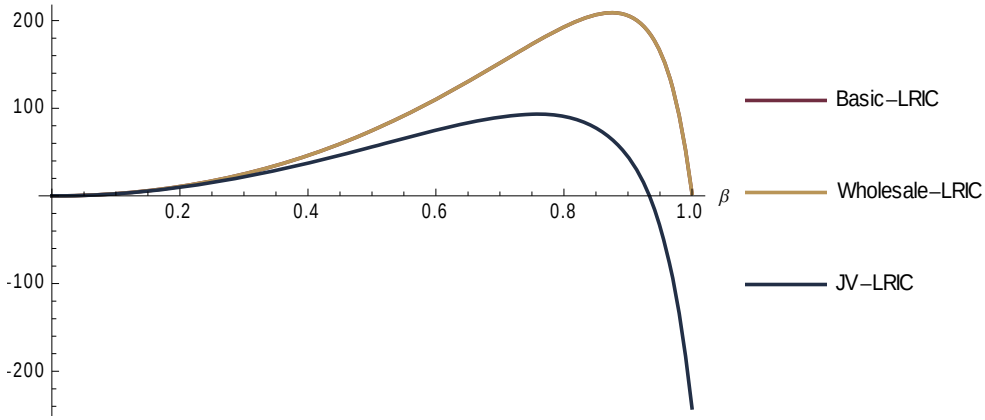
Source: ESMT CA model, A=100, c=20, y=5, n=5 outsiders, m=2 insiders.

Figure 78: Comparative RS NGA investments in a seven-firm industry with three insiders (case 73)



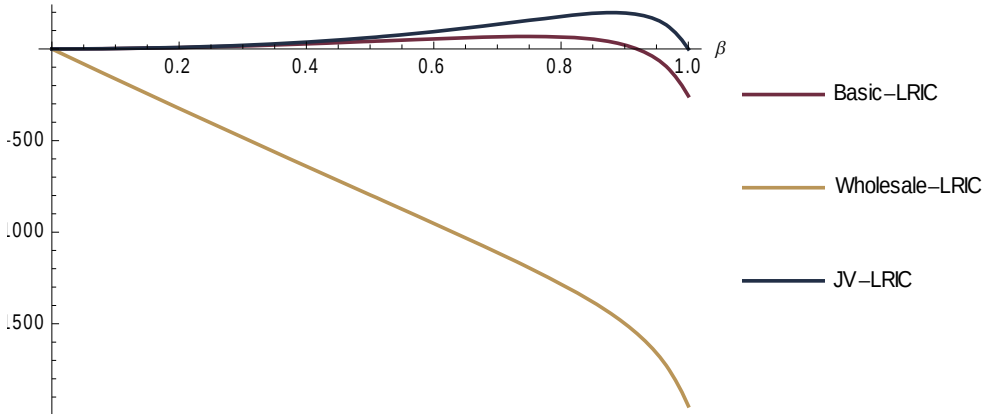
Source: ESMT CA model, A=100, c=20, y=5, n=4 outsiders, m=3 insiders.

Figure 79: Comparative RS NGA investments in a seven-firm industry with two insiders (case 74)



Source: ESMT CA model, A=100, c=20, y=5, n=3 outsiders, m=4 insiders.

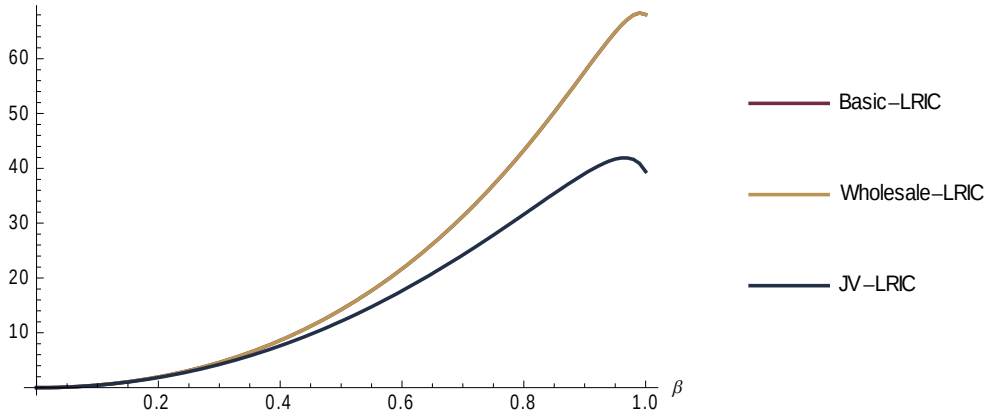
Figure 80: Comparative RS NGA investments in a seven-firm industry with two insiders (case 77)



