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Abstract

Despite growing interest in broadband provided by municipally owned and operated fiber-to-the-home networks, the academic literature has yet to undertake a systematic assessment of these projects' financial performance. To fill this gap, we utilize municipalities' official reports to offer an empirical evaluation of the financial performance of every municipal fiber project in the U.S. operating in 2010 through 2019. An analysis of the actual performance of the resulting fifteen-project panel dataset reveals that none of the projects generated sufficient nominal cash flow in the short run to maintain solvency without infusions of additional cash from outside sources or debt relief. Similarly, 87% have not actually generated sufficient nominal cash flow to put them on track to achieve long-run solvency. In addition, 73% generated negative nominal cash flow over the past three fiscal years, leaving them poorly positioned to make up their deficits and causing them to fall farther into debt. An assessment based on the net present value of these projects' operating cash flow indicates that 53% of projects would not be on track to breakeven even assuming the theoretical best-case performance in terms of capital expenditures and debt service. Close analysis of these projects' performance reveals that revenue generation likely plays a more important role in generating cash flow than efficiency in construction costs or operating efficiency.

1 Introduction

Municipal fiber networks have long been a hot topic. High profile projects (such as the one in Chattanooga, Tennessee), the need for Internet connectivity during the COVID-19 pandemic, and the inclusion of public funding for state and local governments to improve broadband in the Biden Administration's proposed infrastructure legislation have heightened interest in municipal fiber's potential role in closing the digital divide. The November 2020 election illustrated the public divide on the topic, as some U.S. cities approved ballot initiatives

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seeking authorization to proceed with municipal broadband projects, while other cities rejected them.[1]

States and cities evaluating whether to fund such projects would benefit from empirical analyses of the success and failure of past efforts. To date, the literature has drawn mixed conclusions on whether municipal fiber promotes economic growth (Holt and Jamison, 2009; Kenny and Kenny, 2011; Guidry, Carson and Haon, 2012; Oh, 2019; Ford and Seals, 2019) or improves price and service quality (Talbot, Hessekiel, and Kehl, 2017; Chao and Park, 2020; Ford, 2020). A more fundamental limitation of these analyses is that benefits only represent half of the equation: The other side of any cost-benefit analysis requires considering whether municipal fiber projects are likely to be self-sustaining or whether they are likely to generate deficits that cities will have to cover with funds from general tax revenue. Such support may require either one-time subsidies for capital construction or ongoing annual support for projects that continue to generate annual cash flow deficits. Cities weighing the tradeoff between funding municipal fiber projects or other potential priorities need the clearest possible picture of the financial risks that they face.

This article is the first to take a more systematic approach using a unique dataset comprised of the lifetime financial performance of every municipal fiber project in the U.S. that was in operation as of 2011 and provided annual reports of their fiber operations. It represents the only analysis to date that evaluates all of these projects' financial performance based on the highest quality data issued by government sources and employs the measures generally accepted by the financial community for evaluating viability.

[1] Voters in Denver, Berthoud, and Englewood, Colorado, authorized their cities to opt out of a state law prohibiting municipal broadband. Voters in Kaysville, Utah, and Lucas, Texas, rejected municipal fiber projects (Gonsalves, 2020).

2 Literature review

The academic study of government-owned telecommunications networks began with the debate surrounding the 1912 nationalization of the British telephone system (e.g., Holcombe, 1911). The UK government's acquisition of British Telecom touched off a wave of nationalization that led to nearly universal public ownership by the 1970s, with the United States being the notable exception (Noll, 2000).[2] The 1984 denationalization of British Telecom led to a global privatization movement that sparked further study of whether private ownership improved these firms' financial performance and service quality (e.g., Bortolotti et al., 2002). Municipal Wi-Fi enjoyed a brief paroxysm of support during the mid-2000s, which generated another wave of scholarship (e.g., Jassem, 2010).

Commentary and popular attention have increasingly focused on municipal fiber. To date, empirical analyses of these networks' financial performance have rarely been published in scholarly journals and have employed somewhat narrow methodologies that employ short-term snapshots and focus on operating income, which is not the preferred basis for assessing viability, as discussed below (compare Scott and Wellings, 2005; with Lenard, 2004; Balhoff and Rowe, 2005; Davidson and Santorelli, 2014). The only academic publication that focuses on financial returns is Beard et al. (2020, 46–51), which examines five years of operating income for a single project. No prior scholarly work has systematically assessed the entire universe of U.S. municipal fiber projects, evaluated projects over their entire lifetime, nor focused on cash flow instead of income. The closest is an earlier, unpublished version of this study, which analyzed five years of cash flow for twenty projects (Yoo and Pfenninger, 2017a).[3]

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[2] Even the U.S. experimented with government ownership during World War I (Janson and Yoo, 2013).

