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What do telecommunications policy academics have to fear from GPT-3?

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Abstract

Artificial intelligence (AI) tools such as ChatGPT and GPT-3 have shot to prominence recently (Lin 2023), as dramatic advances have shown them to be capable of writing plausible output that is difficult to distinguish from human-authored content. Unsurprisingly, this has led to concerns about their use by students in tertiary education contexts (Swiecki et al. 2022) and it has led to them being banned in some school districts in the United States (e.g. Rosenblatt 2023; Clarridge 2023) and from at least one top-ranking international university (e.g. Reuters 2023). There are legitimate reasons for such fears to be held, as it is difficult to differentiate students' own written work presented for assessment from that produced by the AI tools. Successfully embedding them into educational contexts requires an understanding of the tools, what they are, and what they can and cannot do. Despite their powerful modelling and description capabilities, these tools have (at least currently) significant issues and limitations (Zhang & Li 2021).

As telecommunications policy academics charged with the research-led teaching and supervising both undergraduate and research students, we need to be certain that our graduates are capable of understanding the complexities of current issues in this incredibly dynamic field and applying their learnings appropriately in industry and policy environments. We must be reasonably certain that the grades we assign are based on the students' own work and understanding. To this end, we engaged in an experiment with the current (Q1 of 2023) version of the AI tool to assess how well it coped with questions on a core and current topic in telecommunications policy education: the effects of access regulation (local loop unbundling) on broadband investment and uptake. We found that while the outputs were well-written and appeared plausible, there were significant systematic errors which, once academics are aware of them, can be exploited to avoid the risk of AI use severely undermining the credibility of the assessments we make of students' written work, at least for the time being and in respect of the version of chatbot software we used.

Keywords

Artificial Intelligence (AI); ChatGPT; GPT-3; Academia

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1 Introduction

Academic integrity in both teaching (Christensen & Eaton 2022) and research (Cabanac 2022) is under assault and the attack is powered by modern communication and technology tools – just as legitimate science is. Artificial intelligence (AI) tools such as ChatGPT and GPT-3 have shot to prominence recently (Lin 2023), as dramatic advances have shown them to be capable of writing plausible output that is difficult to distinguish from human-authored content. In response to prompts, the tools can (inter alia) write essays, answer complex questions, match pronouns to their nouns, and conduct sentiment analyses (Sezgin et al. 2022). Indeed, it has been demonstrated that GPT-3 can write a credible academic paper on itself with minimal human input (Thunström & Steingrímsson 2022).

Unsurprisingly, this has led to concerns about their use in many contexts. The credibility of any content is called into question if the veracity of its origins cannot be quickly and easily (not to mention relatively costlessly) ascertained. This is especially important for complex content where comparatively uninformed individuals must rely on summaries and advice produced by (they hope) informed and reliable experts (Akerlof, 1970). It is also important for work produced by students in tertiary education contexts (Swiecki et al. 2022). If an academic cannot distinguish whether work handed in for assessment was created by AI or the student, then how reliable will any assessment activity be in conveying a credible signal to society that the student has mastered the core learning objectives embedded in the assessment exercise? This has led to them being banned in some school districts in the United States (e.g. Rosenblatt 2023; Clarridge 2023) and from at least one top-ranking international university (e.g. Reuters 2023). The issue is particularly relevant for online and distance learning or where there might be no invigilated in-person assessment during a course or entire degree programme, which is the case for the institution of the second author.

On the one hand, there are legitimate reasons for such fears to be held, as it can be difficult to differentiate students' own written work presented for assessment from that produced by the AI tools. Professors from the University of Pennsylvania have observed that "AI is not coming. AI is here. And it cannot be banned. So, what should we do?" (Duckworth and Ungar 2023). As banning will lead to "an escalating arms race between digitally-fluent teenagers and their educators that is unlikely to lead to a decisive victory for the latter", they propose teachers should explore ways to embed chatbots into their teaching and learning processes. As with any modern workplace tool, this is to some extent inevitable.

However, successfully embedding these tools into educational contexts requires a good understanding of the tools, what they are, and what they can and cannot do. Despite their powerful modelling and description capabilities, these tools have (at least currently) significant issues and limitations (Zhang & Li 2021). Katar et al. (2022) suggest that when applied to writing research papers, the AI tools can:

- make mistakes and generate text that is not factually correct or coherent, leading to outputs of questionable reliability and validity;
- be trained on text data with inherent biases, leading to output that may not accurately reflect the diversity of perspectives and experiences in the field; and
- generate research papers that may undermine the credibility and authority of human researchers.

As telecommunications policy academics charged with the research-led teaching and supervising of both undergraduate and research students, we need to be certain that our graduates are capable of understanding the complexities of current issues in this incredibly dynamic field and applying their learnings appropriately in industry and policy environments into which they proceed (or in many cases, are already engaged). That is, we must be reasonably certain that the grades we assign are based on the students' own work and understanding. Otherwise, the entire industry faces the risk of not being able to trust the integrity of graduates' qualifications. To this end, we engaged in an experiment with the current version of the AI tool GPT-3 to assess how well it coped with questions on a core and current topic in telecommunications policy education: the effects of access regulation (local loop unbundling) on broadband investment and uptake. We found that while the outputs were well-written and appeared plausible, there were significant

systematic errors which, once academics are aware of them, can be exploited to avoid the risk of AI use severely undermining the credibility of the assessments we make of students' written work, at least for the time being and in respect of the version of chatbot software we used.

The paper proceeds as follows. First, we briefly examine the nature of Natural Language Processing (NLP) AI tools and discusses the specific characteristics of GPT-3. This section also discusses the challenges it poses for academic assessment processes. Next, we describe the methodology used for our GPT-3 experiment. We then discuss the outputs and their implications for teaching, learning and assessment in the field of telecommunications policy education. Finally, we draw conclusions.

We find that, at the present point in time (Q1 of 2023), an expert telecommunications policy academic is unlikely to give a passing grade to student essays produced on specialist topics using GPT-3 (or competitors). Indeed, it suggests that the quickest way to detect likely instances of use is to routinely subject a sample of references from students' work to a credibility check. And, as we intend, to make our students aware ex ante of the tool's limitations and the fact that we will be reference-checking. That way at least, if students wish to use it, they will have to engage with the actual literature to find genuine articles to argue the case and, inadvertently, likely fulfil the learning objectives intended in the first place!

2 Background

ChatGPT and GPT-3 are two (albeit recent) examples of natural language processing (NLP) applications. These two are produced by OpenAI – originally the university-based Stanford Institute for Human-Centered Artificial Intelligence but now part of Microsoft. GPT is an acronym of *Generative Pre-trained Transformer*. They build on a long line of such applications, including Google Translate. To date, GPT-3 (and its affiliate model ChatGPT) is the language model with the largest number of parameters, scale and volume of internet text and books used for its training (Zhang & Li 2021). It uses sophisticated mathematical modelling to capture myriads of valuable information from its massive text data and dynamically generate accurate vector representations and probabilities of words, phrases, sentences, and paragraphs with contextual information. It is capable of achieving very realistic results on a variety of tasks, including question answering, reading comprehension, text implication, semantic similarity matching, text summarisation, code generation, story creation, and more.

GPT-3 is a pre-trained model which has evolved from earlier models which used discrete statistical models based on frequency to calculate the probability of occurrence of a given language segment or to predict the probability of occurrence of the next word given the previous context. These models had poor description ability, low robustness, and low accuracy. Pre-trained language models use neural networks, combining powerful mathematical tools (such as derivable and differential methods) and extremely large data sets to create tools with superior context modelling ability and delivering more accurate probability calculation and a dynamic vector representation of language fragments with a stronger context correlation than their predecessors. GPT-3 has developed from its two earlier iterations to provide ever-better outputs and more generalisable task responses using an ever-increasing number of parameters. However, GPT-3 is still essentially a data-driven model, so its capabilities are influenced by the coverage, capability and quality of the fitted data. It is considered to have “memory with a certain ability to generalize, due to which it easily retains and learns declarative knowledge, rather than understand knowledge, and does not possess true logical reasoning ability or the ability to distinguish right from wrong.” (Zhang & Li 2021, p 832). These limitations have led some to characterise it as one of a number of “stochastic parrots” (Bender et al. 2021).

Specifically, even though vast amounts of data have been used in its creation, each version is based on a static set of inputs as at the time of its training. The large amounts of computer resource required mean that the creation of each updated version of such pre-trained models has a non-trivial cost in dollars and carbon emissions (Strubell et al. 2019). The current publicly-available version of ChatGPT was finalised in 2021 (although it is expected a new version will be available imminently). Hence, it cannot have within

its repositories any novel content or ideas generated after that date. Furthermore, to the extent that the data used in training it contained any problematic characteristics (e.g. biases or errors – shown to be highly likely despite endeavours to sample widely and to scrub harmful material) then these will be reflected in the outputs generated. Moreover, the size of the training data does not guarantee that the set has captured of a wide diversity of views and language usage patterns representative of society as a whole (e.g. those of non-internet users or those of groups under-represented on the internet).

AI tools such as GPT-3 provide both challenges and opportunities for educators. While it is acknowledged that AI can be harnessed in many positive ways to enhance student learning, and to assist educators in designing clearly written assessment tasks (Swiecki et al. 2022), particular challenges pertain to assessment. A mounting fear currently is that some students will use the tool in response to formal assessment tasks in such a way that they avoid undertaking the key learning activities that the assessment is designed to measure. Specifically, some may avoid time-intensive and complex learning activities by simply entering the assessment question as a prompt and then submitting output produced for assessment. Before these tools, students would also have been able to outsource the task but at a non-trivial cost in money and time.

By submitting work or ideas that are not the student's own, plagiarism has occurred. As each submission of the same question (prompt) produces a different written output (that is, each is creatively original), the tools usually relied upon to detect plagiarism (e.g. Turnitin) that match on the basis of large sections copied material will no longer be effective in assisting educators in ascertaining whether the assessed work is the student's own or, at the very least, actually written by a human being. As the tools improve, it is becoming increasingly difficult for humans to perceive whether the text is human- or AI-generated (Kreps et al. 2022). Plagiarism risk is especially worrisome in a tertiary education context, as the large numbers of students in each lecture class, and the extent to which students are expected to conduct self-motivated learning activities unsupervised, lead to high reliance upon assessment of written work (notably essays) to verify they have mastered key learning objectives.

For specialist subjects such as telecommunications policy, where the issues are both complex and at times controversial, essays provide the best opportunity for students to display both their understanding and critical thinking on the relevant issues. It also enables them to critique and propose novel solutions to a range of legal, regulatory and policy dilemmas. Essays allow the student time to think through the issues and consequences, and to ensure that their answers are logically consistent. Written form is also the most frequent way these matters are communicated within the practitioner community. While alternative assessment methods such as oral interviews and presentations may be used, these are more time-consuming (costly) for the educator to grade than written work and it may prove more challenging for students to capture and convey the relevant complexities. These assessment methods have their place in assessing other learning objectives (e.g. ability to summarise, presentation skills), but they are not perfect substitutes for assessment of the relevant comprehension and critical evaluation skills. They also place students under an additional stresses that may impair some students' performance and hence ability to signal their level of skill mastery.

It should also be remarked that earlier versions of the tools (e.g. GPT-2 or BERT) have been widely available for some years, including in versions that have been custom-trained for specific tasks such as paraphrase plagiarism (Wahle et al. 2021). The more recent models produce paraphrases text that is highly rated by human experts and difficult to algorithmically differentiate from original text (Wahle et al. 2022). Such tools are already fairly widely used by academic (Khabib 2022) as well as journalists and other professionals. Although ongoing research aims to build models to detect AI-generated text, this is subject to a gigantic *caveat*.

Every fast and effective tool to detect AI-generated content can also be incorporated into an AI content generation model to filter its own outputs and only return outputs which pass the AI-detection test.

Since AI-generated content is suddenly incredibly cheap, the only technological solution for academics would be a very effective detection tool for which it is known (with little doubt) that no fast or cheap version exists. The inevitable progress of technology renders this relatively unlikely.

So, should telecommunications policy academics be concerned at the current point of time about the risk of students exploiting the capacities of AI tools to subvert assessment processes by cheaply producing work that merits a passing grade? While fears may be real, we note also that currently the tools are prone to make mistakes and generate text that is not factually correct or coherent, leading to outputs of questionable reliability and validity (Katar et al. 2022). If they are not as yet capable of producing credible output, then such fears may be a little premature. This doesn't mean that at some time in the future, the tools may be capable of producing better outputs, but it does buy a little more time to evaluate a range of options for the future direction of the field.

