Volume 40(1), pp. 45–68
http://orion.journals.ac.za

ORiON
ISSN 0259–191X (print)
ISSN 2224–0004 (online)

The profitability of flat-price broadband with an over-the-top subscription content product – benefits from cooperation

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Received: 16 August 2023; Accepted: 11 March 2024

Abstract

We investigate the effect on the broadband market when an over-the-top subscription content product is introduced. Does it necessarily increase or decrease profitability of the broadband product when it (a) boosts the utility of broadband but (b) imposes additional costs to deliver the broadband service?

The short answer is it depends. The different scenarios that we choose to illustrate this demonstrate that in many cases, the broadband and content providers can jointly benefit from coordination on how the content product is priced. Empirical evidence confirms that coordination does take place where 'network neutrality' is not mandated. In addition to the illustrative scenarios, we run a large number of simulations with a single broadband and single content provider, restricting the firms to integer prices, for different distributions of the customer valuations.

The results show that cooperation between the firms (possibly through paid peering) generally produces better outcomes (also from the consumer point of view) than when the broadband provider reacts by raising the price of broadband independently.

Key words: Pricing, Broadband, Content, Bundles, Two-sided markets.

1 Introduction

As the internet morphed from an academic network to an everyday consumer tool, the question of how to pay for it was always in the background, as it was essentially designed without a charging mechanism. Initial concerns focused on existing media companies possibly leveraging their strong positions in access to restrict the content which is provided

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http://dx.doi.org/10.5784/40-1-003

to internet users [6]. Concerns about vertical integration of access and content providers have also heavily exercised regulators ([7]; [14]; [16]). More recently, the question has shifted from the issues of conduit discrimination and content discrimination that [16] raised about vertically integrated firms, to concerns about what might be called conduit abuse, where a commercial content provider may impose substantial costs on an internet access provider without compensation. This is very much what is at stake in the litigation between Netflix and SK Broadband in South Korea ([2]; [10]) and has been documented in a case study of US rural broadband providers by [9].

The explosion in low-cost video streaming services has given rise to the so-called Streaming Wars and is itself the subject of multiple antitrust concerns [13]. Heavy regulation of film distribution and cable television in the US has given way to a world of vertically integrated streaming operators like Amazon and Netflix with huge subscriber numbers and investments in production and infrastructure [5]. Whereas telecommunications operators dominated the technology space 20 years ago, it is now the streaming giants who do so. The over-the-top streaming video providers have consistently demanded that broadband telecommunications operators deliver their content without charge [12]. However, it has been observed in practice and in theory that broadband and content providers benefit from content producers providing a financial consideration to broadband for delivering content with quality guarantees [19]. Bans on paid prioritisation and on zero-rating (as in Net Neutrality claims) can be very unhelpful in this respect [17]. [11], [3], [4], [1], and others examine the contending claims of broadband and content providers.

Many broadband providers claim that with flat-rate pricing (arguably preferred by consumers), heavy streaming content users are subsidised by other customers, and that broadband providers should be compensated for delivery of high-bandwidth material (paid peering). On the other hand, content providers claim that paid peering reduces consumer surplus as it is alleged that ISPs do not pass on the full amount of the peering payments to end consumers. Content providers also frequently argue that the streaming content increases the value of the broadband connection and allows broadband providers to charge higher prices. [11] show, using a two-sided market model where the ISP sets the peering charge based on revenues from subscribers on one side of the market and content providers on the other, that the direct peering price that optimises consumer surplus can be zero (as content providers maintain), positive (but not quite as much as broadband providers would argue) or negative (meaning the broadband provider should compensate the content provider – a situation which is not usually discussed). Their model presumes two different tiers of broadband service, basic and premium, with those consumers purchasing content all subscribing to the premium tier. The authors do not make clear whether the difference in tiers is due to different speed qualities, different data allowances, or both. However, as they allow for subscriptions to the premium tier without a content purchase, it is likely that they intended the tiers to reflect speed differences (which would require additional infrastructure investment) rather than just data volumes.

There is no doubt that streaming content services add great value to the internet ecosystem, but how the investment to enable these services and the arising revenue should be split is a persistent dilemma [18]. [9] study usage-based pricing in broadband access and find that a richer set of pricing tools not only allows broadband providers to expand access,

but also to capture some of the value generated by streaming services without harming the providers of streaming content. The purpose of this paper is simply to investigate, in a discrete simulation model, the effect on an unmetered broadband market when an over-the-top subscription content product is introduced. Does it necessarily increase or decrease profitability of the broadband product when it (a) boosts the utility of broadband but (b) imposes additional costs to deliver the broadband service? The short answer is it depends. We introduce a model with a small number of consumers to show how the outcomes depend to a significant extent on the structure of the consumer valuations. The different scenarios that we choose to illustrate this demonstrate that, in many cases, broadband and content providers can jointly benefit from coordination on how the content product is priced. This coordination might involve a financial consideration, of course. This contrasts with the case where the broadband provider attempts to unilaterally reprice its product to reflect the increased cost of delivering the content product, which is not always possible. In addition to the illustrative scenarios, we provide a statistical analysis of the outcomes for four different joint distributions of the customer valuations.

Our model does not explore competition between broadband and content providers, a topic which is explored (in a different context) by [21] or [8]. It differs from [11] as it does not rely upon strong assumptions that consumer utilities for broadband and content are independent and normally distributed; we contend that this is highly unlikely to be the case in practice. Instead, we examine concrete cases as well as averages. Our model also differs from [9] as it is restricted to uniform flat-rate pricing of broadband. We also assume that all consumers receive the same quality broadband service, regardless of their content purchase decision. Simulation enables our model to incorporate a wider range of strategic options for content providers and ISPs, by allowing each to set prices to maximise their own profit given revealed consumer valuations, and then negotiate a side payment. This differs from two-sided market models assuming a broadband provider with market power able to unilaterally set prices charged (or rebates offered) to content providers. This enables us to consider the case when the ISP and content provider can vertically integrate.