[3] For our responses to some initial reactions to our report, see Yoo and Pfenninger (2017b).

3 Bonds as the Principal Mechanism for Financing Municipal Fiber Projects

Municipal fiber networks require significant upfront investments requiring tens of millions of dollars. Because cities rarely have that amount of cash on hand, they typically finance such projects by issuing tax-free municipal bonds, which allow them to borrow the cash needed for initial construction and then repay the principal and interest from the returns generated over the lifespan of the project, with the expected life of fiber optic cables to be twenty to twenty-five years and the expected life of digital switching equipment to be between twelve and eighteen years (U.S. Federal Communications Commission, 2000, Appendix B).[4] Because municipal fiber projects require an initial construction period during which they do not generate significant revenue, the debt instruments financing these projects typically permit interest-only payments during a project's initial three-to-five years to give it time to ramp up. Thereafter, payments must cover a portion of the principal in addition to the accrued interest.

The bond documents for the municipal fiber projects included in this study consistently reflect the expectation that the projects would generate sufficient returns to service this debt. First, all of the bonds that provided the initial funding for these projects were issued as "revenue bonds," which are defined as bonds expected to be repaid from funds generated by a specific project or source, as opposed to "general obligation bonds," which are expected to be repaid from the city's sources of general tax revenue, such as property taxes (U.S. Securities and Exchange Commission, 2021).[5] For example, Monticello characterized its initial 2008 financing

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[4] The U.S. Internal Revenue Service (2020, 106) similarly places the depreciable life of distribution plant at twenty-four years and computer-based switching equipment at 9.5 years for telephone companies. The U.S. Government Accountability Office (2012) similarly estimates that the useful life of fiber cables to be between twenty to twenty-five years. The bonds used to finance the vast majority of municipal fiber projects have terms of between twenty and twenty-five years.

[5] This terminology does not apply projects financed through means other than bonds, such as leases (Burlington) and certificates of participating (Salisbury and Wilson).

as "Telecommunications Revenue Bonds" and specified that they were payable "solely from the net revenues of the FTTP project." After it defaulted on the 2008 debt, it characterized the new 2014 debt issued to finance the settlement as "General Obligation Bonds."

Second, the official statements accompanying the initial debt issues, which contain the information that the SEC requires municipal bond issuers to disclose, consistently note that the debt is expected to be repaid out of revenues generated by the municipal fiber project.

Third, the bond instruments used to provide the initial financing for the projects included in this study omitted provisions requiring annual contributions from the cities to cover expected shortfalls. Debt instruments for projects expected to require contributions from general funds invariably include terms specifying the schedule of payments that cities are expected to make from general revenue into reserve funds. No such terms appeared in the projects included in this study.

Fourth, the annual financial reports of all of the cities in this study initially classified their municipal fiber projects as enterprise funds or independent authorities rather than governmental or internal service funds. According to Governmental Accounting Standards Board Statement No. 9 (1989), this signifies the expectation that these projects will repay their costs from project revenue and not from taxes or interfund transfers.

Fifth, many annual financial reports state that the cities expected these projects to cover their costs out of project revenue and that the financing plans do not require cities to make regular contributions from their tax revenue to defray project costs.

None of these features would have been true had the cities that initiated projects expected the projects not to be self-sustaining and would require contributions from general revenue. All indications—the characterization of the bonds as revenue bonds, the language of the official statements, the lack of provisions requiring contributions from general funds, the way these cities accounted for their municipal fiber operations, and numerous representations in these cities' annual financial reports—indicate that the cities initiating these projects did not expect them to generate shortfalls and instead expected them to cover their costs. In many cases, the projects were promoted as potential sources of surplus revenue.

In any event, every city initiating a municipal fiber project would benefit from an evidence-based understanding of previous projects' financial performance to help them assess the likelihood their project will require support from general tax revenue or other sources and the potential magnitude of that support. Regardless of the collateral benefits a municipal fiber project may create, cities must still pay the principal and interest associated with the debt incurred to build out these networks. Indeed, municipalities that initiate projects that are unable to cover their costs of debt and operations will have to make up the shortfall from general tax revenues or to default on their debt, either of which would inevitably affect the cost of financing all of the city's operations, not just the municipal fiber project.