3 Methodology

We created an experiment to test the capabilities of GPT-3 to produce a response to a question commonly used in our teaching, reflecting a significant issue: the effect of access regulation on broadband uptake and investment. This issue is topical and controversial, due to different regulatory approaches being taken in different jurisdictions (notably the United States and the European Union). It is important not just in respect of single technologies (e.g. optical fibre) but also between technologies (notably legacy and frontier networks, such as copper and fibre). The effects are nuanced, with distinctions between short-term and long-term outcomes. This question is at the upper-level undergraduate or graduate level.

A balanced academic assessment of the topic will (in our view) require careful and considered critical evaluation of the various effects. A good answer will require the student to search the literature, identify the main themes

- that access regulation increases competition and broadband uptake in the short term due to many providers being able to offer differentiated services provided on one deployed network (service competition)
- but appears to inhibit network investment in the long run, both on the network in question and new network technologies.

In the long run, broadband uptake is also impaired, as competition between different network types (facilities competition) enables a greater range of products and services to be bundled with broadband access, thereby increasing the addressable customer base.

We posed a range of prompts to the playground version of the model text-davinci-003 on the OpenAI website (<https://platform.openai.com/playground>). For each prompt, we asked for a referenced academic literature review, as this is the type of report we would typically be looking for our students - graduate level and post-experience/professional - to produce. The maximum length was set at 3000 and we asked for the best of 3 efforts. We ran 5 passes of each prompt. The outputs generated and the marking rubrics used for Table 1 are available from the authors on request.

The first prompt was "Write a referenced academic literature review on the effect of local loop unbundling on broadband uptake". This asked about a specific form of access regulation: local loop unbundling. We expected responses to this prompt to focus specifically on copper networks, and to tease out differences between services and facilities competition.

Next, we refined the prompt to "Write a referenced academic literature review on the effect of local loop unbundling on broadband investment and uptake". This prompt was intended to tease out the different effects on uptake and investment.

The third prompt was "Write a referenced academic literature review on the effect of local loop unbundling

on fibre broadband investment and uptake”. This was intended to identify the tensions between benefits from increasing uptake on the legacy (copper) technology but depressing incentives to invest in and delaying deployment of the frontier (fibre) technology.

Fourth, we relaxed the strict requirement on local loop unbundling, and focused the question on fibre: “Write a referenced academic literature review on the effect of access regulation on fibre broadband investment and uptake”.

Finally, we refined the prompt with a specific request to compare the different positions in the European Union and the United States: “Write a referenced academic literature review on the effect of access regulation on fibre broadband investment and uptake, comparing the US and EU”.

The 25 unique outputs generated were then evaluated by a panel of three, made up of an experienced academic researcher (one of the authors) and two experienced tutors, using standard marking rubrics on a scale of 1 (unsatisfactory) to 5 (excellent) across four dimensions:

- correct identification of relevant themes;
- correct attribution and referencing;
- critical evaluation; and
- coherence and clarity of writing.

The marking rubric is the same one used to assess actual essay submissions by graduate level students for several years, based on a pass mark of 50 percent. The final mark awarded was the average of the three scores. The marks were then moderated against historic examples marked using the same rubric to verify consistency.

We discuss the results below and provide the full set of prompts and outputs as an appendix. Few attempts garnered a grade of 10 or higher out of 20.

4 Results

The results against the assessment rubrics are displayed in Table 1 for the 5 prompts (with 5 samples each) and four assessment criteria.

Table 1: Marker 1 results

Prompt	Sample	Identification	Referencing	Evaluation	Coherence	Total (out of 20)	Average for prompt
1	1	2.0	1.5	1.0	4.5	9.0	8.80
	2	2.5	1.5	2.0	4.5	10.5	
	3	2.0	1.0	1.0	4.0	8.0	
	4	2.0	1.0	1.0	4.0	8.0	
	5	2.0	1.5	1.0	4.0	8.5	
2	1	2.5	1.0	1.0	4.5	9.0	9.00
	2	2.0	1.0	1.0	4.0	8.0	
	3	2.0	1.0	1.0	4.0	8.0	
	4	2.0	1.5	1.0	4.5	9.0	
	5	2.5	1.5	2.5	4.5	11.0	
3	1	2.5	1.5	1.5	4.0	9.5	
	2	2.0	1.5	1.0	4.0	8.5	
	3	2.0	1.0	1.0	4.0	8.0	

Prompt	Sample	Identification	Referencing	Evaluation	Coherence	Total (out of 20)	Average for prompt
	4	3.5	1.5	2.5	4.5	12.0	9.30
	5	2.0	1.5	1.0	4.0	8.5	
4	1	3.0	1.0	1.0	4.0	9.0	9.90
	2	3.0	1.0	1.0	4.0	9.0	
	3	3.0	1.0	1.5	4.0	9.5	
	4	3.5	1.0	2.0	4.5	11.0	
	5	3.0	1.0	2.5	4.5	11.0	
5	1	3.0	1.0	2.0	4.0	10.0	9.90
	2	3.5	1.0	1.5	4.5	10.5	
	3	2.5	1.0	1.5	3.5	8.5	
	4	3.0	1.5	1.0	4.5	10.0	
	5	3.5	1.5	1.0	4.5	10.5	
Average		2.58	1.22	1.38	4.20	9.38	

Table 2: Marker 2 results

Prompt	Sample	Identification	Referencing	Evaluation	Coherence	Total (out of 20)	Average for prompt
1	1	2.0	1.5	1.0	4.5	9.0	9.20
	2	2.5	1.5	2.0	4.5	10.5	
	3	2.5	1.0	1.0	4.0	8.5	
	4	2.5	1.0	1.5	4.0	9.0	
	5	2.0	1.5	1.5	4.0	9.0	
2	1	2.5	1.0	1.0	4.0	8.5	9.70
	2	2.5	1.5	1.5	4.0	9.5	
	3	2.5	1.0	1.5	4.5	9.5	
	4	2.5	1.5	1.5	4.5	10.0	
	5	2.5	1.5	2.5	4.5	11.0	
3	1	3.0	1.5	1.5	4.0	10.0	9.80
	2	2.5	1.5	1.0	4.0	9.0	
	3	2.5	1.0	1.0	4.0	8.5	
	4	3.5	2.0	3.0	4.5	13.0	
	5	2.0	1.5	1.0	4.0	8.5	
4	1	3.0	1.0	1.0	4.0	9.0	10.10
	2	3.0	1.0	1.5	4.0	9.5	
	3	3.0	1.0	1.5	4.0	9.5	
	4	3.5	1.0	2.0	4.5	11.0	
	5	3.5	1.0	2.5	4.5	11.5	
5	1	3.0	1.0	2.0	4.0	10.0	
	2	3.5	1.0	1.5	4.5	10.5	

Prompt	Sample	Identification	Referencing	Evaluation	Coherence	Total (out of 20)	Average for prompt
	3	3.0	1.5	1.5	4.0	10.0	
	4	3.0	1.5	1.5	4.0	10.0	
	5	4.0	1.5	1.0	4.5	11.0	10.30
	Average	2.80	1.28	1.54	4.20	9.82	

Table 3: Marker 3 results

Prompt	Sample	Identification	Referencing	Evaluation	Coherence	Total (out of 20)	Average for prompt
1	1	2.0	1.5	1.0	4.5	9.0	
	2	2.5	1.5	2.0	4.5	10.5	
	3	2.5	1.0	1.5	4.5	9.5	
	4	2.0	1.0	1.0	4.0	8.0	
	5	2.0	1.5	1.0	4.0	8.5	9.10
2	1	2.5	1.0	1.0	4.5	9.0	
	2	2.0	1.0	1.0	4.0	8.0	
	3	2.0	1.0	1.5	4.0	8.5	
	4	2.0	1.5	1.0	4.5	9.0	
	5	2.5	1.5	2.5	4.5	11.0	9.10
3	1	2.5	1.5	1.5	4.0	9.5	
	2	2.0	1.5	1.0	4.0	8.5	
	3	2.0	1.0	1.0	4.0	8.0	
	4	3.5	1.5	3.0	4.5	12.5	
	5	2.0	1.5	1.0	4.0	8.5	9.40
4	1	3.0	1.0	1.0	4.0	9.0	
	2	3.0	1.0	1.0	4.0	9.0	
	3	3.0	1.5	1.5	4.0	10.0	
	4	3.5	1.0	2.0	4.5	11.0	
	5	3.0	1.0	2.5	4.5	11.0	10.00
5	1	3.5	1.0	2.0	4.0	10.5	
	2	3.5	1.0	1.5	4.0	10.0	
	3	3.0	1.0	1.5	4.0	9.5	
	4	3.5	1.5	1.0	4.5	10.5	
	5	3.5	1.5	1.0	4.5	10.5	10.20
	Average	2.66	1.24	1.44	4.22	9.56	

Table 4: Average results for the three markers

Prompt	Sample	Identification	Referencing	Evaluation	Coherence	Total (out of 20)	Average for prompt
1	1	2.0	1.5	1.0	4.5	9.0	9.03
	2	2.5	1.5	2.0	4.5	10.5	
	3	2.3	1.0	1.2	4.2	8.7	
	4	2.2	1.0	1.2	4.0	8.3	
	5	2.0	1.5	1.2	4.0	8.7	
2	1	2.5	1.0	1.0	4.3	8.8	9.27
	2	2.2	1.2	1.2	4.0	8.5	
	3	2.2	1.0	1.3	4.2	8.7	
	4	2.2	1.5	1.2	4.5	9.3	
	5	2.5	1.5	2.5	4.5	11.0	
3	1	2.7	1.5	1.5	4.0	9.7	9.50
	2	2.2	1.5	1.0	4.0	8.7	
	3	2.2	1.0	1.0	4.0	8.2	
	4	3.5	1.7	2.8	4.5	12.5	
	5	2.0	1.5	1.0	4.0	8.5	
4	1	3.0	1.0	1.0	4.0	9.0	10.00
	2	3.0	1.0	1.2	4.0	9.2	
	3	3.0	1.2	1.5	4.0	9.7	
	4	3.5	1.0	2.0	4.5	11.0	
	5	3.2	1.0	2.5	4.5	11.2	
5	1	3.2	1.0	2.0	4.0	10.2	10.13
	2	3.5	1.0	1.5	4.3	10.3	
	3	2.8	1.2	1.5	3.8	9.3	
	4	3.2	1.5	1.2	4.3	10.2	
	5	3.7	1.5	1.0	4.5	10.7	
Average		2.68	1.25	1.45	4.21	9.59	

Weighting each of the four assessment criteria equally, 9 of the 25 samples received a “pass” mark (10 or more). The likelihood of receiving a passing mark increased as the prompts got more specific in their framing of the question (phrases 4 and 5 had higher average total marks than phrases 1 to 3). This suggests a legitimate concern that GPT-3 work submitted as the student’s own could undermine the credibility of assessment processes. However, Table 4 also shows that while all samples scored highly on “coherence and clarity of writing” (average 4.21/5), scores for the other categories were less impressive.

4.1 Correct Identification of Relevant Themes

The improvement in the total marks for each sample appear to be a factor of the scores for this category. As the prompts became more specific (adding references to fibre technology and particular reference to the US and the EU), the probability that the sample answers contained text on relevant themes increased. However, while these were identified, they were not always correctly represented. For example, one answer stated that

the US unbundled fibre access in the 1996 Telecommunications Act. For the most part, definitions used were correct (e.g. for local loop unbundling). Adding investment to uptake in the prompt increased the likelihood that references were made to the effects of the regulation on competition.

In general, the information provided on the themes was not especially sophisticated. However, a significant minority (6) provided claims of specific statistically significant effects of the regulation increasing investment and uptake. Most of these were in the responses to prompts 1 and 2. While statistically significant effects were claimed in prompt 4 and 5 responses, these were offered (with one exception) without numerical support. However, as will be discussed subsequently, as the references are fictitious, there is no substance to the claims. Nonetheless, the use of statistics does add a false air of authority to the response.

4.2 Correct Attribution and Referencing

The samples varied in the number of references used and their presentation. While all contained citations, only 11 of the 25 provided a list of References. This was despite asking for a “referenced academic literature review”.

The lack of a reference list made it impossible verify the sources for over half the samples. Some of the references in these samples used the names of recognised academics in the field (e.g. Valletti, Gillet, Koutroumpis, Henten, Gabel). Some attached initials to the names, which were sometimes those of the recognised academic (e.g. A. Henten) but sometimes were not correct (e.g. M.G Koutroumpis, not P.; L.H. Gabel, not D.) Furthermore, none of the dates given for the citations match papers in the authors’ publication records that could be construed to support the stated claims. Mostly, though, the references were to authors without any known standing in the field. Moreover, the absence of prominent scholars who would have been expected to be referenced was notable (e.g. Bohlin, Cave, Crandall, Hausman, Vogelsang were all absent).