2 Methodology

We consider a monopoly broadband provider and a market with ten consumers (labelled 0 to 9). Consumer valuations for a broadband and an over-the-top content product are generated randomly, and we select and discuss a number of interesting cases. Initially, the content service is not available and the broadband provider sets its price so as to maximise profit. It does not change this price when the content subscription option is introduced. In practice, this tends to happen in a market where there is flat and uniform pricing – consumers all pay the same price regardless of how much they use the broadband. Since many consumers do not take up the content product, it is difficult to increase the price of broadband access.

Our broadband provider is assumed to incur a variable cost of $40 for an ordinary broadband user and $50 for a user that subscribes to the content product as well. Purchase of the content product is only possible if the broadband product is also purchased; a consumer purchases both products if the sum of her/his valuations of the two products

exceeds their combined price. The fixed costs of the broadband provider can be ignored in this analysis.

First, outcomes are described for five hypothetical situations (the illustrative scenarios), starting with the broadband price when the content product is not yet available.

1. The monopoly broadband provider sets a price for the broadband product to maximise its profit (labelled 'Broadband only') and the content product is not available (that is, its price is infinite).

2. The content provider independently prices the content product so as to maximise its revenue (labelled 'Content independent'). This can affect the profitability of the broadband product, of course. The prices determined after these two steps are the original prices that are used as inputs for the following two independent options.

3. The broadband provider unilaterally reprices the broadband product to maximise its profit, given that some customers use the higher-cost content product, using the original prices.

4. The broadband and content providers act in concert (labelled 'Joint effort') to determine a content product price that maximises the producer surplus (the sum of the total broadband profit and total content revenue), fixing the original broadband price. In this final step, one can imagine that the broadband and content providers develop a compensation mechanism to incentivise this, such as splitting the marginal increase in the producer surplus.

5. Both broadband and content prices are chosen jointly by the broadband and content providers (labelled 'Vertical integration') to maximise the producer surplus. This could be seen as a merger between the two providers.

Consumer surplus is, as usual, the sum of the differences between consumer valuations and the price they pay. Total surplus (or welfare) is the sum of producer and consumer surplus. Producer surplus is the sum of the profit of the broadband provider and the revenue of the content provider. We assume the content provider to have zero (equivalently, fixed) cost in order to incorporate the presumably very distinct cost structures of the two providers. To guarantee that each run of the model has the same outcome, customers evaluate their choices in a certain order (which is an artefact of the programming) and switch only when the alternative being examined has strictly greater utility to the consumer. Iterating through the options in a different order might give different results.

We consider only integer prices and valuations, and any scenario might have more than one equivalent solution with the same value of the objective function. Our algorithm would simply choose the first solution and then not revise it when equivalent options appear in the search order.

Second, we run the model (with floating-point real numbers as customer valuations, in order to reduce duplicity of solutions) for 100 000 iterations each with four different joint distributions of the customer willingness-to-pay for the two products. This produces the main results of the paper.

3 Illustrative scenarios

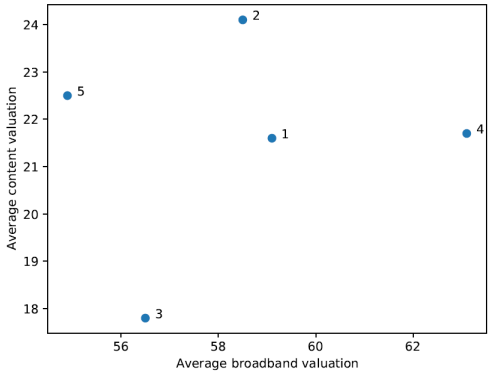

Figure 1: Consumer valuations in the different scenarios

We do not specify the distribution used to generate the random customer valuations as at this stage in the analysis we have not been attempting to determine what a typical case is, but rather explore the range of possible scenarios which can arise. We used a distribution which allowed us to easily generate a diverse range of outcomes for 10 consumers. Similar outcomes can be generated for 100 (or more) consumers. A small number of consumers (10 or 100, say) can be taken to reflect different consumer segments in a market. It is a well-known approach in marketing (if not in economic modelling) to consider discrete segments of the target audience and we believe that here, as in our past work, considerable insight can be gained from this.

The scenarios below were chosen by hand from a small number of trial runs of the model. The random seed used to generate a specific set of customer valuations is given in the Table in order to make the results easily reproducible. As is evident from Figure 1, the sample means and correlations in the scenarios do not indicate any specific trend. In the next section, we explore the trends for a large number of runs of this model.

3.1 Scenario 1

This scenario is a very simple one as there is nothing that can be achieved by repricing the broadband only (or by a joint effort). Introduction of the content product increases the uptake of the broadband product (from 2 to 3) as well as the broadband provider profit as per the hypothesis (of content providers) that content increases attractiveness of broadband. Table 1 shows the actual valuations of the ten consumers in this scenario as well as the random number seed (11912) that gives rise to this. The random number seeds used in this study were produced by a random number generator and then stored for easy replicability of the individual outcomes. Table 2 shows the outcomes for each market arrangement (one arrangement per row) in terms of the product prices and the surplus values. Table 3 shows how many units of each product is sold in this scenario for each market arrangement.