4 Methodology and data

The approach of this analysis is to assess municipal fiber projects' viability in both the short- and long-run. Short-run viability measures the extent to which municipal fiber projects have been able to cover their costs to date. Those that have been unable to do so necessarily had to rely on additional contributions from other sources. Long-run viability assesses the likelihood that a project will break even by the maturity date of its initial debt financing.

4.1 Cash flow as the basis for assessing viability

Financial analysts generally regard cash flow as the preferred basis for assessing a project's financial viability. This is because the availability of cash is what determines whether an enterprise can meet its obligations. Although existing studies and press accounts tend to focus on operating income, many profitable enterprises become insolvent because so much of their cash is tied up in illiquid assets that are not available to pay incoming bills.

Consider the capital costs needed to build a fiber network. From a cash flow perspective, projects typically require a large cash outlay during their initial years and require less capital during their later years, as discussed above. Operating income distorts the impact of this large initial cash expenditure by amortizing these capital costs across the projects' expected lifespan as depreciation expense. The result is that the income statement radically understates the cash demands during a municipal fiber project's early years and overstates the demand on cash in later years. Factors like these cause net income to provide an incomplete reflection of an enterprise's cash needs, which is why Financial Accounting Standards Board Statement No. 95 (1987) began requiring that every financial report must also include a statement of cash flow in addition to a balance sheet and income statement. It is also why financial analysts evaluate projects' likely solvency based on cash flow forecasts rather than profitability (e.g., Beaver, 1966).

4.1.1 Actual performance: Nominal cash flow ("NCF")

Nominal cash flow ("NCF"), which measures the actual cash flowing into and out of a project, is the best measure of a project's viability. Our NCF analysis considers the first two components from Statement No. 9 of the Government Accounting Standards Board's four required components of cash flow statements:[6]

- *Cash flow from operating activities* (sometimes called cash flow from operations ("CFO")) represents operating revenue less operating expenses, excluding expenses that do not require an expenditure of cash, such as depreciation, plus changes in key categories of working capital associated with operations.
- *Cash flow from capital expenditures and debt service* (sometimes called cash flow from financing activities ("CFFA")) represents cash used to purchase capital assets associated with the project (typically the property, plant, and equipment needed to build the fiber network), proceeds from new capital debt financing, payments of capital debt principal and interest due; and other long-term financing.

NCF can be used to evaluate a project's viability in both the short- and long-run. In the short-run, a project's NCF should be sufficient to cover its obligations during every year of its operations, with the expectation being that the debt proceeds will provide sufficient cash to cover network construction costs in the initial years of operations before a project has the chance to become profitable in later years.[7] If a project is unable to meet its cash obligations and requires an infusion of additional cash from outside sources, it will have a negative cumulative NCF, where cumulative NCF is the summation of NCF to date. Put another way, a project that is not viable in the short run will have negative cumulative NCF.

Cumulative NCF can also be used to evaluate long-run solvency by measuring whether a project is on track to generate sufficient cash by the maturity date of its initial debt to retire it. More specifically, we look at each project's cumulative NCF as of 2019 and the amount it generated in the last three fiscal years for which we have complete data (2017, 2018, and 2019) to estimate whether it is on track to pay back its debt by the maturity date of its initial debt.

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6 The analysis omits the latter two components, "Cash flow from noncapital financing activities" and "Cash flow from investing activities," as both are, by definition, peripheral to a projects' operations.

7 Accordingly, and as mentioned above, most debt instruments permit interest-only payments during a project's initial three-to-five years without requiring any principal repayment to give it time to ramp up. Thereafter, operations are supposed to generate sufficient cash to cover the principal and interest due.

Because we are trying to evaluate the project's expectations at the time the city initiated its fiber project, we set the project end date as the maturity date of the initial debt, as this is the date by which those initiating the project are expected to be able to pay off all of the principal and interest needed to finance the project.

To enable comparison across the municipal fiber projects, we had to make several adjustments to CFFA to standardize the treatment of NCF. First, the vast majority of cities in this study transferred funds from other internal sources (such as loans from other funds or transfers of tax revenue from general funds) to cover cash flow shortfalls. Some of these cities treated these transfers as capital funding and included it in CFFA, which artificially inflated their NCF, while others treated them as noncapital funding that was not included in CFFA, which had no effect on NCF. For this analysis, we have excluded from CFFA transfers from internal sources because these projects are supposed to be self-supporting.

Second, CFFA varies based on decisions on how to account for these projects that have nothing to do with financial performance. For example, a large majority carried the debt used to finance these projects on the books of their broadband divisions, while a minority opted to carry them in whole or in part on the books of their electric power divisions. In addition, some cities refinanced or defaulted on their debt for reasons that arose after the project's initiation. For this analysis, we have adjusted CFFA such that we treat all projects as if their debt were carried on the books of their broadband divisions under their initial debt without any defaults or refinancing.