Source: ESMT CA model, A=100, c=20, y=5, n=3 outsiders, m=7 insiders.

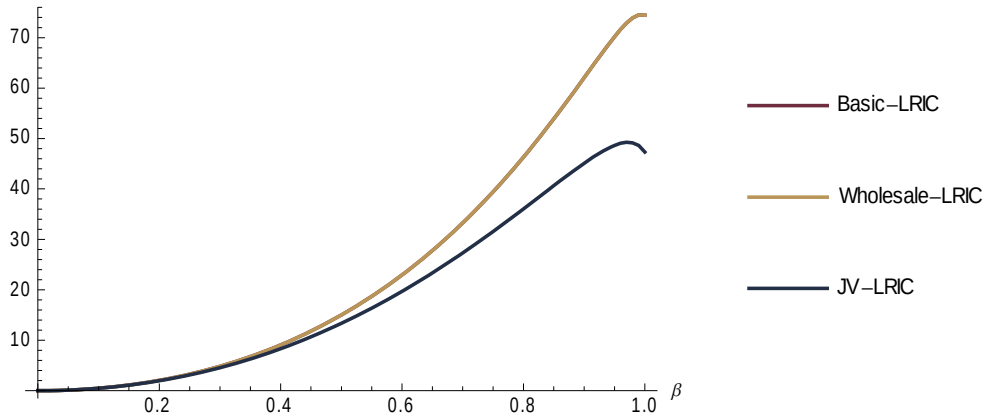
A8.3
Average insider surplus, seven-firm industry with two to seven insiders

Figure 81: Comparative RS insider surplus in a seven-firm industry with two insiders (case 72)



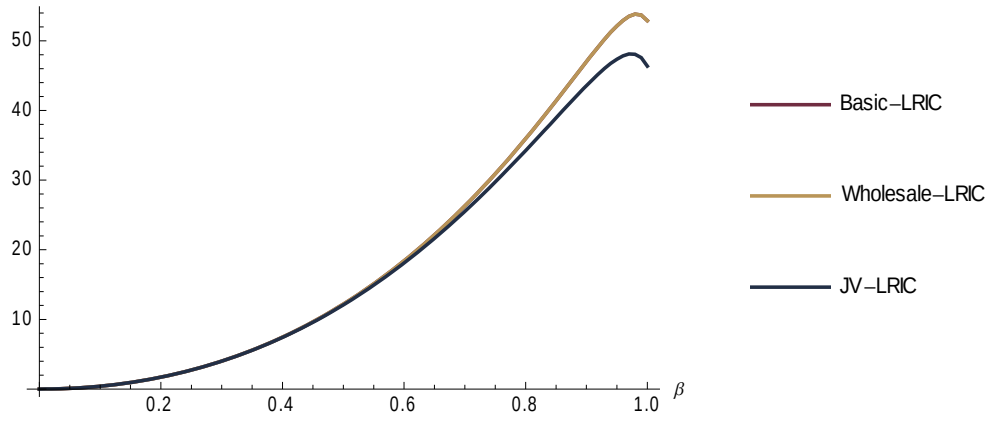
Source: ESMT CA model, A=100, c=20, y=5, n=5 outsiders, m=2 insiders.