Consumer valuations (11912)	0	1	2	3	4	5	6	7	8	9	Average
Broadband	52	49	64	40	91	34	97	47	45	72	59.1
Content	23	24	18	20	17	26	28	16	13	31	21.6

Table 1: Consumer valuations in scenario 1

Outcomes	Broadband price	Content price	Broadband profit	Content revenue	Producer surplus	Consumer surplus	Total surplus
Broadband only	90	∞	100	0	100	8	108
Content independent	90	12	120	36	156	30	186
Repriced broadband	90	12	120	36	156	30	186
Joint effort	90	12	120	36	156	30	186
Vertical integration	102	0	156	0	156	30	186

Table 2: Outcomes for scenario 1

Unit sales	Broadband sales	Content sales
Broadband only	2	0
Content independent	3	3
Repriced broadband	3	3
Joint effort	3	3
Vertical integration	3	3

Table 3: Unit sales for scenario 1

It should be noted that coverage (total unit sales) is low in this scenario. There is no need and no room for coordination of the broadband and content provider, whether through repricing the content product only or through vertical integration. Here the vertical integration amounts to bundling of the two products, but since all broadband users also buy the content product as soon as it is introduced, this is of no consequence. Note that vertical integration would also not reduce consumer surplus. Introduction of the independently priced content product is strictly Pareto improving, also for consumers.

3.2 Scenario 2

Table 4 shows the actual valuations of the ten consumers in this scenario as well as the random number seed (776457) that gives rise to this scenario. Table 5 shows the outcomes for each market arrangement (one arrangement per row) in terms of the product prices and the surplus values. Table 6 shows how many units of each product is sold in this scenario for each market arrangement.

Introduction of the content product decreases broadband provider profit in this scenario since it increases cost and does not increase uptake of the product. The broadband provider would, however, be able to reprice in the presence of the content product, increasing its profitability over the broadband-only case. A joint effort repricing of the content product would set its price to \$1; this would increase the producer surplus over the content independent case but to a lesser extent than the repriced broadband. The vertical integration option would sharply increase producer surplus but dramatically reduce consumer surplus and unit sales for both products.

Consumer valuations (776457)	0	1	2	3	4	5	6	7	8	9	Average
Broadband	35	26	53	49	102	76	89	54	16	85	58.5
Content	20	14	27	32	0	34	33	23	34	24	24.1

Table 4: Consumer valuations in scenario 2

Outcomes	Broadband price	Content price	Broadband profit	Content revenue	Producer surplus	Consumer surplus	Total surplus
Broadband only	75	∞	140	0	140	52	192
Content independent	75	23	110	69	179	74	253
Repriced broadband	85	23	150	69	219	34	253
Joint effort	75	1	185	6	191	150	341
Vertical integration	101	7	214	21	235	18	253

Table 5: Outcomes for scenario 2

Unit sales	Broadband sales	Content sales
Broadband only	4	0
Content independent	4	3
Repriced broadband	4	3
Joint effort	7	6
Vertical integration	4	3

Table 6: Unit sales for scenario 2

This is again a fairly simple scenario where the broadband provider is able to react to the costs associated with the content product. Total surplus is however greater in the case of a joint effort (and uptake much higher), so some might see a case for a purely regulatory intervention. The broadband provider would have no incentive to coordinate with the content provider, since it could unilaterally increase the broadband price, thereby ending up with even higher profit without risking antagonising the content provider, as the repricing of the broadband product would not affect the content revenue. That is, collusion on repricing the content product seems unlikely unless the content provider can threaten to withdraw the content product. However, a regulator may find mandatory collusion desirable to obtain the joint effort outcome, given its consumer surplus superiority over the other options. Vertical integration will however be attractive to the producers, in the absence of any prohibition on it.

3.3 Scenario 3

Table 7 shows the actual valuations of the ten consumers in this scenario as well as the random number seed (3767446) that gives rise to this scenario. Table 8 shows the outcomes for each market arrangement (one arrangement per row) in terms of the product prices and the surplus values. Table 9 shows how many units of each product is sold in this scenario for each market arrangement.

In this scenario, the content product reduces broadband profitability in a way that the broadband provider cannot reverse by repricing the broadband product. Here, the content

Consumer valuations (3767446)	0	1	2	3	4	5	6	7	8	9	Average
Broadband	18	20	32	105	9	67	88	85	117	24	56.5
Content	13	24	18	30	17	13	9	16	23	15	17.8

Table 7: Consumer valuations in scenario 3

Outcomes	Broadband price	Content price	Broadband profit	Content revenue	Producer surplus	Consumer surplus	Total surplus
Broadband only	84	∞	176	0	176	59	235
Content independent	84	15	146	45	191	83	274
Repriced broadband	85	15	150	45	195	79	274
Joint effort	84	22	156	44	200	68	268
Vertical integration	84	22	156	44	200	68	268

Table 8: Outcomes for scenario 3

and broadband providers could act jointly by increasing the content price and increase the producer surplus. Vertical integration would lead to the same outcome.

Unit sales	Broadband sales	Content sales
Broadband only	4	0
Content independent	4	3
Repriced broadband	4	3
Joint effort	4	2
Vertical integration	4	2

Table 9: Unit sales for scenario 3

This is a case where the broadband provider is disadvantaged by the introduction of the content product, but in theory could incentivise the content provider by paying it to increase its price to \$22, which would imply a loss of \$1 in content revenue but an increase in \$6 broadband profitability. Any payment greater than \$1 but less than \$6 would leave both providers better off, but a regulator might prefer the simply repriced broadband case which has higher total (and consumer) surplus.

3.4 Scenario 4

Table 10 shows the actual valuations of the ten consumers in this scenario as well as the random number seed (705242) that gives rise to this scenario. Table 11 shows the outcomes for each market arrangement (one arrangement per row) in terms of the product prices and the surplus values. Table 12 shows how many units of each product is sold in this scenario for each market arrangement.

The broadband and content providers in this scenario have a clear incentive to act jointly. Repricing broadband after the introduction of the content product does not allow the broadband provider to restore its profitability and leaves the content provider and consumers worse off. The broadband provider would nevertheless choose to reprice broadband as a first response, as this would increase its profit from 72 to 98. Full vertical integration would have a small benefit for the producers over the joint effort situation.