The combination of these adjustments yields the following formula for Adjusted NCF, which allows these projects to be compared on an equal basis by excluding the impact of decisions regarding whether to make internal transfers or to refinance or default on the initial debt:

Adjusted NCF ("*ANCF*") = *CFO* + *CFFA* + *adjustment for internal transfers included in CFFA* + *adjustment for differences in debt financing*

Illustrations of the expected pattern of NCF are depicted in Table 1 and Figure 1, which are based on the Forecasted Statement of Operations included in Appendix F to the official statement for the 2008 Bond issued to finance the fiber project in Monticello, Minnesota. For the sake of clarity, this example is based on Monticello's projected performance, not its actual performance.[8]

[8] In these projections, adjusted NCF is the same as NCF because the projections necessarily do not include any unexpected deviations that projects unexpectedly deployed that were not originally envisioned by the plan (e.g., transfers, refinancing).

Table 1:
Projected annual and cumulative NCF for Monticello, 2008–2015

	2008	2009	2010	2011	2012	2013	2014	2015
Cash flow from operating activities	(468,885)	(2,016,902)	(549,531)	436,569	879,246	1,586,317	1,918,825	2,213,870
Additions to broadband plant	(10,961,191)	(3,575,820)	(2,363,979)	(726,031)	(624,904)	(1,265,741)	(434,799)	(404,149)
Net cash provided by financing activities	25,094,060	0	0	0	0	(70,000)	(220,000)	(380,000)
NCF	13,663,984	(5,592,722)	(2,913,510)	(289,462)	254,342	250,576	1,264,026	1,429,721
Cumulative NCF	13,663,984	8,071,262	5,157,752	4,868,290	5,122,632	5,373,208	6,637,234	8,066,955

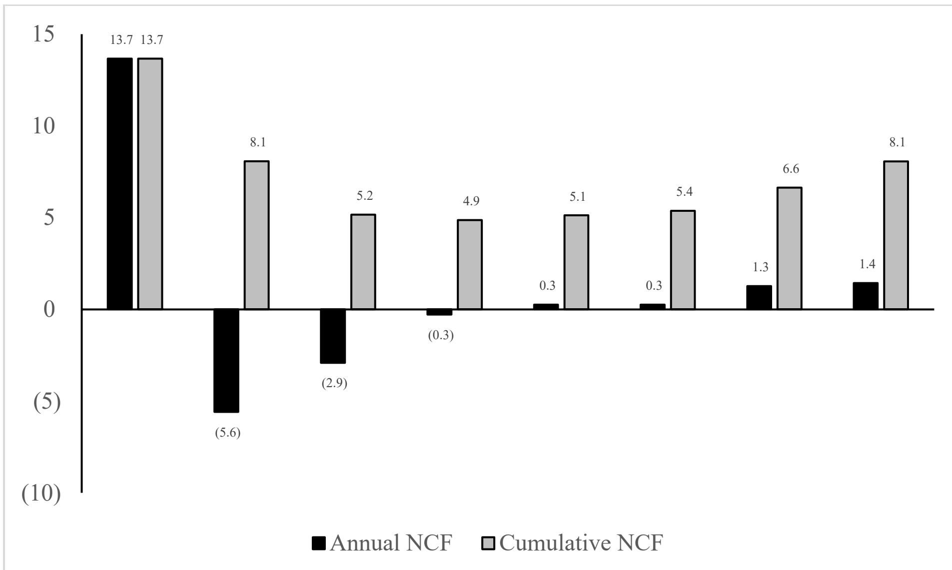

Figure 1: Projected annual NCF forecast for Monticello, Minnesota, years 2018–2015 ($ million)

The forecast projects positive NCF in year one because of the bond proceeds, negative NCF during years two through four due to the slow startup of operations and the early capital required to build the network, and increasingly positive NCF starting in year five. Regarding short-run solvency, the bond proceeds are forecast to be large enough to ensure that cumulative NCF remains positive even during the initial years of NCF deficits. After year four, the project is expected to generate positive annual NCF that is sufficiently large to allow the project to cover its obligations during every year of operations and to pay off its debt when it matures. As we shall see, Monticello fell far short of its projected +$8.1 million cumulative NCF surplus, instead generating a ($4.7 million) deficit.