Of the referenced papers in the 11 samples with complete reference lists, not a single one could be traced to an actual published paper. URLs of papers attributed to papers published by entities such as the European Union, Ofcom and the Department of Trade and Industry either did not exist or linked to papers that were not the ones cited. Journal articles were cited to journals where such papers would be expected to be published (e.g. Telecommunications Policy, American Economic Review, Journal of Law and Economics). The year, issue and page numbers appear to be consistent, but the cited papers do not appear in those issues. This is consistent with the core task of the text engine which is only to produce plausible (but not necessarily sensible or factually correct) text.

Furthermore, there were instances of the content attributed to a referenced paper being quite inconsistent with either the facts or the views that the author has been associated with. E.g. it is most unlikely that George Ford would have authored a paper finding that US “states with copper access regulation had significantly higher levels of fiber-optic broadband deployment than states without such regulation” for two reasons:

- the US does not have mandatory access regulation for broadband, and
- George Ford’s work generally challenges rather than supports regulatory interventions.

An experienced researcher could also identify that sometimes, especially in responses to prompt 5, that European authors’ names were associated with discussion on the US context and vice-versa. Notable “errors” here included associating the names of some authors with studies in countries where the name would be more common (e.g. Yoo for a South Korean example, de Ridder for a Netherlands example). Again, an expert in the field would know that Christopher Yoo is American and based in the United States, John de Ridder in Australia, and both have written extensively on cross-country analyses rather than individual country studies.

That the referencing is so poor is not unexpected, given the way in which GPT-3 assembles its outputs. Its

algorithms construct text based on the linguistic associations it observes in its training data. With sufficient data, it can construct apparently plausible statements about the prompt subject, and associate within that author names and even journals, years and issues represented within that corpus. It is not a search engine, looking for specific evidence of a fact or concept, or seeking an article based on an author's name. The references it creates are therefore just plausible linguistic constructions. They have been "invented" using patterns it has been trained to associate. Hence it can assign articles to plausible journals, and even to plausible issues for given years, but cannot trace a concept back to an originating author as a researcher would do using a search engine, citation references and abstract scans.

Referencing thus stands as one of GPT-3's current weaknesses. It appears that (at the moment) requiring students to furnish a list of references in an approved manner will enable markers to relatively easily and cost-effectively filter GPT-3 output from students' own work. Checking a sample of the references will likely expose the AI version quickly. However, as both Microsoft and Google are working to incorporate their respective AI text generators with their search engines, this advantage might not last for long. There is also nothing to stop a third party from creating software that marries GPT-3 outputs with a list of references which is actually more correct.

4.3 Critical Evaluation

Critical evaluation also stands out as a weakness in the GPT-3 samples. The sample outputs all contained plausible discussions of single concepts within their own contexts. However, none of the samples managed to place two contradictory concepts into the same sentence, or explain why they contradicted each other. For the most part, critical evaluation in the first three prompt outputs presented just one view of the issue – that access regulation unequivocally increased broadband investment and uptake. As the prompts got more specific (notably 4 and 5), then the likelihood of a sentence acknowledging that findings were mixed increased (albeit that our sample size means we cannot exclude this as a random effect). However, these outputs relied mainly on the structure of the output, not a critical juxtaposing of concepts, to display conflicting ideas. This was particularly noticeable in the responses to prompt 5, where the outcomes in the US and the EU were mostly presented in different sections, with no explicit comparison between them. In responses to this prompt, the few examples of critical examination within a section related to ancillary objectives not included in the prompt, such as the digital divide.

Some of the samples contained logical inconsistencies. The factual errors and apparent naivety of the critical analysis in the sample pieces would likely be quickly identified if an experienced researcher in the field graded them. A less-expert marker (tutor or teaching assistant) might not so easily or quickly identify these errors, given the ease of readability of the content presented.

4.4 Coherence and Clarity of Writing

All of the samples were written in clear and coherent English, with excellent spelling and grammar. All had a logical structure, generally either based around papers discussed, article flow (Introduction, Content, Conclusion) or, for prompt 5, a discussion on the EU separate from the discussion on the US. Introductions and conclusions were usually consistent with the content, in that they signalled and summarised what was said in between. This is one of the big innovations of tools such as GPT-3. Previously, a passage in good English signalled that the writer had invested a reasonably amount of effort in the crafting of the text. One might expect that such a writer would also have applied an equal or greater amount of work to the content because s/he would otherwise risk the effort with the language having gone to waste. This signal has been stripped of much of its value since it is now easy to produce clear and coherent text in English and in other languages.

5 Discussion

The context in which our experiment was conducted merits further discussion. The easy diffusion of information through online channels had created earlier the hope that the old problems (including in policy) of information that is expensive and unevenly distributed have been solved (Tabarrok & Cowen 2015). However the cheap and efficient distribution of content that is (at least, a little bit) costly to create have unfortunately already given us the scourges of misinformation and disinformation (Horne 2021) while the options to regulate these are not inspiring (Hazlett 2022). This was true when real people were still working quite hard to produce 'fake news' for online consumption (Kreps et al. 2020).

Our experiment illustrates that although high-quality responses are still not that easy to produce, the production of medium/low quality information is now easy and inexpensive. Looking at table 4, we see that for each question (prompt) at least one of the five AI responses received an average passing grade from the markers. We did not even take into account the possibility of a human (or other agent) doing a quick screening of the five or so responses and picking the best one. If a student were able to do that, our experiment shows it would be easy to achieve a mediocre passing grade using the AI tool.

Although our human evaluators do not attach high valuations to current AI-produced text on advanced topics in the field, the ability of AI to produce cogent, grammatically correct writing at all (not to mention sound and video material) raises many questions. Up to now, media (including textual information and even dis- or misinformation) was costly to produce but inexpensive to distribute. It made sense to read a contribution on Stack Exchange, Reddit or Wikipedia since its mere existence signalled some effort from a human being which was costly to that person. The quality of the writing itself was a signal of value, augmented by the input of other users through rating of responses (Stack Exchange) or editing (Wikipedia), both of which involve further somewhat costly human effort.

It has however already become fairly difficult for users to distinguish between very cheap AI-generated content and human effort in some areas such as news reporting (Kreps et al. 2022). There is little doubt that AI's (or AIs') ability to churn out (low) medium-quality cultural productions is now far higher than that of a human being, taking into account the fuel (food) and education requirements of the human. A trained AI model can be duplicated without additional training which takes decades in the case of homo sapiens sapiens. It is complete plausible that skilled humans in working with AI will (and already are) produce high-quality cultural products more profitably than any of the two working alone. A concern for students of the information economy should however be how users will identify the high-quality products, especially in text.

We could conjecture that for now the answer could lie in reasonable quality video (including 3D and other enhancements), assuming that is not as easily faked, at least for a while still. Information might be deemed reliable in the market in case

- a. it looks good (a signal that the media cost money to produce) or
- b. the source is highly trustworthy for some reason.

This is in fact how media has always worked. There is more to worry about in online forums where people have been interacting peer-to-peer as individuals with a real (but small) stake in the communication, be it purely their time or their reputation. How will Wikipedia, Reddit or Stack Exchange look when the participants are largely (millions or billions of) intelligent bots? Will they be useful to people, or to the bots themselves? Perhaps in 20 years' time it will all look much like the pre-Internet era again and the free and cheap (sometimes, amateurish) exchange of ideas between actual people that has been responsible for much open source software, Wikipedia and other marvels, will look like a quaint episode in the history of technology.

6 Conclusion

On the basis of this experiment, we conclude that, at the present point in time, machine outputs will face difficulties in obtaining a passing grade to questions posed about this complex topic when assessed by an experienced telecommunications policy academic, due to the factual errors, naivety of critical arguments and misallocation of statements to original authors. However, outputs assessed by less-experienced markers may pose a greater risk to the integrity of the assessment process. Requiring students to provide a detailed reference list as part of the requested task will likely reduce this risk somewhat. Additional effort may be required to check a sample of the references, but the probability of detection is high, given that none of the GPT-3 references in this experiment were genuine.

This resourcing issue is likely to extend more broadly than our area and we counsel academics to raise this matter with their managers. Maintaining assessment integrity is going to be at least a little more costly due to the availability of these tools. Academic managers should also reflect on the implication for repeated assessment. If a student can cheaply access new assessment opportunities, the student might simply decide to keep on submitting AI-generated responses until it works. At the very least, students can use tools like GPT-3 to generate text to pad their assignments which, again, means more work for the assessors.

Assuming students will use AI tools to shorten the time taken to prepare assessments (by avoiding the necessary reading and learning before creating the written output), then do we have anything to fear from students being aware of the referencing and logical error weaknesses and seeking short-cuts to get around them? In our view, if a student was to use AI to generate an output, then to convert it to an acceptable piece of work for submission they would have to engage in a literature search to find papers written by the relevant authors, saying the same things that the naively-argued AI piece has produced. That is, they would have to in effect undertake the literature review task asked for in the first place. At least, the resulting piece would still contain the same naive arguments, but the required learning objectives would likely have been achieved. At best, in finding the relevant articles, the student may begin to see ways of enhancing the GPT-3 text, for example improving the extent of the critical evaluation. Again the learning objectives would have been achieved, but with a better piece of work as the result.

We therefore conclude by agreeing with Duckworth & Ungar (2023) that we have no option but to work with the new tools, and exploit their strengths and weaknesses as best we can to meet our teaching, learning and assessment objectives. We shall be sharing this piece with our students before we assign essay tasks, so that they too are aware of what these tools can and cannot do. In that way, hopefully, the risk of them being used inappropriately in our classes is reduced. We also plan to create tasks where students are asked to take an output from a standard GPT-3 prompt and critique it for its logical strengths and weaknesses, based on what has been taught in class. As each output is unique, no two students will have the same issues to find, making unacceptable collaboration and work-sharing less likely. Again, we acknowledge that this will make marking more costly, but that does appear to be the price to pay for the tools being available in the first place.

Finally, we note that, likely because of its prominence in the field, the journal *Telecommunications Policy* is disproportionately represented in the “fake referencing” observed in our experiment. This serves to reinforce both the complexity and the broad range of effects arising from the use of AI text generation. In this case, (mis)use in an academic context likely threatens the reputation of the journal. We encourage our fellow academics to think carefully about the potential use of the tool in class, so that the positive benefits are acquired without negative externalities accruing to the venues where we publish our research.

References

Akerlof, G. (1970). The market for “lemons”: quality uncertainty and the market mechanism. *The Quarterly Journal of Economics* 84(3) pp. 488-500.

- Cabanac, G. (2022). Decontamination of the scientific literature. arXiv preprint arXiv:2210.15912. <https://arxiv.org/pdf/2210.15912.pdf> (retrieved 2023-02-15).
- Christensen Hughes, J., & Eaton, S. E. (2022). Student integrity violations in the academy: More than a decade of growing complexity and concern. *Academic integrity in Canada: An enduring and essential challenge*, 61-79. <https://library.oapen.org/bitstream/handle/20.500.12657/53333/978-3-030-83255-1.pdf?sequence=1#page=80> (retrieved 2023-02-15).
- Clarridge, C. (2023). ChatGPT banned by Seattle Schools – for now. AXIOS Seattle, January 25 2023. <https://www.axios.com/local/seattle/2023/01/24/chatgpt-banned-seattle-schools-artificial-intelligence> (retrieved 2023-02-03).
- Duckworth, A., & Ungar, L. (2023). ChatGPT Should be Harnessed, not Banned. *Government Technology*, January 23 2023. <https://www.govtech.com/opinion-chatgpt-should-be-harnessed-not-banned>. (retrieved 2023-02-03).
- Hazlett, T. W. (2022). Free speech and the challenge of efficiency. *Telecommunications Policy*, 46(9), 102409.
- Horne, C. L. (2021). Internet governance in the “post-truth era”: Analyzing key topics in “fake news” discussions at IGF. *Telecommunications Policy*, 45(6), 102150.
- Katar, O., Ozkan, D., Yildirim, Ö., Acharya, U.R. & GPT (2022). Evaluation of GPT-3 AI language model in research paper writing. 10.13140/RG.2.2.11949.15844. https://www.researchgate.net/publication/366484704_Evaluation_of_GPT-3_AI_language_model_in_research_paper_writing (retrieved 2023-01-13).
- Khabib, S. (2022). Introducing artificial intelligence (AI)-based digital writing assistants for teachers in writing scientific articles. *Teaching English as a Foreign Language Journal*, 1(2), 114-124.
- Kreps, S., McCain, M., & Brundage, M. (2022). All the news that’s fit to fabricate: AI-generated text as a tool of media misinformation. *Journal of Experimental Political Science*, 9(1), 104–117.
- Lin, H. Y. (2023). Standing on the Shoulders of AI Giants. *Computer*, 56(01), 97-101.
- Reuters (2023). Top French university bans use of ChatGPT to prevent plagiarism. January 28 2023. <https://www.reuters.com/technology/top-french-university-bans-use-chatgpt-prevent-plagiarism-2023-01-27/> (retrieved 2023-01-13).
- Rosenblatt, K. (2023). ChatGPT banned from New York City public schools’ devices and networks. January 6, 2023. <https://www.nbcnews.com/tech/tech-news/new-york-city-public-schools-ban-chatgpt-devices-networks-rcna64446> (retrieved 2023-01-13).
- Sezgin, E., Sirrianni, J., & Linwood, S.L. (2022). Operationalizing and Implementing Pretrained, Large Artificial Intelligence Linguistic Models in the US Health Care System: Outlook of Generative Pretrained Transformer 3 (GPT-3) as a Service Model. *Journal of Medical Internet Research Medical Informatics* 10(2): e32875, doi: 10.2196/32875.
- Strubell, E., Ganesh, A., McCallum, A. (2019). Energy and Policy Considerations for Deep Learning in NLP. In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics*. p 3645–3650.
- Swiecki, Z., Khosravi, H., Chen, G., Martinez-Maldonado, R., Lodge, J.M., Milligan, S., Selwyn, N., & Gašević, D. (2022). Assessment in the age of artificial intelligence. *Computers and Education: Artificial Intelligence*, (3). <https://doi.org/10.1016/j.caeai.2022.100075> (retrieved 2023-02-14).
- Tabarrok, A., & Cowen, T. (2015). The end of asymmetric information. *Cato Unbound*, 6. <https://www.cato-unbound.org/print-issue/1915/> (accessed 2023-04-26).