Consumer valuations (705242)	0	1	2	3	4	5	6	7	8	9	Average
Broadband	50	98	94	69	45	59	57	70	44	45	63.1
Content	24	32	31	26	18	10	20	26	15	15	21.7

Table 10: Consumer valuations in scenario 4

Outcomes	Broadband price	Content price	Broadband profit	Content revenue	Producer surplus	Consumer surplus	Total surplus
Broadband only	68	∞	112	0	112	59	171
Content independent	68	25	72	100	172	74	246
Repriced broadband	99	25	98	50	148	7	155
Joint effort	68	25	72	100	172	74	246
Vertical integration	94	0	176	0	176	70	246

Table 11: Outcomes for scenario 4

Unit sales	Broadband sales	Content sales
Broadband only	4	0
Content independent	4	4
Repriced broadband	2	2
Joint effort	4	4
Vertical integration	4	4

Table 12: Unit sales for scenario 4

In this scenario, the content provider has revenue of \$100 in the joint effort case (if it could be achieved), which is \$50 more than if broadband were repriced. Were the content provider to pay the amount of \$26 (being $98-72$, or more) to the broadband provider, the broadband provider should accept the joint effort solution and a regulator should favour this case as it leaves consumers and producers better off. If the broadband provider is in the position to completely block the content product, it could demand additional compensation. Even if the content provider were to fully compensate the broadband firm (by \$40), the content provider would remain better off than with the broadband repriced at \$99. This scenario is one in which full cost recovery by the broadband provider leaves everyone better off. Vertical integration would have a similar effect.

3.5 Scenario 5

Table 13 shows the actual valuations of the ten consumers in this scenario as well as the random number seed (4241962) that gives rise to this scenario. Table 14 shows the outcomes for each market arrangement (one arrangement per row) in terms of the product prices and the surplus values. Table 15 shows how many units of each product is sold in this scenario for each market arrangement.

In this scenario, the broadband provider can recover a small part of its decrease in profit by effecting a small increase in broadband price after the introduction of the content product. Producer surplus is, however, maximised by a joint effort where the price of the content product is dropped to \$3. There is nothing to gain from full vertical integration, which has an outcome identical to the joint effort.

Consumer valuations (4241962)	0	1	2	3	4	5	6	7	8	9	Average
Broadband	78	17	45	87	57	59	91	45	52	18	54.9
Content	21	30	13	35	24	29	10	20	24	19	22.5

Table 13: Consumer valuations in scenario 5

Outcomes	Broadband price	Content price	Broadband profit	Content revenue	Producer surplus	Consumer surplus	Total surplus
Broadband only	77	∞	111	0	111	25	136
Content independent	77	20	91	40	131	41	172
Repriced broadband	78	20	94	40	134	38	172
Joint effort	77	3	135	15	150	91	241
Vertical integration	80	0	150	0	150	91	241

Table 14: Outcomes for scenario 5

Unit sales	Broadband sales	Content sales
Broadband only	3	0
Content independent	3	2
Repriced broadband	3	2
Joint effort	5	5
Vertical integration	5	5

Table 15: Unit sales for scenario 5

A regulator should favour the joint effort position (or, equivalently, vertical integration) which leaves producer and consumer surplus higher than it would otherwise be. In this scenario, the broadband provider would have to compensate the content provider for a loss in revenue of \$25 (being $40 - 15$). Since the broadband provider is \$41 (being $135 - 94$) better off than with simply repricing the broadband, it can afford to do so. Paying a full \$25 to the content provider would, however, leave the broadband firm worse off than before the content product was introduced because it would then have a nett profit of 110 (being $135 - 25$) rather that 111. The appropriate financial consideration to induce a joint effort should therefore be the subject of negotiation which would be strongly influenced by whether the broadband provider is able to block the content product to force a return to the initial (broadband only) case.

3.6 Synopsis of the illustrative scenarios

The five scenarios discussed above show that very different outcomes are possible for a broadband provider when a subscription content product is introduced. The difference lies in the specific structure of the customer valuations, rather than just average values. Naturally, these can be regarded as rough but nevertheless illustrative examples of what may arise in practice.

Scenarios 3, 4 and 5 illustrate circumstances where the broadband provider cannot recover its profitability after introduction of the content product through raising its uniform price for all consumers. What can follow in each of these circumstances depends on the relative

Scenario	Average broadband	Average content	Correlation
1	59.1	21.6	0.25
2	58.5	24.1	-0.25
3	56.5	17.8	0.27
4	63.1	21.7	0.81
5	54.9	22.5	-0.05

Table 16: Average product valuations for the 5 scenarios

Scenario	Best joint outcome for providers	Best outcome for consumers
1	Content product available, no repricing of broadband.	Same as for providers.
2	Vertical integration.	Regulator imposes cooperation between providers to reprice the content, reducing producer surplus and keeping original broadband price.
3	Broadband provider bribes content provider to increase content price / Vertical integration.	Content product available but no coordination between providers.
4	Vertical integration but content provider bribes broadband provider not to increase broadband price or content independently priced only slightly worse.	Vertical integration only slightly worse then other options but repriced broadband only is much worse.
5	Broadband provider bribes content provider to decrease content price or vertical integration.	Exactly the same as for providers.

Table 17: Most desirable outcomes for producers and consumers (respectively)

incentives and negotiating positions of the broadband and content providers. Full cost recovery by the broadband provider is one of the options and is a Pareto improvement in some scenarios. In scenario 2, the broadband provider is able to simply increase the broadband price, which is optimal for the firms but not for the consumer. Scenario 4 corresponds to a charge paid by the content provider for delivering its traffic to broadband users.

In all scenarios, the specific values of consumer valuations determines the outcome in a way that it is not determined directly by the average values, as we can see in Table 16 and in Figure 1.

It is rather, we suspect, the structure of consumer valuations that determines the outcome. The most desirable outcome from the point of view of broadband providers, content providers and consumers varies considerably. We cannot claim that any of the five scenarios is representative of possible outcomes, but to some extent this illustrates how looking at an average outcome can obfuscate the possible situations appearing in practice.