4.1.2 Theoretical performance: Net present value ("NPV") of cash flow from operations ("CFO")

Another common approach to estimating the value of a project is capitalizing its income. One standard way of doing so is calculating the project's net present value ("NPV") by summing the project's annual CFO, discounted by the project's weighted average cost of capital ("WACC"), and subtracting its overall project cost. This approach sets aside any shortcomings in the actual approach employed to finance the project and focuses exclusively on the strength or weakness of a project's operating performance. In many ways, this analysis represents a best-case scenario based on the assumption that the project made the optimal decisions regarding capital expenditure and debt financing.

If NPV is greater than or equal to zero as of 2019, the project has already broken even and will remain viable so long as CFO does not turn negative in the future. If NPV is negative as of 2019, the deficit can be divided by the years remaining until maturity of the initial debt to determine the annual discounted CFO needed for the project to break even. This can be compared to the project's average annual discounted CFO in recent years to assess whether the project's recent performance is sufficient to make up that shortfall by the maturity date. As with the cumulative NCF approach to evaluating long-term solvency, we use each project's performance over the past three fiscal years (2017, 2018, and 2019) to measure its ability to make up any shortfalls without additional contributions from general revenues.

Sample forecasts are presented in Table 2 and Figure 2, which like Table 1 and Figure 1 are based on Appendix F of the official statement accompanying the 2008 Bond issued to finance the fiber project in Monticello, Minnesota. As before, this illustration is based on Monticello's projected performance, not its actual performance.

Table 2:
Projected annual and cumulative discounted CFO for Monticello, 2008–2015

	2008	2009	2010	2011	2012	2013	2014	2015
Project cost	(26,445,000)							
CFO	(468,885)	(2,016,902)	(549,531)	436,569	879,246	1,586,317	1,918,825	2,213,870
Discounted CFO	(468,885)	(1,890,609)	(482,866)	359,587	678,857	1,148,087	1,301,779	1,407,898
NPV	(26,913,885)	(28,804,494)	(29,287,360)	(28,927,773)	(28,248,916)	(27,100,828)	(25,799,049)	(24,391,152)

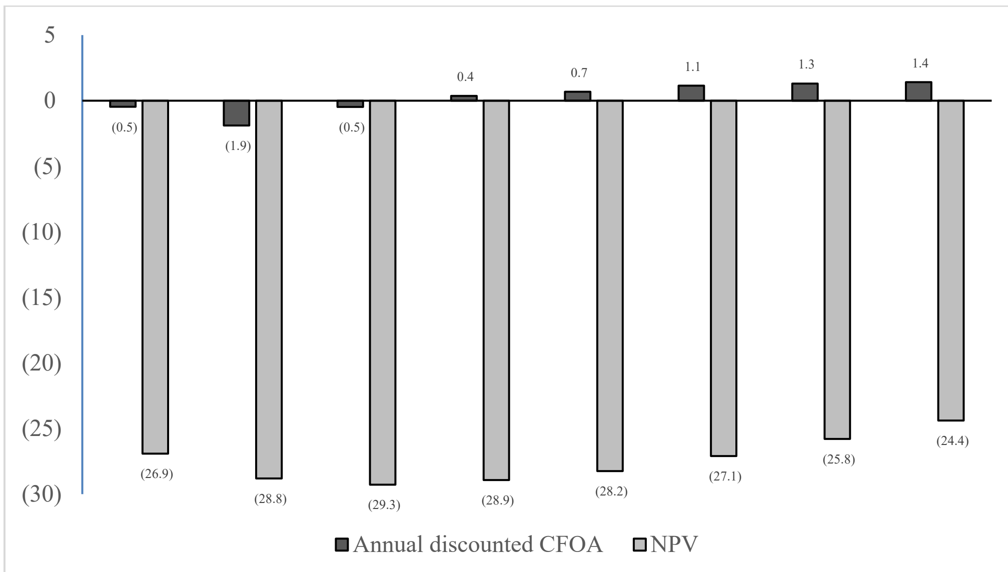

Figure 2: Projected annual discounted CFO and NPV forecast for Monticello, 2008–2015 ($ million)

This forecast projects an NPV of ($24.4 million) after the project's first eight years, reaching an annual discounted CFO of +$1.4 million in 2015. To generate positive NPV by the initial bond maturity date of 2031, this project would have to generate an average annual discounted CFO of +$1.5 million over the sixteen years from 2016 to 2031, inclusive. This projection implicitly requires discounted CFO to grow at an annual growth rate of +0.5% over that time in order to reach positive NPV and break even, which seems quite reasonable. The analysis that follows reveals that Monticello's actual performance did not meet its forecast, generating an NPV that was ($7.7 million) below its forecast.