- Thunström, A. O., & Steingrímsson, S. (2022). Can GPT-3 write an academic paper on itself, with minimal human input?. <https://hal.science/hal-03701250/document> (retrieved 2023-01-12).
- Wahle, J. P., Ruas, T., Meuschke, N., & Gipp, B. (2021, September). Are neural language models good plagiarists? A benchmark for neural paraphrase detection. In 2021 ACM/IEEE Joint Conference on Digital Libraries (JCDL) (pp. 226-229). IEEE.
- Wahle, J. P., Ruas, T., Kirstein, F., & Gipp, B. (2022). How Large Language Models are Transforming Machine-Paraphrased Plagiarism. arXiv preprint arXiv:2210.03568. <https://arxiv.org/abs/2210.03568> (retrieved 2023-02-14).
- Zhang, M., & Li, J. (2021). A commentary of GPT-3 in MIT Technology Review 2021. *Fundamental Research*, 1(6), 831-833.

Appendix (GPT-3 outputs)

Outputs obtained in the week of 6 February 2023 using the GPT-3 model text-davinci-003 on the OpenAI website (<https://platform.openai.com/playground>) are given below. Maximum length was set at 3000 and otherwise the default parameter settings were used. Since it is not possible to manually set a random seed, these results are not necessarily reproducible verbatim.

Prompt 1

Write a referenced academic literature review on the effect of local loop unbundling on broadband uptake

(1)

Local loop unbundling (LLU) is a telecommunications policy which enables access to the copper wire network from the telephone exchange to the customer premises, allowing for greater competition in the telecommunications market. LLU was first introduced in the UK in 2001 as a way to increase competition and reduce prices for consumers. This literature review will discuss the impact of LLU on broadband uptake and its implications for policy.

The introduction of LLU has been found to be a significant factor in the growth of broadband uptake in the UK. A study by Ofcom (2005) found that LLU was responsible for an estimated 70-80% of the increase in broadband subscribers between 2001 and 2004. Similarly, a study by the Department of Trade and Industry (DTI) (2006) found that LLU had a significant positive impact on broadband uptake in the UK, increasing take-up by approximately 1.3 million subscribers.

In addition to the increase in broadband uptake, LLU has been found to have a positive effect on the quality of broadband services. Studies by the DTI (2006) and Ofcom (2005) have found that LLU has resulted in increased speeds, reliability and availability of broadband services. This has been attributed to increased competition in the market, as LLU has allowed for more providers to enter the market and offer more competitive prices for broadband services.

The introduction of LLU has also had an impact on prices for broadband services. Studies by Ofcom (2005) and the DTI (2006) have found that LLU has resulted in a decrease in prices for broadband services. This is largely attributed to the increased competition in the market, as more providers are able to offer more competitive prices.

In conclusion, the introduction of LLU has had a significant impact on broadband uptake in the UK. LLU has resulted in increased speeds, reliability and availability of broadband services, as well as lower prices for consumers. This has had a positive effect on the telecommunications market, as it has allowed for greater competition and more choice for consumers. Therefore, LLU can be seen as an effective policy tool for increasing broadband uptake and improving the quality of broadband services.

References

Department of Trade and Industry (2006) The impact of local loop unbundling on the UK broadband market. Retrieved from: <https://webarchive.nationalarchives.gov.uk/20070602095603/http://www.dti.gov.uk/files/file37175.pdf> (link led to another paper – paper of that title not found using Google)

Ofcom (2005) Local Loop Unbundling: An Impact Assessment. Retrieved from: https://www.ofcom.org.uk/___data/assets/pdf_file/0028/20255/llu_impact.pdf (page not found - paper of that name and date not found on Ofcom site)

(2)

Local loop unbundling (LLU) is a process that allows telecommunications companies to access the last mile of copper cable used to connect customers to a telephone exchange. This access enables them to provide customers with broadband services. As broadband services become increasingly important for economic growth and social development, there has been a great deal of research investigating the effect of LLU on broadband uptake. This literature review summarises the current evidence on the impact of LLU on broadband uptake.

The main argument in the literature is that LLU increases the availability of broadband services, which in turn increases the uptake of broadband services. This is supported by a number of studies. For example, a study by Pérez-Hernández et al. (2015) found that LLU had a positive effect on broadband uptake in Spain, with a 10% increase in LLU resulting in a 5.3% increase in broadband uptake. Similarly, a study by Dixit and Goyal (2008) found that LLU had a positive effect on broadband uptake in the UK, with a 10% increase in LLU resulting in a 5.4% increase in broadband uptake.

However, not all studies have found a positive effect of LLU on broadband uptake. For example, a study by Wang et al. (2017) found that LLU had a negative effect on broadband uptake in China, with a 10% increase in LLU resulting in a 0.3% decrease in broadband uptake. Similarly, a study by Ma and Xu (2008) found that LLU had a negative effect on broadband uptake in India, with a 10% increase in LLU resulting in a 0.6% decrease in broadband uptake.

Overall, the literature suggests that LLU has a positive effect on broadband uptake. However, the magnitude of this effect varies across countries, and there is evidence to suggest that LLU may have a negative effect on broadband uptake in some countries. As such, further research is needed to better understand the effects of LLU on broadband uptake in different countries.

References

Dixit, S. and Goyal, S. (2008). Local loop unbundling and broadband uptake: Evidence from the UK. *Telecommunications Policy*, 32(7-8), pp.401-415. Ma, J. and Xu, H. (2008). Local loop unbundling and broadband uptake: Evidence from India. *Telecommunications Policy*, 32(7-8), pp.416-425.

Pérez-Hernández, L., López-García, P. and Sainz-García, J. (2015). Local loop unbundling and broadband uptake: Evidence from Spain. *Telecommunications Policy*, 39(8), pp.726-737.

Wang, X., Li, B. and Li, Y. (2017). Local loop unbundling and broadband uptake: Evidence from China. *Telecommunications Policy*, 41(7), pp.654-664.

(3)

Local loop unbundling (LLU) is a telecommunications policy that allows multiple service providers to access the local loop infrastructure of a single incumbent provider. This policy has been widely adopted in the European Union and other countries in an effort to promote competition in the broadband market and improve broadband access. This literature review examines the effect of local loop unbundling on broadband uptake.

First, a study by Aghion et al. (2006) found that local loop unbundling had a positive effect on broadband uptake in the United Kingdom. The authors found that the introduction of LLU in the UK led to a significant increase in broadband subscriptions, with the greatest increase occurring in areas where there was the greatest competition. They also found that the introduction of LLU had a positive effect on the quality of services offered, with increased competition leading to lower prices and better services.

Second, a study by Böhnke et al. (2013) examined the impact of local loop unbundling on broadband uptake in Germany. The authors found that the introduction of LLU had a positive effect on broadband uptake, with the greatest increase occurring in areas where there was the greatest competition. They also found that the introduction of LLU had a positive effect on the quality of services offered, with increased competition leading to lower prices and better services.

Third, a study by Chaudhuri et al. (2010) examined the impact of local loop unbundling on broadband uptake in Italy. The authors found that the introduction of LLU had a positive effect on broadband uptake, with the greatest increase occurring in areas where there was the greatest competition. They also found that the introduction of LLU had a positive effect on the quality of services offered, with increased competition leading to lower prices and better services.

Finally, a study by Zhang et al. (2015) examined the impact of local loop unbundling on broadband uptake in China. The authors found that the introduction of LLU had a positive effect on broadband uptake, with the greatest increase occurring in areas where there was the greatest competition. They also found that the introduction of LLU had a positive effect on the quality of services offered, with increased competition leading to lower prices and better services. Overall, the evidence from the literature suggests that local loop unbundling has had a positive effect on broadband uptake in countries where it has been adopted. The introduction of LLU has led to increased competition, which in turn has led to lower prices and better services, resulting in increased broadband uptake.

(4)

Local loop unbundling (LLU) is a telecommunications policy which allows access to the local loop, which is the physical connection between a customer's premises and the exchange of their telecommunications provider. LLU has been used in many countries as a way of increasing competition in the telecommunications market and encouraging the uptake of broadband services. This literature review will examine the effect of LLU on broadband uptake.

The first study to examine the effect of LLU on broadband uptake was conducted by Valletti (2008). The study found that LLU had a positive effect on broadband uptake, with increases in uptake of up to 20%. This was attributed to the increased competition in the market, resulting in lower prices and better service quality.

A similar finding was reported by Gillett (2009). The study found that LLU had a positive effect on broadband uptake, with increases in uptake of up to 10%. This was attributed to the increased competition in the market, resulting in lower prices and better service quality.

The findings of Valletti (2008) and Gillett (2009) have been supported by other studies. For example, a study conducted by Suh and Taylor (2010) found that LLU had a positive effect on broadband uptake, with increases in uptake of up to 16%. This was attributed to the increased competition in the market, resulting in lower prices and better service quality.

The findings of these studies suggest that LLU has had a positive effect on broadband uptake. The increased competition in the market has resulted in lower prices and better service quality, which has encouraged more people to take up broadband services. This has resulted in increased broadband uptake in those countries where LLU has been implemented.

Overall, the evidence suggests that LLU has had a positive effect on broadband uptake. The increased competition in the market has resulted in lower prices and better service quality, which has encouraged more people to take up broadband services. This has resulted in increased broadband uptake in those countries where LLU has been implemented.

(5)

Local loop unbundling (LLU) is a policy which allows different telecommunications companies to access the copper wire infrastructure of the incumbent telecommunications provider in order to provide telephone and broadband services to their customers. This policy has been widely adopted across the European Union (EU) since the late 1990s, and has been credited with increasing the availability of broadband services. This literature review will examine the impact of local loop unbundling on broadband uptake in the EU.

The first study to examine the impact of LLU on broadband uptake was conducted by Valletti (2008).

He found that LLU had a positive effect on broadband uptake in the EU. Specifically, he found that LLU increased the number of broadband subscribers by 8-11% in countries where it was adopted. This finding was supported by a study conducted by Valletti and Criscuolo (2009), which found that LLU increased broadband penetration by 26-28%.

Another study, conducted by Valletti and Criscuolo (2010), examined the effect of LLU on broadband speeds in the EU. They found that LLU had a positive effect on broadband speeds, with countries that adopted LLU having average download speeds that were 11-13% higher than those of countries that did not adopt LLU. This finding was supported by a study conducted by Garcia-Murillo (2011), which found that LLU increased average download speeds by 8-10%.

The effect of LLU on broadband prices has also been examined. A study conducted by Valletti and Criscuolo (2012) found that LLU had a positive effect on broadband prices, with countries that adopted LLU having average prices that were 7-9% lower than those of countries that did not adopt LLU. This finding was supported by a study conducted by Jenssen and Koutroumpis (2013), which found that LLU had a positive effect on broadband prices, with prices being 4-7% lower in countries that adopted LLU.

Overall, this literature review has shown that local loop unbundling has had a positive effect on broadband uptake in the EU. Specifically, it has been found that LLU has increased the number of broadband subscribers, increased broadband speeds, and reduced broadband prices. This suggests that LLU has been an effective policy for increasing broadband uptake in the EU.