4 Main results

For the statistical analysis, we allow the customer valuations to have randomly selected floating-point values. This avoids having multiple equivalent customer choices at the cost of substantially increased data storage and slower processing. For each of the four distributions, we run the model 100 000 times – each time with different customer valuations. Where the firms face equivalent choices, a coin is flipped. The Python code for doing this

ran for more than 12 hours on a reasonably powered desktop computer and the data for the total of 400 000 iterations is over 500 megabytes (compressed). For each distribution, we represent the customer valuations graphically, compute the frequency with which each of the market arrangements was optimal with respect to producer, consumer and total surplus (respectively) and tabulate mean values.

Since the choices of the firms are restricted to integers, it frequently happens that two arrangements have the same outcome and therefore we tabulate the frequency of joint optimality for consumer surplus for each distribution. Note that the price of the content product is always infinite in the *Broadband only* arrangement and its mean is often infinite for certain arrangements, which is caused by at least one outcome (among the 100 000) where the outcome has the content product priced at the maximum in the search space, i.e. where it is effectively unavailable.

In every case, the arrangement *Vertical integration* optimises producer surplus (as expected) but consumer surplus is not necessarily optimised only by the *Content independent* arrangement for our 10 (groups of) consumers.

4.1 Independently uniformly distributed valuations

Consumer valuations are chosen independently and distributed uniformly random in the intervals [0,120] and [0,40] respectively. Table 19 shows that the joint effort and content independent outcomes are jointly optimal for consumer surplus 48.1% of the time and the likelihood of the former being optimal (61.8%) is not far behind that of the latter (71.4%) as shown in Table 18. Mean consumer surplus is higher for the joint effort than for any other arrangement as in Table 20.

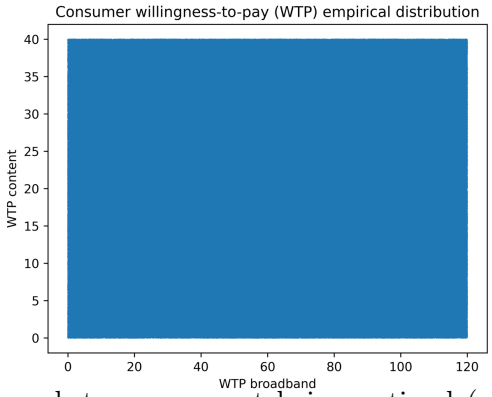

Figure 2: Frequency of market arrangement being optimal (percentage) (independently uniformly distributed)

	Producer surplus	Consumer surplus	Total surplus
Broadband only	0.4	0.0	0.4
Content independent	18.0	71.4	63.0
Repriced broadband	31.1	33.3	52.8
Joint effort	33.0	61.8	58.8
Vertical integration	100.0	36.2	75.8

Table 18: Frequency of market arrangement being optimal (percentage) (independently uniformly distributed)

Broadband only	Content independent	Repriced broadband	Joint effort	Vertical integration	
Broadband only	0.0	0.0	0.0	0.0	0.0
Content independent	0.0	71.4	29.2	48.1	17.4
Repriced broadband	0.0	29.2	33.3	24.7	17.9
Joint effort	0.0	48.1	24.7	61.8	23.7
Vertical integration	0.0	17.4	17.9	23.7	36.2

Table 19: Frequency of market arrangements being jointly optimal (percentage) for consumer surplus (independently uniformly distributed)

Outcomes	Broadband price	Content price	Broadband profit	Content revenue	Producer surplus	Consumer surplus	Total surplus
Broadband only	85.06	∞	173.28	0.00	173.28	48.30	221.58
Content independent	85.06	22.02	153.81	59.08	212.89	63.52	276.41
Repriced broadband	89.16	22.02	163.98	55.85	219.83	48.17	268.00
Joint effort	85.06	∞	166.30	53.28	219.58	66.20	285.78
Vertical integration	91.94	∞	196.89	34.96	231.85	59.51	291.35

Table 20: Mean outcome for each market arrangement (independently uniformly distributed)

4.2 Independently normally distributed valuations

Consumer valuations are chosen independently and normally distributed with mean 60 and standard deviation 15 or 20 and 10, respectively. Values outside the intervals [0,120] and [0,40] are rounded up or down but a uniform random value in the interval [0,1] is added to the bounds (when rounding) in order to avoid multiple equivalent outcomes. Once again, Table 23 shows that the mean consumer surplus is highest for the joint effort which is fairly likely to be jointly optimal (41.5% as in Table 22) with the independently priced content arrangement. Total surplus is only slightly lower than the vertical integration optimum. Table 21 shows that *Content independent* is more frequently optimal for consumer surplus even though it is not the optimal arrangement for mean consumer surplus (Table 23).

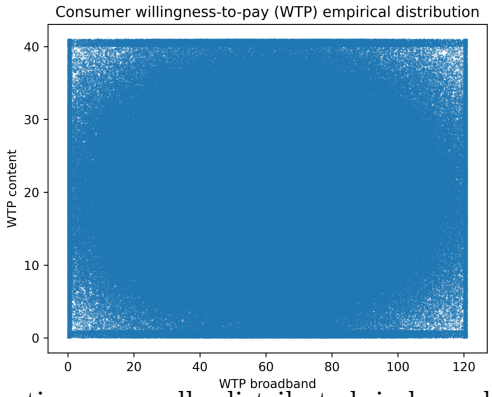

Figure 3: Consumer valuations normally distributed, independent (scatterplot of realised values)

	Producer surplus	Consumer surplus	Total surplus
Broadband only	0.0	0.0	0.0
Content independent	14.0	69.5	60.9
Repriced broadband	29.2	24.1	41.7
Joint effort	29.6	57.0	52.5
Vertical integration	100.0	34.1	71.1

Table 21: Frequency of market arrangement being optimal (percentage) (independently normally distributed)