4.2 The data

The creation of the novel dataset underlying this analysis began with a systematic effort to identify every municipal fiber project in the U.S. that received its initial financing in, or before, fiscal year 2011. The issuance of the initial debt was used as the starting date for each of these projects because that is the date from which the projects began accruing interest that must be paid regardless of when the networks began generating revenue. Tracking data through fiscal year 2019 provided at least ten years of data for all projects that are still operating and provides complete data for projects that have already terminated operations. Ending the analysis before fiscal year 2020 effectively avoids having to take the effects of the COVID-19 pandemic into account.

The principal resource for identifying municipal fiber projects is Appendix 1 of the Executive Office of the President's January 2015 report on *Community-Based Broadband Solutions*, which provides a comprehensive list of municipal broadband networks and identifies the technology each one uses. We augmented this list by consulting other industry and scholarly resources that list municipal fiber projects (e.g., Fiber-to-the-Home Council, 2009; Montagne and Chaillou, 2010; Mitchell, 2012). Review of these lists identified eighty-eight municipal fiber projects operating in fiscal year 2011.

We then examined the annual financial reports for these projects to determine how many provided separate reports for their fiber operations.[9] A review of the annual financial reports identified fifteen projects operating in 2011 that provided complete reports of their fiber operations from project initiation through fiscal year 2019 or project termination. Basic data about these projects appear in Table 3, including debt information, housing units, median household income, and population density.

[9] The annual reports were obtained from Bloomberg's Data Transparency feature, the Electronic Municipal Market Access Service ("EMMA") of the Securities and Exchange Commission's ("SEC's") Municipal Securities Rulemaking Board ("MSRB"), public postings to the Internet, and direct requests for information.

Table 4:
Project and demographic data

Municipality	Fiscal year of initial financing	Term of initial financing (years)	Amount of initial financing	Population	Housing units	Median household income	Population per square mile
Jackson, TN	2004	22	54,300,000	67,187	25,925	46,112	1,152
Provo, UT	2004	22	39,500,000	116,616	34,454	53,864	2,799
Windom, MN	2004	20	12,690,000	4,428	1,999	44,991	1,094
UTOPIA, UT	2005	22	185,000,000	474.442	148,226	70,908	2,925
Burlington, VT	2005	20	33,500,000	42,545	16,552	51,394	4,128
Morristown, TN	2005	25	19,500,000	29,782	11,639	32,193	1,089
Pulaski, TN	2006	19	8,500,000	7,643	3,189	31,519	1,018
Clarksville, TN	2007	25	41,675,000*	58.985	58,985	51,281	1,601
Wilson, NC	2007	26	31,800,000	49,272	19,667	42,036	1,584
Lafayette, LA	2007	24	125,000,000	126,199	52,267	51,477	2,274
Tullahoma, TN	2008	20	16,975,000	19,852	8,079	48,770	847
Chattanooga, TN	2008	25	280,600,000*	264,553	185,000	48,508	1,391
Monticello, MN	2008	23	26,445,000	13,583	4,984	65,398	1,552
Salisbury, NC	2009	21	35,865,000	33,727	12,524	41,901	1,513
Dunnellon, FL	2011	15	5,500,000	2,057	1,043	33,197	328
Low	2004	15	5,500,000	2,057	1,043	31,519	295
High	2011	26	185,000,000	474,442	185,000	70,465	4,119
Median	2007	22	31,800,000	41,500	16,552	48,770	1,528
Mean	2007	22	45,736,538	51,865	38,969	47,570	1,686

* Project financed by electric power division.

The total amount financed and WACC are derived from the text and the coupon rates for the actual debt instruments or from the official statements that SEC rules require municipal bond issuers to provide to underwriters.[10] For projects that used multiple rounds of funding to finance

[10] The official statements were obtained from EMMA, Bloomberg, and public postings to the Internet. For two projects (Burlington and Dunnellon), the information was derived from the actual loan agreements, which were submitted during litigation over the default on the debt. Debt instruments that included financing for both fiber and nonfiber projects (Chattanooga, Clarksville, Morristown, and Wilson) were allocated across the projects per the infrastructure expenditures reflected in the official statements. All demographic data are taken from the U.S. Census. Regarding the multicity projects, housing units for the Utah Open Infrastructure Agency ("UTOPIA") represent the total households in all of the pledging cities, and the median household income is for the median of the pledging cities. Housing units for Chattanooga represent the total electric households served by the EPB, and median household income is for the Chattanooga Metropolitan Statistical Area.