References Garcia-Murillo, M. (2011). Local Loop Unbundling and Broadband Penetration: Evidence from the European Union. *Telecommunications Policy*, 35(3), 257-269.

Jenssen, A., & Koutroumpis, P. (2013). The Impact of Local Loop Unbundling on Broadband Prices in the EU. *Telecommunications Policy*, 37(4), 291-303. Valletti, T. (2008). Local Loop Unbundling and Broadband Penetration: Evidence from the European Union. *Telecommunications Policy*, 32(8-9), 551-560.

Valletti, T., & Criscuolo, C. (2009). Local Loop Unbundling and Broadband Penetration: Further Evidence from the European Union. *Telecommunications Policy*, 33(10), 602-612. V

alletti, T., & Criscuolo, C. (2010). Local Loop Unbundling and Broadband Speed: Evidence from the European Union. *Telecommunications Policy*, 34(6), 378-386.

Valletti, T., & Criscuolo, C. (2012). Local Loop Unbundling and Broadband Prices: Evidence from the European Union. *Telecommunications Policy*, 36(5), 341-351.

Prompt 2

Write a referenced academic literature review on the effect of local loop unbundling on broadband investment and uptake

(1)

The introduction of local loop unbundling (LLU) has been an integral part of the development of broadband infrastructure in Europe and many other countries around the world. LLU is a regulatory policy which allows access to the local telephone network, usually held by an incumbent provider, so that other service providers can use it to deliver their own services. This has enabled the emergence of multiple suppliers of broadband services in the market, and has been credited with increased competition and lower prices. However, there remain a number of questions about the effect of LLU on broadband investment and uptake, and this literature review aims to examine the existing evidence.

The first study to examine the impact of LLU on investment and uptake was conducted by Koutroumpis (2009). The study used a panel data set from 20 countries in Europe to analyse the impact of LLU on broadband penetration, average connection speed and average monthly prices. The results showed that LLU

had a positive and statistically significant effect on all three measures. The study concluded that LLU had a significant effect on the uptake of broadband services, and that it had a positive impact on investment in broadband infrastructure.

Rice et al. (2014) conducted a study in the UK to analyse the impact of LLU on broadband uptake. The study used a panel data set from 2007 to 2012 and found that LLU had a positive effect on the uptake of fixed broadband services. The study also found that LLU had a positive effect on the uptake of mobile broadband services. The authors concluded that LLU had a significant positive effect on broadband uptake in the UK.

Forsyth and Shepherd (2016) conducted a study in the UK to examine the effect of LLU on investment in broadband infrastructure. The study used a panel data set from 2005 to 2013 and found that LLU had a positive and statistically significant effect on investment in broadband infrastructure. The authors concluded that LLU had a significant effect on broadband investment in the UK.

Garcia-Rojas and Rama (2020) conducted a study in the UK to analyse the impact of LLU on investment and uptake of broadband services. The study used a panel data set from 2005 to 2018 and found that LLU had a positive and statistically significant effect on both investment and uptake of broadband services. The authors concluded that LLU had a significant positive effect on broadband investment and uptake in the UK. In summary, the findings of the studies reviewed in this paper suggest that LLU has a positive effect on investment and uptake of broadband services.

The studies have found that LLU has a positive and statistically significant effect on both investment and uptake of fixed and mobile broadband services. The authors of the studies concluded that LLU had a significant effect on broadband investment and uptake. The results of these studies provide strong evidence of the positive effect of LLU on broadband investment and uptake.

(2)

Introduction

Local loop unbundling (LLU) is a policy adopted by many countries worldwide to promote competition in the telecommunications sector. The policy requires incumbent operators to open up their networks and allow competitors to access the local loop infrastructure for a fee. The policy is designed to promote competition in the telecommunications sector, specifically in the broadband market. This literature review will discuss the effect of local loop unbundling on broadband investment and uptake.

Analysis

A number of studies have been conducted to investigate the effects of local loop unbundling on broadband investment and uptake. A study by Menon (2009) found that local loop unbundling had a positive effect on broadband investment and uptake in countries that adopted the policy. The study found that LLU led to an increase in the number of broadband subscribers and an increase in the average speed of broadband services. The study also found that LLU led to a decrease in the price of broadband services.

A study by Chen and Hsu (2009) also found that local loop unbundling had a positive effect on broadband investment and uptake. The study found that LLU led to a decrease in the price of broadband services and an increase in the number of broadband subscribers. The study also found that LLU led to an increase in the average speed of broadband services.

A study by Gaudin et al. (2011) found that local loop unbundling had a positive effect on broadband investment and uptake in countries that adopted the policy. The study found that LLU led to an increase in the number of broadband subscribers and an increase in the average speed of broadband services. The study also found that LLU led to a decrease in the price of broadband services.

Conclusion

The studies reviewed in this literature review indicate that local loop unbundling has a positive effect on broadband investment and uptake. The studies found that LLU led to an increase in the number of broadband subscribers, an increase in the average speed of broadband services, and a decrease in the price of broadband services. This suggests that LLU is an effective policy tool for promoting competition in the telecommunications sector and increasing broadband investment and uptake.

(3)

Local Loop Unbundling (LLU) is an approach to broadband access that allows operators to use existing copper cables to provide services to their customers. It has been widely used in Europe and other parts of the world as a way to increase competition and investment in broadband access. This literature review aims to assess the effect of LLU on broadband investment and uptake.

Literature Review

A study by Sá et al (2017) looked at the effect of LLU on broadband investment and uptake in Portugal between 2005 and 2013. The study found that LLU had a positive effect on broadband investment and uptake. Specifically, it found that the introduction of LLU policies led to a significant increase in investment in broadband infrastructure, as well as a significant increase in the number of broadband subscribers. The study also found that the increased competition resulting from LLU policies led to lower prices for broadband services.

A study by Höffler and Valletti (2008) looked at the effect of LLU on broadband investment and uptake in Germany between 1998 and 2005. The study found that LLU had a positive effect on broadband investment and uptake. Specifically, it found that the introduction of LLU policies led to a significant increase in investment in broadband infrastructure, as well as a significant increase in the number of broadband subscribers. The study also found that the increased competition resulting from LLU policies led to lower prices for broadband services.

A study by de Ridder et al (2013) looked at the effect of LLU on broadband investment and uptake in the Netherlands between 2000 and 2011. The study found that LLU had a positive effect on broadband investment and uptake. Specifically, it found that the introduction of LLU policies led to a significant increase in investment in broadband infrastructure, as well as a significant increase in the number of broadband subscribers. The study also found that the increased competition resulting from LLU policies led to lower prices for broadband services.

Conclusion

The studies reviewed in this literature review suggest that LLU has had a positive effect on broadband investment and uptake. Specifically, the studies found that LLU led to an increase in investment in broadband infrastructure, as well as an increase in the number of broadband subscribers. Additionally, the increased competition resulting from LLU policies led to lower prices for broadband services. The findings of these studies suggest that LLU is an effective policy tool for increasing broadband investment and uptake.

(4)

Local loop unbundling (LLU) has been seen as a key policy instrument for increasing broadband investment and uptake in many countries over the past two decades. This literature review will examine the impact of LLU on broadband investment and uptake, and will review the evidence from various studies to determine whether LLU has been successful in achieving its objectives.

The first study to be reviewed is by Gagnon and Valletti (2009). This study looks at the impact of LLU on broadband investment in the European Union. It finds that LLU has had a positive effect on broadband investment, with a 10% increase in investment in countries that had adopted LLU. The authors also find that LLU has had a positive effect on broadband uptake, with a 5% increase in households with broadband access in countries that had adopted LLU.

The second study to be reviewed is by Czernich et al. (2011). This study looks at the impact of LLU on broadband investment and uptake in Germany. The authors find that LLU has had a positive effect on broadband investment, with a 9% increase in investment in LLU-enabled areas. They also find that LLU has had a positive effect on broadband uptake, with a 4% increase in households with broadband access in LLU-enabled areas.

The third study to be reviewed is by Yoo (2015). This study looks at the impact of LLU on broadband investment and uptake in South Korea. The authors find that LLU has had a positive effect on broadband investment, with a 10% increase in investment in LLU-enabled areas. They also find that LLU has had a positive effect on broadband uptake, with a 5% increase in households with broadband access in LLU-enabled areas.

Overall, the evidence from these studies suggests that LLU has had a positive effect on broadband investment and uptake. LLU has been successful in increasing investment in broadband infrastructure and increasing the number of households with broadband access. This suggests that LLU has been an effective policy instrument for increasing broadband investment and uptake.

References

Czernich, N., Falck, O., Kretschmer, T., & Woessmann, L. (2011). Broadband infrastructure and economic growth. *The Economic Journal*, 121(551), 505-532.

Gagnon, J., & Valletti, T. (2009). Local loop unbundling and broadband investment: Evidence from the European Union. *Telecommunications Policy*, 33(9-10), 575-587.

Yoo, C. (2015). Broadband infrastructure and economic growth in South Korea: The impact of local loop unbundling. *Telecommunications Policy*, 39(3), 271-284.

(5)

Local loop unbundling (LLU) is a regulatory policy that has been used by many countries to promote competition and investment in the telecommunications industry. LLU allows competitors to access the local loop of an incumbent operator and provide broadband services to end users. The policy has been implemented in a number of countries, including the US, the UK, France, Germany, and Japan. This literature review examines the effect of LLU on broadband investment and uptake.

The evidence for the effect of LLU on broadband investment is mixed. Studies have found that in countries with LLU, the number of competitors increased and the level of investment in infrastructure increased (Bertrand et al., 2005; Economides and Himmelberg, 2005). However, other studies have found that LLU did not lead to increased investment (Koutroumpis, 2004; Laffont and Tirole, 2001). The results of these studies suggest that the impact of LLU on investment depends on the specific regulatory framework in place and the market conditions in the country.

The evidence for the effect of LLU on broadband uptake is also mixed. Studies have found that in countries with LLU, the number of subscribers increased (Economides and Himmelberg, 2005; Koutroumpis, 2004). However, other studies have found that LLU had a limited effect on broadband uptake, particularly in countries with low levels of competition (Laffont and Tirole, 2001; Bertrand et al., 2005). The results of these studies suggest that the impact of LLU on uptake depends on the level of competition in the market and the availability of other broadband services.

In conclusion, the evidence for the effect of LLU on broadband investment and uptake is mixed. The results of the studies suggest that the impact of LLU depends on the regulatory framework in place and the market conditions in the country. Further research is needed to understand the effect of LLU on broadband investment and uptake in different countries.

References

Bertrand, M., Mehta, P., and Milgrom, P. (2005). Competition and investment incentives in telecommunications networks. *The RAND Journal of Economics*, 36(2), 319-344.

Economides, N., and Himmelberg, C. (2005). The economics of local loop unbundling: An empirical analysis. *The Journal of Industrial Economics*, 53(4), 571-598.

Koutroumpis, P. (2004). The impact of local loop unbundling on investment and competition. *Telecommunications Policy*, 28(10-11), 721-737.

Laffont, J.-J., and Tirole, J. (2001). *Competition in telecommunications*. The MIT Press.

Prompt 3

Write a referenced academic literature review on the effect of local loop unbundling on fiber broadband investment and uptake

(1)

Local loop unbundling (LLU) is a process that allows access to the high-speed fiber broadband network of a local telephone company. It is becoming increasingly popular as a way to increase fiber-optic broadband investment and uptake. This literature review will explore the evidence for and against the effects of local loop unbundling on fiber broadband investment and uptake.

First, a study by Höffler and Valletti (2010) found that local loop unbundling had a positive effect on the investment of fiber-optic broadband. The authors examined the effects of LLU on the number of fiber-optic broadband subscribers in the European countries of Germany, France and the UK. The results showed that LLU had a statistically significant positive effect on the number of subscribers. The authors suggest that LLU encourages competition, which leads to increased investment in fiber-optic broadband infrastructure.

Second, a study by Colombo and Gheno (2013) examined the effect of LLU on the uptake of fiber-optic broadband in Italy. The authors found that the presence of LLU was associated with a higher level of fiber-optic broadband uptake. The authors conclude that LLU encourages competition, which leads to increased investment in fiber-optic broadband infrastructure and, in turn, increased uptake of the technology.

Third, a study by Gebauer, Weimann, and Zierahn (2015) examined the effect of LLU on fiber-optic broadband investment and uptake in Germany. The authors found that LLU had a positive effect on both investment and uptake of fiber-optic broadband. The authors suggest that LLU encourages competition, which leads to increased investment and uptake of fiber-optic broadband.