	Broadband only	Content independent	Repriced broadband	Joint effort	Vertical integration
Broadband only	0.0	0.0	0.0	0.0	0.0
Content independent	0.0	69.5	20.2	41.5	13.5
Repriced broadband	0.0	20.2	24.1	17.8	13.2
Joint effort	0.0	41.5	17.8	57.0	20.8
Vertical integration	0.0	13.5	13.2	20.8	34.1

Table 22: Frequency of market arrangements being jointly optimal (percentage) for consumer surplus (independently normally distributed)

Outcomes	Broadband price	Content price	Broadband profit	Content revenue	Producer surplus	Consumer surplus	Total surplus
Broadband only	76.58	∞	145.58	0.00	145.58	51.90	197.48
Content independent	76.58	18.96	121.46	64.37	185.83	72.26	258.08
Repriced broadband	82.58	18.96	134.86	57.46	192.33	49.24	241.57
Joint effort	76.58	∞	135.20	57.54	192.74	74.25	266.99
Vertical integration	83.76	∞	170.76	34.04	204.80	68.18	272.98

Table 23: Mean outcome for each market arrangement (independently normally distributed)

4.3 Positively correlated normally distributed valuations

Valuations are chosen as in the previous subsection but from a joint normal distribution with a correlation of 0.6. Once again, the joint effort has superior consumer surplus in the mean (Table 26) and is both quite likely to optimise consumer surplus (64.9% by Table 24) and has near even odds (49.5% by Table 25) to be jointly optimal with the independently priced content.

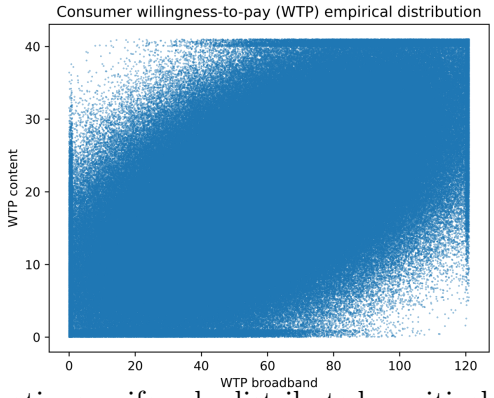

Figure 4: Consumer valuations uniformly distributed, positively correlated (scatterplot of realised values)

	Producer surplus	Consumer surplus	Total surplus
Broadband only	0.0	nan	0.0
Content independent	18.1	75.6	68.5
Repriced broadband	40.8	20.1	43.2
Joint effort	35.8	64.9	59.5
Vertical integration	100.0	35.6	74.2

Table 24: Frequency of market arrangement being optimal (percentage) (positively correlated normally distributed)

Broadband only	0.0	0.0	0.0	0.0	0.0
Content independent	0.0	75.6	18.3	49.5	17.5
Repriced broadband	0.0	18.3	20.1	17.0	14.4
Joint effort	0.0	49.5	17.0	64.9	26.8
Vertical integration	0.0	17.5	14.4	26.8	35.6

Table 25: Frequency of market arrangements being jointly optimal (percentage) for consumer surplus (positively correlated normally distributed)

Outcomes	Broadband price	Content price	Broadband profit	Content revenue	Producer surplus	Consumer surplus	Total surplus
Broadband only	76.64	∞	145.81	0.00	145.81	51.91	197.72
Content independent	76.64	21.99	113.57	81.40	194.96	75.31	270.27
Repriced broadband	85.32	21.99	127.46	71.09	198.55	46.83	245.38
Joint effort	76.64	∞	125.57	74.74	200.30	77.04	277.35
Vertical integration	88.26	∞	175.19	34.72	209.91	70.89	280.80

Table 26: Mean outcome for each market arrangement (positively correlated normally distributed)

4.4 Negatively correlated normally distributed valuations

Valuations are chosen as in the previous subsection but from a joint normal distribution with correlation of -0.6. The joint effort is considerably less likely to be jointly optimal with independently priced content (31.4%) than for the other distributions. This is consistent with expectations in the bundling literature, where negative correlation strongly favours bundling the products to increase sales. In practice, negative correlations between product valuations are thought to be common (for example) for television channels catering to divergent audiences.

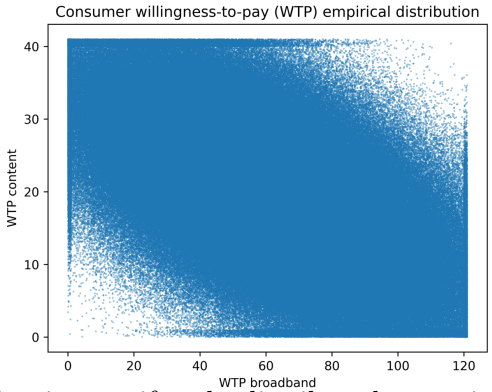

Figure 5: Consumer valuations uniformly distributed, negatively correlated (scatterplot of realised values)

	Producer surplus	Consumer surplus	Total surplus
Broadband only	0.5	0.0	0.6
Content independent	8.6	62.0	51.5
Repriced broadband	17.3	24.1	37.5
Joint effort	22.4	46.4	47.1
Vertical integration	100.0	31.7	69.4

Table 27: Frequency of market arrangement being optimal (percentage) (negatively correlated normally distributed)

Broadband only	0.0	0.0	0.0	0.0	0.0
Content independent	0.0	62.0	17.6	31.4	8.1
Repriced broadband	0.0	17.6	24.1	14.1	8.5
Joint effort	0.0	31.4	14.1	46.4	13.3
Vertical integration	0.0	8.1	8.5	13.3	31.7

Table 28: Frequency of market arrangements being jointly optimal (percentage) for consumer surplus (negatively correlated normally distributed)

Outcomes	Broadband price	Content price	Broadband profit	Content revenue	Producer surplus	Consumer surplus	Total surplus
Broadband only	76.52	∞	145.45	0.00	145.45	51.96	197.41
Content independent	76.52	14.57	125.39	49.19	174.58	68.46	243.04
Repriced broadband	80.28	14.57	138.90	44.28	183.18	51.06	234.24
Joint effort	76.52	∞	140.82	42.08	182.90	70.55	253.45
Vertical integration	80.55	∞	170.98	26.04	197.02	67.24	264.25

Table 29: Mean outcome for each market arrangement (negatively correlated normally distributed)

5 Analysis

For every distribution that we considered, the mean consumer surplus is worst for the arrangement *Repriced broadband* in which the broadband provider reacts by repricing the broadband product for all consumers. The mean consumer surplus is less in this arrangement even than before the introduction of the content product. However, for each of the four distributions, the mean consumer surplus values are relatively close (when compared to the other two arrangements) for the three arrangements

- content independent,
- join effort and
- vertical integration.