principal construction, the project cost represents the total capital raised by the multiple rounds.[11] We made adjustments to the total amount financed so that we could compare all of the projects as if they were financed as stand-alone broadband projects. This means that the total amount financed omits any subsidies provided by state governments or the federal government. For example, the total amount financed does not include Chattanooga's stimulus funding of $111.6 million or UTOPIA's funding of $16.2 million. We also made adjustments where the projects were financed as smart grid projects; Chattanooga and Clarksville were financed as such, meaning that the network construction costs and corresponding debt service (i.e., capital costs) were carried by the electric power divisions of these independent authorities instead of their broadband divisions, which paid periodic use charges to the electric power divisions proportionate to their actual network usage (i.e., operating expenses). Converting these capital expenses into pay-as-you-go operating expenses allowed these projects to shift the capital risk associated with these networks to their electric power operations.

Interestingly, all of these projects are located in areas that satisfy the U.S. Census definition of urban, and only one falls below the standard used by the U.S. Department of Agricultural Economic Research Service that defines rural areas as those with a population density of less than 500 persons per square mile. Also notable is the fact that each of these projects was an overbuild of areas already receiving broadband service from one or more private providers. None was a greenfield project designed to provide service to residences who could not previously access broadband.

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[11] These projects include Burlington, Lafayette, Morristown, UTOPIA, and Windom.

To assess the representativeness of this sample, we compared the basic demographic data of these projects with those of the overall universe of municipal fiber projects. The results are summarized in Table 4, and the full results are reported in Online Appendix A.

Table 4:
Project and demographic data

	Population	Housing units	Median household income	Population per square mile
Median – study cities	41,500	16,096	47,310	1,452
Median– all municipal fiber cities	13,583	8,079	50,591	1,190
Mean – study cities	97,678	35,290	47,297	1,512
Mean – all municipal fiber cities	49,329	18,392	50,647	1,430

The projects included in this study tended to be considerably larger than the typical city supporting a municipal fiber project. This is unsurprising, given that larger projects are more likely to be able to support the expense of providing separate reports of the financial performance of their fiber operations. They are also denser and have a lower median household income than the overall universe of municipal fiber projects. The larger size and higher population density make the study sample to be slightly biased toward more successful projects than the overall universe of municipal fiber projects, mitigated slightly by the small difference in median household income.

5 Results

We now apply the NCF and NPV analysis described above to these fifteen projects. Full details are available in Online Appendix B.

5.1 Actual performance: Adjusted nominal cash flow ("ANCF")

The results of our cumulative ANCF analysis are summarized in Table 5. The second column assesses short-run solvency by examining the lowest cumulative ANCF during each project's life. If this number is negative, the project has not generated sufficient cash flow to cover its costs in at least one year and has required infusions of additional cash from outside sources to remain solvent.

The other columns assess long-run solvency. The third column reports each project's cumulative ANCF as of 2019 to determine if it is currently running a deficit or surplus. The fourth column reports the ANCF each project has generated over the past three fiscal years (2017, 2018, and 2019). The fifth column uses the recent returns reported in the fourth column to project how many years each project would need to make up for any deficits reported in the third column. The sixth column, which reports the number of years until the maturity date of the initial debt, can be compared with the fifth column to determine whether a project is on track to repay its debt. The seventh column measures how much each project's annual ANCF must improve in order to break even by subtracting its recent actual performance (reported in the fourth column) from the cumulative ANCF as of 2019 (second) divided by the number of years to initial debt maturity (sixth).

Table 5:
Cumulative ANCF analysis

Project	Lowest cumulative ANCF through 2019	Cumulative ANCF as of 2019	Average annual ANCF, 2017–19	Years to break even at 2017-19 ANCF rates	Years until initial debt maturity
Chattanooga, TN	(24,164,960)	68,578,465	22,742,128	0	15
Wilson, NC	(7,544,971)	(4,672,373)	731,218	6	14
Clarksville, TN	(28,536,619)	(23,218,789)	1,275,398	18	14
Lafayette, LA	(46,769,435)	(44,625,525)	714,637	62	13
Windom, MN	(2,376,777)	(1,988,432)	19,761	101	6
Jackson, TN	(6,857,654)	1,561,170	(1,002,459)	never	7
Tullahoma, TN	(194,672)	(194,672)	(533,779)	never	9
Pulaski, TN	(3,317,057)	(3,317,057)	(453,755)	never	6
Morristown, TN	(14,579,821)	(14,579,821)	(874,204)	never	11
Monticello, MN	(16,732,246)	(16,732,246)	(1,768,214)	never	12
Salisbury, NC	(24,455,847)	(24,455,847)	(3,209,227)	never	10
UTOPIA, UT	(159,270,166)	(159,270,166)	(14,431,235)	never	8
Dunnellon, FL	(8,643,210)	(8,643,210)	n/a	never	7
Provo, UT	(11,126,580)	(9,765,585)	n/a	never	7
Burlington, VT	(32,059,526)	(32,059,526)	n/a	never	9