The evidence from the above studies suggests that local loop unbundling has a positive effect on fiber-optic broadband investment and uptake. LLU encourages competition and leads to increased investment in fiber-optic broadband infrastructure, which in turn leads to increased uptake of the technology. The evidence from these studies implies that local loop unbundling can be an effective policy tool for promoting investment and uptake in fiber-optic broadband.

References

Colombo, C., & Gheno, P. (2013). Local Loop Unbundling and the Take-up of Fiber Optic Broadband in Italy. *Telecommunications Policy*, 37(7-8), 574-590. (Cited journal issue does not exist – there is a 37(8) and 37(6-7), but not 37(7-8) <https://www.sciencedirect.com/journal/telecommunications-policy/issues>)

Gebauer, J., Weimann, J., & Zierahn, U. (2015). Local Loop Unbundling and Investment in Fiber-Optic Broadband. *Telecommunications Policy*, 39(2), 135-150. (The citation is false - <https://www.sciencedirect.com/journal/telecommunications-policy/vol/39/issue/2>)

Höffler, F., & Valletti, T. (2010). The effects of local loop unbundling on competition and broadband uptake. *The Economic Journal*, 120(546), 979-1012. (The citation is false – this issue is a special issue on New

(2)

Local loop unbundling (LLU) is a telecommunications policy introduced in the late 1990s which allows competitors to access the incumbent's local loop and provide services over the copper access network without the need for significant infrastructure investment. The policy has been implemented in many countries, including the United Kingdom, France, Germany, and Japan, and has been credited with increasing competition, decreasing prices, and improving customer service. In addition, LLU has been linked to increased investment in fiber broadband networks and increased uptake of these services. This literature review examines the evidence on the impact of LLU on fiber broadband investment and uptake.

The first study to examine the impact of LLU on fiber broadband investment and uptake was conducted in the United Kingdom. The study found that LLU had a significant positive impact on the availability of fiber broadband services. Specifically, it found that LLU increased the likelihood that a local exchange would be upgraded to fiber by 6.7%. It also found that the presence of LLU increased the take-up of fiber services by 5.3%. The study concluded that LLU had a positive effect on fiber broadband investment and uptake in the UK.

A similar study was conducted in France. The study found that LLU had a positive impact on fiber broadband investment and uptake. Specifically, it found that LLU increased the likelihood that a local exchange would be upgraded to fiber by 5.8%. It also found that the presence of LLU increased the take-up of fiber services by 4.3%. The study concluded that LLU had a positive effect on fiber broadband investment and uptake in France.

A third study was conducted in Germany. The study found that LLU had a positive impact on fiber broadband investment and uptake. Specifically, it found that LLU increased the likelihood that a local exchange would be upgraded to fiber by 7.2%. It also found that the presence of LLU increased the take-up of fiber services by 5.9%. The study concluded that LLU had a positive effect on fiber broadband investment and uptake in Germany.

Finally, a fourth study was conducted in Japan. The study found that LLU had a positive impact on fiber broadband investment and uptake. Specifically, it found that LLU increased the likelihood that a local exchange would be upgraded to fiber by 8.4%. It also found that the presence of LLU increased the take-up of fiber services by 8.7%. The study concluded that LLU had a positive effect on fiber broadband investment and uptake in Japan.

Overall, the evidence from these four studies suggests that LLU has a positive effect on fiber broadband investment and uptake in the countries studied. The studies found that LLU increases the likelihood that a local exchange will be upgraded to fiber and increases the take-up of fiber services. This suggests that LLU is an effective policy for encouraging investment in and uptake of fiber broadband services.

References

1. Czernich, N., Falck, O., Kretschmer, T., & Woessmann, L. (2011). Broadband infrastructure and economic growth. *The Economic Journal*, 121(552), 505-532.
2. Czernich, N., Falck, O., Kretschmer, T., & Woessmann, L. (2010). Broadband infrastructure and economic growth: Evidence from OECD countries. *The Economic Journal*, 120(541), 505-532.
3. Grembi, V., & Valletti, T. (2008). Local loop unbundling, investment and consumer welfare. *Telecommunications Policy*, 32(10-11), 644-655.
4. Hoernig, S., & Valletti, T. (2006). Local loop unbundling and investment. *Telecommunications Policy*, 30(3-4), 185-200.

(3)

Local loop unbundling (LLU) is the process of separating the local loop from the incumbent telecommunications network and providing access to other service providers. It is a key tool in increasing competition in the broadband market by allowing new entrants to offer services over the incumbent's infrastructure. This can lead to increased investment in fiber broadband infrastructure, as well as increased uptake of fiber broadband services. This literature review aims to analyze the impact of local loop unbundling on fiber broadband investment and uptake.

A study by Lehr et al. (2018) investigated the effects of local loop unbundling on fiber broadband investment and uptake in the European Union. The study found that local loop unbundling had a positive impact on fiber broadband investment and uptake, with a statistically significant increase in investment in fiber infrastructure and a significant increase in fiber uptake in countries that had implemented local loop unbundling.

In a study by Chiaraviglio et al. (2015), the impact of local loop unbundling on fiber broadband investment and uptake in Italy was analyzed. The results showed that local loop unbundling had a positive effect on fiber broadband investment, with an increase in investment in fiber infrastructure in areas where local loop unbundling had been implemented. Additionally, the study found that local loop unbundling had a positive effect on fiber uptake, with a statistically significant increase in fiber uptake in areas where local loop unbundling had been implemented.

A study by Scott et al. (2013) investigated the effects of local loop unbundling on fiber broadband investment and uptake in the United States. The study found that local loop unbundling had a positive effect on fiber broadband investment, with a statistically significant increase in investment in fiber infrastructure in areas where local loop unbundling had been implemented. The study also found that local loop unbundling had a positive effect on fiber uptake, with a statistically significant increase in fiber uptake in areas where local loop unbundling had been implemented.

Overall, the studies reviewed in this literature review have consistently found that local loop unbundling has a positive effect on fiber broadband investment and uptake. The results of the studies suggest that local loop unbundling is an effective tool for increasing investment in fiber infrastructure and increasing uptake of fiber broadband services. Thus, local loop unbundling should be considered as a viable option for increasing competition in the broadband market and promoting the deployment of fiber broadband services.

(4)

Introduction

The telecommunications industry has undergone significant changes over the past two decades. In particular, the emergence of local loop unbundling (LLU) has had a profound impact on the industry, allowing new entrants to access the local loop of incumbent operators and provide services on their own. This has resulted in increased competition and improved services for consumers. This paper reviews the literature on the effect of local loop unbundling on fiber broadband investment and uptake.

Background

Local loop unbundling is the process of allowing competitors to access the local loop of an incumbent operator and provide services on their own. The local loop is the physical connection between the customer's premises and the local exchange. In some countries, such as the United States, the local loop is owned and operated by the incumbent operator. In other countries, such as the United Kingdom, the local loop is owned by the incumbent but may be leased to competitors.

In the early 2000s, the European Commission began to promote LLU as a way to increase competition in the telecommunications industry. The Commission argued that allowing competitors to access the local loop of incumbents would lead to increased investment in infrastructure, improved services, and lower prices for consumers.

Effect of LLU on Investment

The literature on the effect of LLU on investment in fiber broadband infrastructure has been mixed. A number of studies have found that LLU has had a positive effect on investment in fiber broadband infrastructure. For example, a study by the Organisation for Economic Co-operation and Development (OECD) found that LLU had a positive effect on investment in fiber broadband infrastructure in countries where it was implemented.

Similarly, a study by the European Commission found that LLU had a positive effect on investment in fiber broadband infrastructure in countries where it was implemented. The study found that LLU had a significant positive effect on investment in fiber-to-the-home (FTTH) infrastructure, with the greatest effect in countries where LLU was implemented most extensively.

However, other studies have found that LLU has had a negative effect on investment in fiber broadband infrastructure. For example, a study by the International Telecommunications Union (ITU) found that LLU had a negative effect on investment in fiber broadband infrastructure in countries where it was implemented. The study concluded that LLU had a negative effect on investment in fiber-to-the-home (FTTH) infrastructure, with the greatest effect in countries where LLU was implemented most extensively.

Effect of LLU on Uptake

The literature on the effect of LLU on fiber broadband uptake has also been mixed. A number of studies have found that LLU has had a positive effect on uptake. For example, a study by the European Commission found that LLU had a positive effect on fiber broadband uptake in countries where it was implemented. The study found that LLU had a significant positive effect on fiber broadband uptake, with the greatest effect in countries where LLU was implemented most extensively.

Similarly, a study by the International Telecommunications Union (ITU) found that LLU had a positive effect on fiber broadband uptake in countries where it was implemented. The study found that LLU had a significant positive effect on fiber broadband uptake, with the greatest effect in countries where LLU was implemented most extensively.

However, other studies have found that LLU has had a negative effect on fiber broadband uptake. For example, a study by the Organisation for Economic Co-operation and Development (OECD) found that LLU had a negative effect on fiber broadband uptake in countries where it was implemented. The study concluded that LLU had a negative effect on fiber broadband uptake, with the greatest effect in countries where LLU was implemented most extensively.

Conclusion

The literature on the effect of local loop unbundling on fiber broadband investment and uptake is mixed. While some studies have found that LLU has had a positive effect on investment and uptake, other studies have found that LLU has had a negative effect. The effectiveness of LLU in promoting investment and uptake of fiber broadband appears to depend on the extent to which it is implemented and the regulatory framework in which it operates.

Overall, the literature suggests that LLU has the potential to increase investment in fiber broadband infrastructure and promote uptake of fiber broadband services. However, the effectiveness of LLU in achieving these goals appears to depend on the extent to which it is implemented and the regulatory framework in which it operates.

References

European Commission. (2005). The impact of local loop unbundling on investment in fibre-to-the-home infrastructure. Retrieved from <https://ec.europa.eu/digital-single-market/en/news/impact-local-loop-unbundling-investment-fibre-home-infrastructure>

Organisation for Economic Co-operation and Development. (2008). The impact of local loop unbundling

on investment in fibre-to-the-home infrastructure. Retrieved from <https://www.oecd.org/sti/ieconomy/40621437.pdf>

International Telecommunications Union. (2009). The impact of local loop unbundling on investment in fibre-to-the-home infrastructure. Retrieved from https://www.itu.int/dms_pub/itu-s/opb/stg/S-STG-2009-SG06-C-PDF-E.pdf

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Local loop unbundling (LLU) is a policy implemented by governments and regulators to promote competition in the telecommunications market. LLU involves the separation of the incumbent operator's customer access network from its other services. It allows alternative operators to install their own equipment in the incumbent's local exchange and provide services to their own customers without having to invest in their own physical network infrastructure. This policy has been implemented in many countries around the world with the aim of increasing competition and lowering prices in the telecommunications market.

The impact of LLU on fiber broadband investment and uptake has been a topic of considerable interest in recent years. A number of studies have been conducted to examine the effect of LLU on the deployment of fiber networks and the uptake of fiber broadband services.

One study by Park et al. (2017) examined the impact of LLU on fiber broadband investment and uptake in Korea. The study found that LLU had a positive effect on fiber broadband investment and uptake. The authors found that LLU had a significant effect on capital expenditure, with operators investing more in fiber networks when LLU was implemented. They also found that LLU had a positive effect on the uptake of fiber broadband services, with the number of subscribers increasing significantly after the implementation of LLU.

A similar study by Chen et al. (2019) examined the impact of LLU on fiber broadband investment and uptake in Taiwan. The authors found that LLU had a positive effect on fiber broadband investment and uptake. They found that LLU had a significant effect on capital expenditure, with operators investing more in fiber networks when LLU was implemented. They also found that LLU had a positive effect on the uptake of fiber broadband services, with the number of subscribers increasing significantly after the implementation of LLU.

A further study by Chatterjee et al. (2020) examined the impact of LLU on fiber broadband investment and uptake in India. The authors found that LLU had a positive effect on fiber broadband investment and uptake. They found that LLU had a significant effect on capital expenditure, with operators investing more in fiber networks when LLU was implemented. They also found that LLU had a positive effect on the uptake of fiber broadband services, with the number of subscribers increasing significantly after the implementation of LLU.

Overall, the evidence from these studies suggests that LLU has a positive effect on fiber broadband investment and uptake. LLU appears to have a significant effect on capital expenditure, with operators investing more in fiber networks when LLU is implemented. It also appears to have a positive effect on the uptake of fiber broadband services, with the number of subscribers increasing significantly after the implementation of LLU.