The independently priced content might however (likely) prompt the broadband provider to unilaterally reprice its product which results in the worst possible outcome. Note that the vertical integration arrangement (which can be reached through any form of cooperation between the firms) also has a better mean outcome for consumers than the repriced broadband. Simple repricing of the broadband product has the lowest mean consumer surplus for every joint distribution, and it is in every case less likely to maximise consumer surplus than is vertical integration.

The market arrangements that we describe do not explicitly include paid peering, where the content provider would explicitly pay the broadband provider for delivery of its content. The possibility of paid peering is however implied. In order to avoid the real possibility of the broadband provider unilaterally repricing the broadband product, the content firm might select to pay for delivery. In the joint effort arrangement, the content provider might choose to do the same. In fact, the payment could also go the other way. In the vertical integration arrangement of maximal cooperation, the same is possible. The possible outcomes depend on the structure of the consumer valuations, as illustrated by our stylised examples in Section 3. What is abundantly clear however is that the reaction of the broadband provider to reprice the broadband service in response (without any other coordination) is a bad outcome for consumers. The outcome that might arise in a market where payments are freely negotiated between the firms will, of course, depend on the relative negotiating power of the broadband and content provider.

6 Discussion

The escalating war of words between content and broadband providers revolves around two apparently opposing statements.

1. Broadband providers assert that they provide a content delivery service to the small number of streaming video giants that account for over 70% of traffic on their networks and, if necessary, the authorities should force content providers to pay for the service.

2. Content providers retort that streaming video has made broadband a far more valuable service and that delivery of movies, music and other copyrighted material should be free and, if necessary, the authorities should force broadband providers to provide the delivery service for free.

Both points of view are partly factual and partly wishful thinking. They can be broken down into four more likely tenets.

A The bulk of broadband traffic today consists of streaming media content that is delivered by a small number of global firms.

B This streaming media content has massively enhanced the utility of home broadband and people love it.

C Content providers have developed a myriad of ways to monetise the content, be it through advertising, paid content bundles, image quality (standard definition versus high definition and so on), tolerating or (alternately) cracking down on password sharing etc.

D Broadband providers have only started to find ways to monetise the consumer demand for streaming media traffic and are constrained (in most markets) by long-standing pricing practices as well as by 'network neutrality' rules of varying stringency.

Tenets (A) to (C) are not controversial. One solution is paid peering which has been discussed in this paper and by [11] where both works conclude that depending on the circumstances, the optimal payment could be either zero or from the content provider to the broadband provider or, in fact, in the opposite direction. This paper specifically looks at coordinated pricing of the broadband and content products as a complete service bundle. It does not however fully incorporate the possibility that both the broadband and content provider could differentiate their products. However, it clearly illustrates that the arrangements (free settlement, sending party pays or receiving party pays) that arise can depend purely on the underlying distribution of consumer valuations of the broadband (separate) and content products.

In order to understand why (D) is completely reasonable, it is necessary to consider the economics of goods (or services) with high sunk cost. Both broadband access and streaming content production have this property although broadband providers have higher ongoing expenses when they increase coverage or have to upgrade their infrastructure to handle higher traffic loads, especially in the middle-mile consisting of routers, backhaul connections and other hardware. Pure digital goods are intangible goods in digital form and have near-zero cost of reproduction. Marginal cost of production for a firm is almost nothing. Examples include software, entertainment and many services. These are often protected by intellectual property law. Pricing of digital goods is about extracting maximum revenue for a given set of consumer preferences through appropriate pricing mechanisms – e.g. subscription TV bundles, Audible plans etc.

Many goods and services that are not purely digital also have high sunk costs and the marginal cost of production is low. Examples include mobile network usage, gym memberships and (to a lesser extent) fibre connections. Pricing of these goods and services is also driven mainly by how revenue can be extracted for a given set of consumer preferences and bundling plays an important role. We can call these near digital goods. The mechanism that firms use is called price discrimination in economics and it amounts to charging somewhat higher prices to customers with a high willingness to pay (similar to upmarket supermarkets) and lower prices to customers with a lower willingness to pay (similar to discount supermarkets) through a variegated product offering, including bundles.

Bundling is a well-known mechanism for increasing consumer welfare in many circumstances. The customer recognises that overall value of the bundling is a better deal than buying the elements individually. The reason for this is well understood: consumer preferences are highly diverse and by bundling products (and by creating a variety of bundles) it is possible to increase overall sales compared to the case of unbundled pricing. Consumer mobile packages are often sold as bundles of data, voice minutes, SMS and more (often including a handset). Pay television channels are not sold separately but in packages. Bundling is a key feature in the markets where information goods are exchanged. Information goods include music and other audio streaming, gaming and subscription television or video streaming services that make up a substantial share of the modern economy.

For bundling to actually happen, there has to be a variety of goods (or services) that can constitute the bundle. This is decidedly not an issue for content providers who have no lack of variety. It is however an issue for broadband providers, especially when we have uniform pricing where a service trades at a single price over a large territory where varying (sunk) costs are in play. Regulating the ability to bundle can be harmful: more products and more bundles help firms to appropriately price (near) digital goods so as to increase revenue and uptake.