Figure 82: Comparative RS insider surplus in a seven-firm industry with three insiders (case 73)



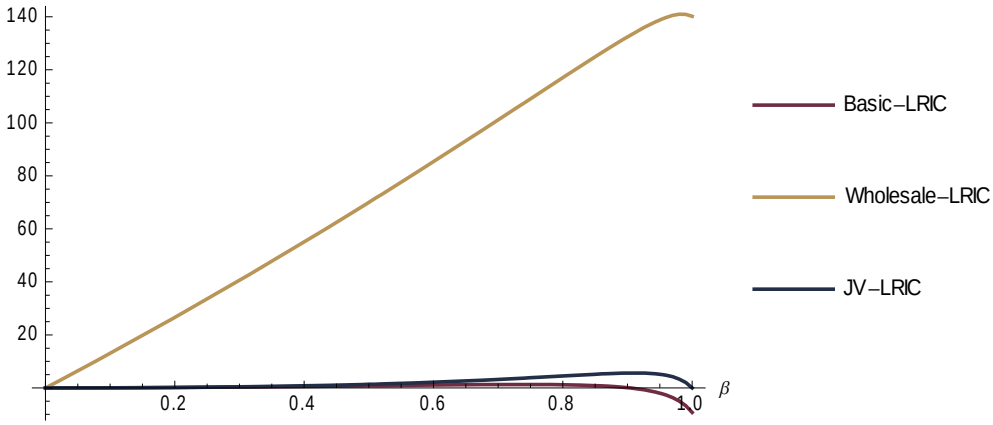
Source: ESMT CA model, A=100, c=20, y=5, n=4 outsiders, m=3 insiders.

Figure 83: Comparative RS insider surplus in a seven-firm industry with two insiders (case 74)



Source: ESMT CA model, A=100, c=20, y=5, n=3 outsiders, m=4 insiders.

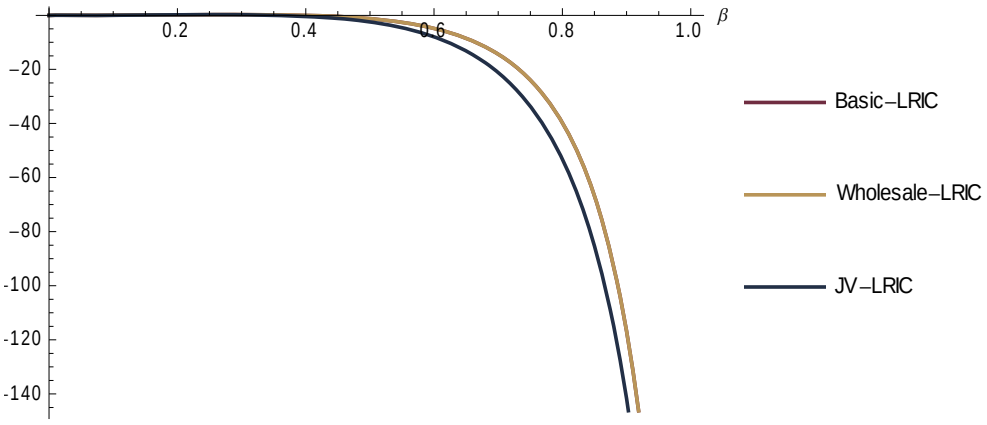
Figure 84: Comparative RS insider surplus in a seven-firm industry with two insiders (case 77)



Source: ESMT CA model, A=100, c=20, y=5, n=3 outsiders, m=7 insiders.

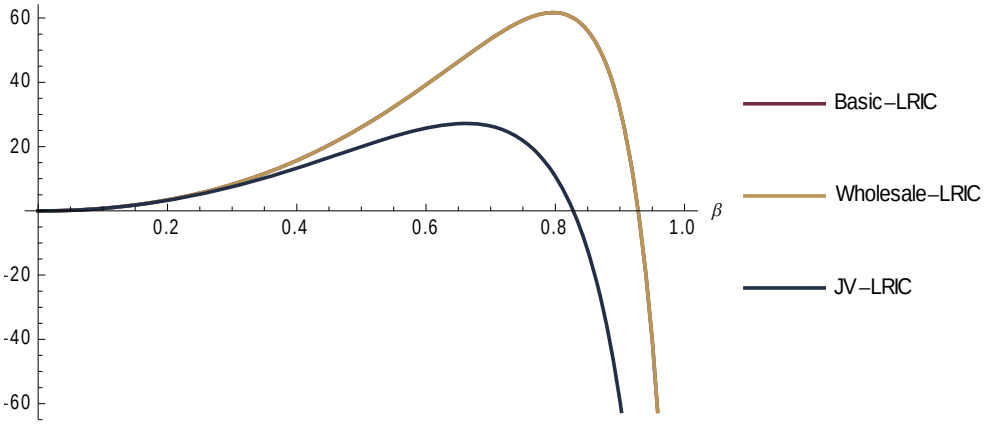
A8.4
Total surplus, seven-firm industry with two to seven insiders