References

Chen, Y., Ku, Y., & Wang, S. (2019). The Impact of Local Loop Unbundling on Fiber Broadband Investment and Uptake in Taiwan. *Telecommunications Policy*, 43(7), 718–733. <https://doi.org/10.1016/j.telpol.2019.05.008>

Chatterjee, D., & Dutta, S. (2020). Impact of Local Loop Unbundling on Fiber Broadband Investment and Uptake in India. *Telecommunications Policy*, 44(4), 1020–1032. <https://doi.org/10.1016/j.telpol.2019.10.013>

Park, S., Joo, Y., & Kim, S. (2017). Impact of Local Loop Unbundling on Fiber Broadband Investment and Uptake in Korea. *Telecommunications Policy*, 41(10), 1025–1037. <https://doi.org/10.1016/j.telpol.2017.08.004>

Prompt 4

Write a referenced academic literature review on the effect of access regulation on fiber broadband investment and uptake

(1)

The growth of the internet has been a significant factor in the development of the global economy. As such, the regulation of access to the internet is a key issue in the debate over the role of governments in promoting economic development. The effect of access regulation on fiber broadband investment and uptake has been the subject of much research in recent years. This literature review examines the findings of these studies, with a focus on how access regulation affects fiber broadband investment and uptake.

The literature on this topic has consistently found that access regulation has a positive correlation with fiber broadband investment and uptake. Specifically, access regulation has been found to increase fiber broadband investment and uptake in three primary ways. First, access regulation allows providers to obtain a guaranteed return on their investment in fiber infrastructure, which encourages them to invest more heavily in this technology. Second, access regulation can reduce barriers to entry for smaller providers and thus increase competition in the market, which can lead to better service and lower prices for consumers. Finally, access regulation can also reduce the risk associated with investing in fiber infrastructure, which can lead to increased investment in this technology.

Studies have also found that access regulation affects fiber broadband uptake in a number of ways. Specifically, access regulation can increase fiber broadband uptake by increasing the number of service providers, which can lead to more competition in the market and thus lower prices for consumers. Additionally, access regulation can increase fiber broadband uptake by providing consumers with more choice of service providers, which can lead to better service and more reliable connections. Finally, access regulation can also increase fiber broadband uptake by encouraging providers to invest in improved infrastructure, which can lead to higher speeds and better quality connections.

Overall, the literature on this topic has consistently found that access regulation has a positive effect on fiber broadband investment and uptake. This finding is important, as it suggests that access regulation can be an effective tool for governments to promote economic development. By increasing investment in fiber infrastructure and encouraging competition in the market, access regulation can lead to increased access to high-speed internet services, which can have a positive effect on economic growth.

(2)

The rapid development of information and communication technologies (ICTs) in the past two decades has led to the growth of high-speed fibre broadband networks. This has facilitated increased access to the internet, allowing users to engage in activities such as online shopping, streaming and teleworking with greater speed and reliability. As a result, access to fibre broadband has become a key factor for economic and social development in many countries. However, the growth of fibre broadband networks has been hindered by the lack of access regulation. This literature review examines the impact of access regulation on fibre broadband investment and uptake, with a focus on the European Union (EU).

The EU has implemented a number of policies to promote the development of fibre broadband networks, including open access regulation. Open access regulation requires network operators to offer access to their

fibre broadband networks to third parties, such as internet service providers (ISPs). This is intended to promote competition in the fibre broadband market, allowing ISPs to offer a wider range of services and prices to customers. The European Commission has also taken steps to reduce the cost of fibre broadband infrastructure, such as providing funding for the deployment of fibre networks in rural areas.

A number of studies have examined the impact of open access regulation on fibre broadband investment and uptake. A study by Franssen et al. (2016) found that open access regulation had a positive effect on fibre broadband investment in the EU, with investment increasing by 5.6% in countries with open access regulation compared to those without. This increase in investment was attributed to increased competition, which allowed ISPs to offer more competitive services and prices. The study also found that open access regulation had a positive effect on fibre broadband uptake, with uptake increasing by 10.2% in countries with open access regulation compared to those without.

A study by Guglielmetti et al. (2018) examined the impact of open access regulation on fibre broadband uptake in the EU. The study found that open access regulation had a positive effect on fibre broadband uptake, with uptake increasing by an average of 8.3% in countries with open access regulation compared to those without. The study also found that the positive effect of open access regulation on fibre broadband uptake was stronger in countries with higher levels of competition in the fibre broadband market.

Overall, the academic literature suggests that open access regulation has a positive effect on fibre broadband investment and uptake in the EU. Open access regulation enables ISPs to offer a wider range of services and prices to customers, which increases competition in the fibre broadband market and encourages investment in fibre broadband infrastructure. Open access regulation also increases fibre broadband uptake, as it allows ISPs to offer more competitive services and prices to customers. As a result, open access regulation appears to be an effective tool for promoting the development of fibre broadband networks in the EU.

(3)

The increasing deployment and use of fiber broadband networks has been a major focus of economic policy in recent years, as evidenced by the considerable government investment in fiber infrastructure in many countries. This investment has been driven, in part, by the view that fiber broadband can provide economic, social and cultural benefits to the population. However, there is still disagreement over the extent to which access regulation should be used to facilitate investment in and uptake of fiber broadband networks. This literature review examines the effect of access regulation on fiber broadband investment and uptake.

The literature on the impact of access regulation on fiber broadband investment and uptake is mixed. While some studies have found that access regulation can be beneficial in promoting fiber broadband investment, others suggest that it may be detrimental by reducing investment incentives. For example, a study by M.T. Sørensen (2018) found that access regulation in the Danish fiber market had a negative effect on the cost of infrastructure investment. In contrast, a study by M.G. Koutroumpis et al. (2018) found that access regulation in the Greek market had a positive effect on investment incentives and uptake of fiber broadband.

The impact of access regulation on fiber broadband investment and uptake is further complicated by the fact that it depends on the specific regulatory framework in place. For example, a study by L. Guo et al. (2015) found that in the Chinese market, access regulation had a positive effect on investment incentives, but only when the regulatory framework was designed to encourage competition. Similarly, a study by A. Henten et al. (2010) found that access regulation in the Netherlands had a positive effect on investment incentives, but only when the regulatory framework was designed to promote competition and efficiency.

In addition to these empirical studies, there is a growing body of theoretical literature on the impact of access regulation on fiber broadband investment and uptake. For example, a study by D. M. Levy (2016) argued that access regulation can be beneficial if it is designed to promote competition between different

providers and to ensure that access prices reflect the true cost of providing service. Similarly, a study by L. H. Gabel (2016) argued that access regulation can be beneficial if it is designed to promote investment in new technologies and to ensure that access prices reflect the true cost of providing service.

Overall, the literature on the effect of access regulation on fiber broadband investment and uptake is mixed, and further research is needed to better understand the relationship between access regulation and fiber broadband investment and uptake. It is clear, however, that access regulation can have an important impact on investment incentives and uptake of fiber broadband, and that the specific regulatory framework in place can have a significant effect on the impact of access regulation.

(4)

Introduction

Fiber broadband is a high-speed internet access technology that has become increasingly popular in recent years, due to its enhanced speed and reliability compared to traditional copper cable broadband. As the demand for broadband services in both urban and rural areas continues to grow, access regulation is playing an increasingly important role in determining the level of investment and uptake of fiber broadband. This literature review will examine the impact of access regulation on fiber broadband investment and uptake.

Summary of Findings

The literature suggests that access regulation can have both positive and negative effects on fiber broadband investment and uptake. On the one hand, access regulation can create incentives for fiber broadband investment, as it can provide access to the existing copper infrastructure and the ability to offer bundled services. On the other hand, access regulation can also create barriers to investment, as it can lead to increased costs for access to the existing infrastructure and limit the ability to offer new services.

Access regulation can also have an effect on the uptake of fiber broadband. Studies have found that access regulation can lead to increased uptake of fiber broadband in both urban and rural areas. However, access regulation can also lead to decreased uptake of fiber broadband in some cases, due to increased costs or reduced availability of services.

Discussion

Access regulation is an important factor in determining the level of investment and uptake of fiber broadband. Studies have found that access regulation can create incentives for investment, as it can provide access to existing copper infrastructure and the ability to offer bundled services. Access regulation can also create barriers to investment, as it can lead to increased costs for access to the existing infrastructure and limit the ability to offer new services. In terms of the uptake of fiber broadband, access regulation can have both positive and negative effects. Studies have found that access regulation can lead to increased uptake of fiber broadband in both urban and rural areas. However, access regulation can also lead to decreased uptake of fiber broadband in some cases, due to increased costs or reduced availability of services.

Conclusion

This literature review has examined the effect of access regulation on fiber broadband investment and uptake. The literature suggests that access regulation can have both positive and negative effects on fiber broadband investment and uptake. On the one hand, access regulation can create incentives for investment, as it can provide access to existing copper infrastructure and the ability to offer bundled services. On the other hand, access regulation can also create barriers to investment, as it can lead to increased costs for access to the existing infrastructure and limit the ability to offer new services. In terms of the uptake of fiber broadband, access regulation can have both positive and negative effects. While access regulation can lead to increased uptake of fiber broadband in both urban and rural areas, it can also lead to decreased uptake of fiber broadband in some cases, due to increased costs or reduced availability of services.

(5)

Introduction

The impact of access regulation on fiber broadband investment and uptake has been the subject of considerable research in recent years. This literature review will present the findings of recent studies on this topic. It will also provide an overview of how access regulation can affect the incentives of providers to invest in fiber broadband infrastructure, as well as the impact of access regulation on consumer uptake of fiber broadband services.

Access Regulation and Fiber Broadband Investment

The literature on the effect of access regulation on fiber broadband investment is mixed. On the one hand, some studies suggest that access regulation can incentivize investment in fiber broadband infrastructure. For instance, a study of the European Union found that access regulation has a positive effect on fiber broadband investment, particularly in countries with more stringent regulations (Garcia-Palacios, et al., 2019). Similarly, a study of the United States found that access regulation has a positive effect on fiber broadband investment, with the most significant effect occurring in states with the most stringent regulations (Rai & Bhattacharjee, 2018).

On the other hand, other studies suggest that access regulation can have a negative effect on fiber broadband investment. For instance, a study of the United States found that access regulation has a negative effect on fiber broadband investment, particularly in states with more stringent regulations (Cox & Ross, 2019). Similarly, a study of the European Union found that access regulation has a negative effect on fiber broadband investment, with the most significant effect occurring in countries with the most stringent regulations (Garcia-Palacios, et al., 2019).

Access Regulation and Fiber Broadband Uptake

The literature on the effect of access regulation on fiber broadband uptake is also mixed. On the one hand, some studies suggest that access regulation can incentivize consumer uptake of fiber broadband services. For instance, a study of the United States found that access regulation has a positive effect on consumer uptake of fiber broadband services, with the most significant effect occurring in states with the most stringent regulations (Cox & Ross, 2019). Similarly, a study of the European Union found that access regulation has a positive effect on consumer uptake of fiber broadband services, particularly in countries with more stringent regulations (Garcia-Palacios, et al., 2019).

On the other hand, other studies suggest that access regulation can have a negative effect on consumer uptake of fiber broadband services. For instance, a study of the United States found that access regulation has a negative effect on consumer uptake of fiber broadband services, particularly in states with more stringent regulations (Rai & Bhattacharjee, 2018). Similarly, a study of the European Union found that access regulation has a negative effect on consumer uptake of fiber broadband services, with the most significant effect occurring in countries with the most stringent regulations (Garcia-Palacios, et al., 2019).

Conclusion

This literature review has presented the findings of recent studies on the effect of access regulation on fiber broadband investment and uptake. The findings suggest that access regulation can have both positive and negative effects on fiber broadband investment and uptake. Further research is needed to better understand the impact of access regulation on fiber broadband investment and uptake.

Prompt 5

Write a referenced academic literature review on the effect of copper network access regulation on fiber broadband investment and uptake, comparing the US and EU

(1)

Introduction

The access regulation of copper networks has been the subject of much debate in recent years, particularly in the US and EU. While the US has adopted a more relaxed approach to copper network access regulation, the EU has adopted a more restrictive approach. This literature review will assess the effect of copper network access regulations on fiber broadband investment and uptake, comparing the US and EU.

US Copper Network Access Regulation

In the US, copper network access regulation has been fairly relaxed over the past decade. The Federal Communications Commission (FCC) has been very supportive of market competition, allowing broadband providers to choose the technologies they use and give them the freedom to determine their own pricing models. This has enabled broadband providers to invest heavily in fiber networks, leading to greater levels of fiber broadband uptake. For example, a study by the Organisation for Economic Co-operation and Development (OECD) found that the US had the highest level of fiber broadband uptake among OECD countries in 2017, with 39% of all broadband connections being based on fiber networks (OECD, 2017).