Regulations on 'network neutrality' inhibited the ability of broadband providers to innovate and differentiate the product but it has no effect on content providers' ability to do the same. Whereas content providers frequently complain about broadband providers' throttling of streaming content when there is network congestion, it is well documented that Netflix (for example) used to throttle its DVD-by-mail subscribers[1].

It is helpful to consider two jurisdictions which have never had 'network neutrality' in order to observe how wired (generally, unmetered) and wireless (generally, unmetered) networks can manage to differentiate their access product. Australia has mainly wired broadband in households (with a very high percentage fibre) and South Africa has mainly mobile broadband for the majority of the population.

The two case studies suggest that markets can work out a variety of arrangements that ensure that consumers receive the content that they crave without putting the shackles on how broadband providers can charge. As in the case of Optus in Australia, this can involve some revenue sharing between the content provider (Netflix and others) and the operator (Optus). In South Africa, it is likely that most of the content consumed by users

[1]Netflix 'Throttling' the Brakes on Frequent Renters? `https://www.foxnews.com/story/netflix-throttling-the-brakes-on-frequent-renters` (2015)

on mobile networks is advertising supported and the same model is not available. Mobile operators do not have market power which is one of the factors implying that the absence of 'network neutrality' regulation is not a problem [15]. For mobile operators especially the absence of market power might indicate the suitability of some regulation to enable fair cost recovery from content providers (who have some market power due to copyright law).

6.1 Australia (wired broadband)

A metered broadband market prevailed in Australia for longer than in many other developed countries with 'data caps' and high overage (out-of-bundle) charges a common practice until recently. In this market, Netflix initially had no qualms about entering into deals with major broadband providers to have Netflix traffic exempted from data caps although there was some handwringing about this later on[2]. These agreements had a commercial basis[3].

Bulletin boards and social media in Australia have recently alleged that broadband providers sometimes throttle Netflix (and other streaming media traffic) but it is entirely possible that this is merely a marketing tool for VPN providers who claim to bypass this. Instead, new forms of cooperation between broadband and content providers have emerged. Major telecommunications operator Optus in 2022 included Netflix as option on its SubHub[4] streaming content subscription platform. That is, Optus broadband users pay a monthly feee for SubHub, from which they can then add Netflix (at $6 for the standard service) as an option. This is exactly the kind of commercial arrangement that the simulation work in this paper suggests would be observed.

6.2 South Africa (wireless broadband)

Mobile broadband in South Africa is mainly metered, with a few exceptions, and prepaid. Network operators bundle some local content services for mobile devices with data packages or make the content services available at discounted rates. Consumer can buy data (at a discount) that can be used only for one service e.g. WhatsApp. They can also buy packages with bundles of different kinds of data: X gigabytes general data, Y gigabytes WhatsApp and Z gigabytes streaming audio or video (on partner providers) for a fixed single price and period of validity. Mobile data traffic in the country is increasing at a rate of 20% per year[5].

The fact that 'social bundles' of content-specific data sell at a discount to general purpose data (which it should, otherwise there would be no point) should be read in conjunction

[2]Netflix regrets unmetered data deals with Optus, iiNet `https://www.smh.com.au/technology/netflix-regrets-unmetered-data-deals-with-optus-iinet-20150416-1mm5ey.html` (2015)

[3]Netflix opposes data cap exemptions, except when it benefits from them `https://arstechnica.com/information-technology/2015/03/netflix-opposes-data-cap-exemptions-except-when-it-benefits-from-them/` (2015)

[4]Optus bags Netflix as a SubHub partner `https://www.reviews.org/au/mobile/optus-bags-netflix-as-a-subhub-partner/` (2022)

[5]Vodacom's revenue breaches R100bn amid booming data demand `https://www.news24.com/fin24/companies/vodacoms-revenue-breaches-r100bn-amid-booming-data-demand-20220516` (2022)

with this data being sold in relatively big units or bundled in with general purpose data so that the revenue per gigabyte of (for example) YouTube data actually consumed need not necessarily be lower than for general-purpose data.

7 Conclusion

The model that we have considered is a very simple one that nevertheless illustrates how the optimal outcomes for producers and consumers, as well as the most desirable degree of cooperation between producers, are contingent on the structure of consumer valuations. Weak points of the model include:

- monopolies in content and in broadband provision;
- no empirical confirmation of proposed consumer valuations;
- no investigation of the effect of varying the cost to the broadband provider that is imposed by users of the content service;
- undifferentiated products.

Nevertheless, we believe the model to be useful in understanding the interactions that can arise between content and access providers; we are convinced that it goes some way towards detracting from the often-articulated sentiment that content always makes the access product more valuable and that the content should be delivered without further financial consideration ('Network Neutrality'). Furthermore, the scenarios illustrate that producer and consumer preference in this regard are sometimes aligned and at other times not.

Our findings can be contrasted with those of [11] who nevertheless also conclude that settlement-free peering is not always optimal. [20] found that both profit-optimal and welfare-optimal strategies for broadband providers would include both settlement-free and paid peering, which is consistent with the scenarios which we have discussed here.

Our discrete scenarios illustrate that the optimal direction of payment (and indeed if there should be one) is highly context-dependent, and that context is determined ultimately by consumers and not producers or regulators. Empirical evidence from Australia and from South Africa suggest the coordination can and does take place in practice. The main result of the statistical analysis is that it is very unlikely for the market arrangement where broadband is simply repriced as reaction to the introduction of the content product to be optimal. In fact, some kind of paid peering is the most likely optimal outcome and produces superior consumer surplus. However, the probability of this depends on the distribution of the consumer valuations.

The detailed analysis poses some challenges for sector governance – the optimal payments may differ significantly even within a single regulatory territory, rendering "one rule fits all" decisions on the direction and magnitude of payments problematic. It also challenges content and conduit providers to understand more about consumer preferences before reaching for litigation or lobbying to mediate payment disputes.

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