Figure 85: Comparative RS total surplus in a seven-firm industry with two insiders (case 72)



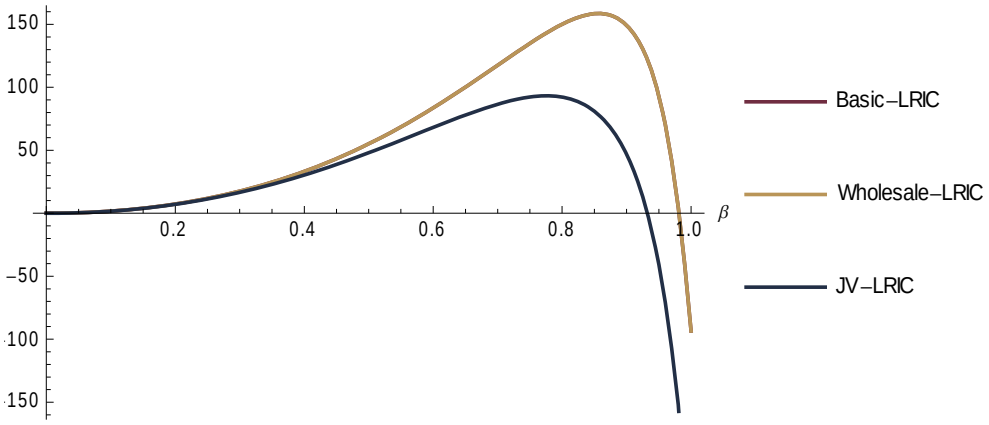
Source: ESMT CA model, A=100, c=20, y=5, n=5 outsiders, m=2 insiders.

Figure 86: Comparative RS total surplus in a seven-firm industry with three insiders (case 73)



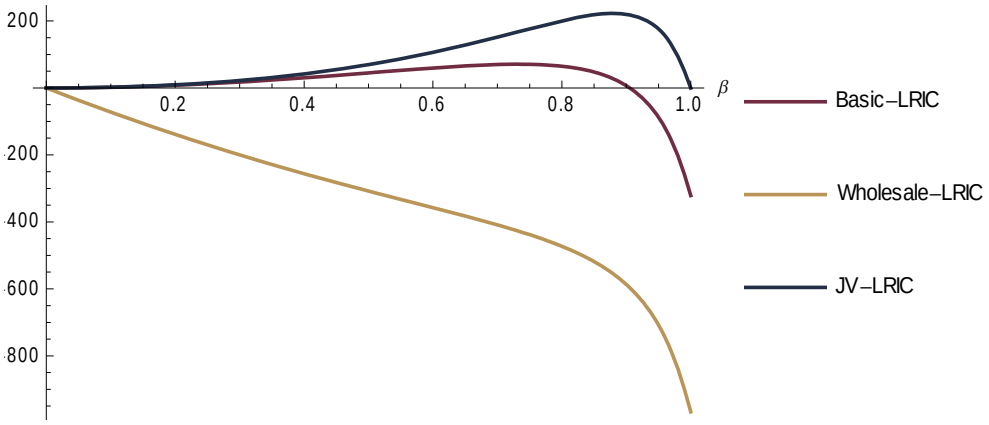
Source: ESMT CA model, A=100, c=20, y=5, n=4 outsiders, m=3 insiders.

Figure 87: Comparative RS total surplus in a seven-firm industry with two insiders (case 74)



Source: ESMT CA model, A=100, c=20, y=5, n=3 outsiders, m=4 insiders.

Figure 88: Comparative RS total surplus in a seven-firm industry with two insiders (case 77)



Source: ESMT CA model, A=100, c=20, y=5, n=3 outsiders, m=7 insiders.

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