EU Copper Network Access Regulation

In contrast to the US, the EU has adopted a more restrictive approach to copper network access regulation. The European Commission (EC) has mandated that all Member States must provide broadband access to consumers via copper networks. This has led to increased competition in the broadband market, as providers are forced to compete with each other in order to provide the best possible service. This has also led to increased investment in fiber networks, as providers are incentivized to invest in faster and more reliable technologies in order to differentiate themselves from competitors. A study by the European Commission found that fiber broadband uptake in the EU had increased significantly since the introduction of the copper network access regulation, with 28% of all broadband connections being based on fiber networks in 2017 (EC, 2017).

Conclusion

This literature review has assessed the effect of copper network access regulations on fiber broadband investment and uptake in the US and EU. It is clear that the US's more relaxed approach to copper network access regulation has enabled broadband providers to invest heavily in fiber networks, leading to greater levels of fiber broadband uptake. In comparison, the EU's more restrictive approach to copper network access regulation has led to increased competition in the broadband market, resulting in increased investment in fiber networks and greater levels of fiber broadband uptake.

(2)

Introduction

Regulation of copper network access has become an increasingly important issue in the development of broadband infrastructure. This literature review seeks to investigate the effect of copper network access regulation on fiber broadband investment and uptake, comparing the US and EU to better understand the impact of regulation on this sector. This review will focus on how regulation has impacted on the investment

decisions of broadband providers and how these decisions have influenced the uptake of fiber broadband services by consumers.

European Union

The European Commission introduced a set of regulations in 2002, known as the 'Access Directive', which requires telecommunications network operators to make their copper networks available to other operators on a wholesale basis. This has allowed for the emergence of virtual network operators (VNOs), who can lease copper access from an existing provider and bundle it with their own services to offer a retail service to consumers. This has helped to create a more competitive broadband market, with increased competition between different providers leading to lower prices and improved services.

A study by Los et al. (2015) found that the introduction of the Access Directive had a positive effect on the investment decisions of broadband providers in the EU, with the increased competition leading to more investment in fiber-optic networks. The authors also found that the regulations had a positive effect on consumer uptake of fiber services, with VNOs offering more competitively priced packages than traditional network operators.

A study by Koutroumpis et al. (2012) examined the impact of the Access Directive on broadband uptake in the EU. The authors found that, while the regulations had resulted in increased competition between providers, there was still a significant 'digital divide' between countries with a high level of access to broadband services and those with lower levels of access. The authors concluded that the regulations had not been sufficient to bridge this digital divide, and that further action may be needed to ensure that all EU citizens have access to adequate broadband services.

United States

In the US, the Federal Communications Commission (FCC) has adopted a range of regulations to promote competition in the broadband market, including rules requiring providers to make their copper networks available to other operators on a wholesale basis. The regulations also require broadband providers to charge a fair and reasonable price for access to their networks.

A study by Mazzucato et al. (2013) found that the introduction of the FCC's regulations had a positive effect on the investment decisions of broadband providers in the US, with the increased competition leading to more investment in fiber-optic networks. The authors also found that the regulations had a positive effect on consumer uptake of fiber services, with VNOs offering more competitively priced packages than traditional network operators.

A study by Paunov (2013) examined the impact of FCC regulations on broadband uptake in the US. The author found that, while the regulations had led to increased competition between providers, there was still a significant 'digital divide' between different regions in the US, with some areas having much higher levels of access to broadband services than others. The author concluded that the regulations had not been sufficient to bridge this digital divide, and that further action may be needed to ensure that all US citizens have access to adequate broadband services.

Conclusion

This literature review has examined the impact of copper network access regulation on fiber broadband investment and uptake in the US and EU. The studies reviewed indicate that the introduction of regulations in both regions has had a positive effect on the investment decisions of broadband providers, leading to increased investment in fiber-optic networks. The studies also found that the regulations had a positive effect on consumer uptake of fiber services, with VNOs offering more competitively priced packages than traditional network operators. However, the studies also indicated that the regulations had not been sufficient to bridge the 'digital divide' between different regions, and that further action may be needed to ensure that all citizens have access to adequate broadband services.

(3)

Introduction

The impact of copper network access regulation on fiber broadband investment and uptake has been the subject of much debate in recent years, with the United States and European Union at the center of the discussion. This literature review will compare the effects of copper network access regulation on fiber broadband investment and uptake in the US and EU, as well as other countries. A range of studies from the past decade will be referenced in order to illustrate the differing effects of copper network access regulation in the US and EU.

United States

In the US, the Telecommunications Act of 1996 has been seen as having a positive effect on the development of fiber broadband. The Act allowed for competition between incumbent providers and new entrants. This increased competition led to improved broadband speeds, as well as an increase in fiber broadband investment and uptake. A study by the National Telecommunications and Information Administration (NTIA) found that the Act had “positively impacted the availability and uptake of fiber broadband in the US.” The study also found that the Act had led to a “significant increase in the deployment of fiber-optic broadband services.”

European Union

In the EU, the European Commission has adopted a different approach to copper network access regulation. The Commission has adopted a “functional separation” approach, where incumbent providers are required to separate their retail and wholesale operations. This has been seen as having a positive effect on fiber broadband investment and uptake in the EU. A study by the European Commission found that the “functional separation” approach had led to an increase in the deployment of fiber-optic broadband services. The study also found that the approach had led to an increase in the speed of broadband services in the EU.

Other Countries

In other countries, the effects of copper network access regulation on fiber broadband investment and uptake have varied. A study by the Organisation for Economic Co-operation and Development (OECD) found that countries such as Singapore, Japan, and Korea had experienced significant increases in fiber broadband investment and uptake due to their copper network access regulations. The study also found that countries such as India and Brazil had experienced a slower rate of increase in fiber broadband investment and uptake.

Conclusion

This literature review has compared the effects of copper network access regulation on fiber broadband investment and uptake in the US and EU, as well as other countries. In the US, the Telecommunications Act of 1996 has been seen as having a positive effect on fiber broadband investment and uptake. In the EU, the “functional separation” approach has led to an increase in fiber broadband investment and uptake. In other countries, the effects of copper network access regulation on fiber broadband investment and uptake have varied. Overall, this review has demonstrated that copper network access regulation can have a positive effect on fiber broadband investment and uptake.

(4)

Introduction

The telecommunications industry is of great importance to modern economies, providing the infrastructure for economic growth and development. Copper network access regulation has been one of the major regulatory tools used by governments to promote competition and investment in the telecommunications

industry. In recent years, the industry has seen a shift from copper-based networks to fiber-based networks, as fiber offers higher speeds, greater capacity and greater reliability than copper-based networks. This shift has led to an increased interest in the effects of copper network access regulation on fiber broadband investment and uptake, particularly in comparison between the United States (US) and the European Union (EU).

This literature review will provide a comparative analysis of the effect of copper network access regulation on fiber broadband investment and uptake in the US and EU. It will first discuss the existing evidence on the impact of copper network access regulation on fiber broadband investment and uptake in the US. It will then discuss the evidence on the impact of copper network access regulation on fiber broadband investment and uptake in the EU. Finally, it will provide a comparison of the evidence from the US and EU, and offer some concluding remarks.

US Evidence

The US has long been a leader in telecommunications regulation, with the Telecommunications Act of 1996 providing the primary regulatory framework for the industry. This Act established a number of rules and regulations to promote competition within the telecommunications industry, including a requirement for incumbent carriers to provide access to their copper network infrastructure to competitors. Since then, the Federal Communications Commission (FCC) has been actively involved in promoting competition in the industry, including the continued regulation of copper network access.

Several studies have examined the impact of copper network access regulation on fiber broadband investment and uptake in the US. A study by Ford et al. (2007) examined the impact of copper network access regulation on the deployment of fiber-optic broadband in the US. The authors found that states with copper network access regulation had significantly higher levels of fiber-optic broadband deployment than states without such regulation. Similarly, a study by Koutroumpis et al. (2011) examined the impact of copper network access regulation on fiber broadband investment in the US. The authors found that states with copper network access regulation had significantly higher levels of fiber broadband investment than states without such regulation.

EU Evidence

The European Union (EU) has also been actively involved in promoting competition in the telecommunications industry. In particular, the EU's Electronic Communications Framework (ECF) has established a number of rules and regulations to promote competition and investment in the telecommunications industry, including a requirement for incumbent carriers to provide access to their copper network infrastructure to competitors.

Several studies have examined the impact of copper network access regulation on fiber broadband investment and uptake in the EU. A study by Spiliopoulou et al. (2014) examined the impact of copper network access regulation on the deployment of fiber-optic broadband in the EU. The authors found that countries with copper network access regulation had significantly higher levels of fiber-optic broadband deployment than countries without such regulation. Similarly, a study by Koutroumpis and Papapetrou (2015) examined the impact of copper network access regulation on fiber broadband investment in the EU. The authors found that countries with copper network access regulation had significantly higher levels of fiber broadband investment than countries without such regulation.

Comparison and Conclusion

The evidence from both the US and EU suggests that copper network access regulation has a positive effect on fiber broadband investment and uptake. In particular, both studies found that states/countries with copper network access regulation had significantly higher levels of fiber-optic broadband deployment and fiber broadband investment than states/countries without such regulation. This suggests that copper network access regulation is an effective tool for promoting competition and investment in the telecommunications industry, and encouraging the deployment of fiber broadband.

Overall, the evidence from both the US and EU suggests that copper network access regulation can be an effective tool for promoting competition and investment in the telecommunications industry, and encouraging the deployment of fiber-optic broadband. This provides valuable insight into the regulation of the telecommunications industry, and may be useful for policymakers in both the US and EU as they consider how best to promote competition and investment in the telecommunications industry.

References

Ford, G., Lehr, W., & Mitchell, B. (2007). The impact of unbundling rules on the deployment of fiber-optic broadband. *Telecommunications Policy*, 31(2), 97-116.

Koutroumpis, P., & Papapetrou, E. (2015). The impact of unbundling regulation on the investment in fiber networks. *Telecommunications Policy*, 39(1-2), 58-76.

Koutroumpis, P., Lehr, W., & Mitchell, B. (2011). The impact of unbundling regulation on the investment in fiber networks. *Telecommunications Policy*, 35(3-4), 167-184.

Spiliopoulou, G., Koutroumpis, P., & Lehr, W. (2014). The impact of unbundling regulation on the deployment of fiber-optic broadband: A cross-country analysis. *Telecommunications Policy*, 38(4), 301-318.

(5)

Introduction

The rapid growth of the Internet has created a need for high-speed broadband services, such as fiber. The United States and the European Union have implemented different approaches to regulating access to copper networks, which have had an effect on the investment and uptake of fiber broadband services. This literature review examines the impact of copper network access regulation on fiber broadband investment and uptake in the US and the EU.

US Regulation

US broadband regulation has focused on encouraging competition among operators, rather than regulating access to copper networks. This has resulted in a lack of incentives for operators to invest in fiber networks. For example, a study by Lehr and MacKie-Mason (2006) found that the US had invested less in fiber networks compared to other countries due to its lack of access regulation. Furthermore, the study found that the lack of regulation had led to a decrease in competition and an increase in prices for broadband services.

Another study by Economides and Hermalin (2005) examined the impact of US access regulation on fiber deployment and found that access regulation had a positive effect on fiber penetration. The study argued that access regulation encourages investment in fiber networks by creating incentives for operators to upgrade existing networks. This in turn leads to increased competition and lower prices for consumers.

EU Regulation

EU regulation of access to copper networks has been more stringent than in the US. The European Commission's Third Telecommunications Package requires operators to provide access to their copper networks at regulated prices. This has created incentives for operators to invest in fiber networks, as they can recoup their costs by charging access fees to competitors.

A study by van Schewick (2008) examined the impact of EU access regulation on fiber investment and found that access regulation had a positive effect on fiber deployment. The study argued that access regulation increases competition, which encourages operators to invest in new technologies such as fiber. Furthermore, the study found that access regulation leads to lower prices for consumers, which in turn leads to increased uptake of fiber services.

Conclusion

The literature reviewed in this paper suggests that access regulation of copper networks has a significant impact on fiber investment and uptake in the US and the EU. In the US, the lack of access regulation has resulted in a decrease in competition and an increase in prices for broadband services. In contrast, EU access regulation has encouraged investment in fiber networks, leading to increased competition and lower prices for consumers.

References

Economides, N. and Hermalin, B. (2005). Access Regulation and Local Loop Investment. *American Economic Review*, 95(3), pp.737-752.

Lehr, W. and MacKie-Mason, J. (2006). The Economics of Unbundled Access Regulation: Perverse Incentives and the Need for New Institutions. *Journal of Law & Economics*, 49(2), pp.631-677.

van Schewick, B. (2008). Access Regulation and Investment Incentives in the European Telecommunications Market. *Telecommunications Policy*, 32(5-6), pp.279-295.