In terms of actual performance, none of the fifteen projects satisfied the short-run test for viability based on ANCF by generating cumulative ANCF surpluses every year of their operation. That means that all the projects either required infusions of cash from outside sources or debt relief through refinancing. The size of the peak cumulative ANCF deficits ranged from ($0.2 million) to ($159.3 million), with the median peak deficit running ($14.6 million), and the average peak deficit running ($25.80 million). To date, Tullahoma's short-run deficit is fairly small, although recent returns suggest that it will widen unless its financial performance substantially improves.

In terms of long-run viability, only two projects (13%) have generated sufficient cumulative ANCF to be on track to cover their initial debt by before it is scheduled to mature : Chattanooga has already broken even, and Wilson would break even in six years if it is able to maintain the level of performance it has achieved over the past three years, which would be swell before the maturity date of its initial debt in fourteen years. Of the remaining thirteen projects (87%), only three generated positive cumulative ANCF over the last three fiscal years (Clarksville, Lafayette, and Wilson), although at too low a level to break even by the maturity date of their initial debt, although Clarksville is close. The remaining ten projects (67%) either generated negative ANCF over the last three fiscal years or had already been sold at a significant loss. Note that Jackson ran a small cumulative ANCF surplus through 2019, but its negative ANCF over the past three fiscal years indicate that the surplus will turn into a deficit in roughly a year and a half unless it substantially improves the fiscal performance of its operations.

Somewhat surprisingly, ten of the fifteen projects (67%) have either generated negative cumulative ANCF over the past three fiscal years (2017, 2018, and 2019) or have already ceased operations at a loss. Projects that generate negative cumulative and annual ANCF have no chance of repaying their debt and, even worse, risk sinking further into debt with every year they continue to operate.

5.2 Theoretical performance: Net present value ("NPV") of discounted cash flow from operations ("CFO")

The NPV analysis of these projects' discounted CFO yields slightly different results, which are reported in Table 6. The second column reports the project financing, adjusted as described in Section 3.2 above. The third column reports the cumulative discounted CFO from the initiation of the project through fiscal year 2019. The fourth column reports the projects' NPV, calculated by subtracting the cumulative discounted CFO (third column) from the initial project financing (second column). The fifth column reports the average annual discounted CFO each project has generated over the past three fiscal years (2017, 2018, and 2019). The sixth column uses the recent returns (fifth column) to project how many years each project would need to make up for any deficits (fourth column). The seventh column reports the number of years until the maturity date of the initial debt, which can be compared to the sixth column to determine whether a project is on track to repay its debt. The eighth column calculates how much each project's annual discounted CFO must improve in order to break even by subtracting its recent actual performance reported (fifth column) from the NPV as of 2019 (fourth column) by the number of years to initial debt maturity (seventh column).

Table 6:
Cumulative lifetime discounted CFO and NPV analysis

Project	Initial project financing	Cumulative discounted CFO as of 2019	NPV as of 2019	Average annual discounted CFO, 2017–19	Estimated years to break even as of 2019	Years until initial debt maturity
Jackson, TN	54,300,000	76,617,231	22,317,231	5,687,460	0	7
Chattanooga, TN	280,600,000	228,523,244	(52,076,756)	27,952,186	2	15
Wilson, NC	29,190,000	22,234,399	(6,955,601)	2,756,778	3	14
Morristown, TN	19,500,000	12,604,555	(6,895,445)	1,597,193	4	11
Lafayette, LA	125,000,000	71,568,919	(53,431,081)	10,402,161	5	13
Tullahoma, TN	16,975,000	10,473,169	(6,501,831)	1,079,637	6	9
Clarksville, TN	41,675,000	6,145,754	(35,529,246)	2,601,301	14	14
Pulaski, TN	8,500,000	3,999,274	(4,500,726)	383,430	12	6
Windom, MN	12,690,000	4,382,488	(8,307,512)	418,371	20	6
Salisbury, NC	35,865,000	(795,753)	(36,660,753)	103,269	355	10
Monticello, MN	26,445,000	(5,895,812)	(32,340,812)	1,965	16,461	12
UTOPIA, UT	85,000,000	(17,538,964)	(102,538,964)	(59,648)	never	8
Dunnellon, FL	7,350,000	(3,408,484)	(10,758,484)	n/a	n/a	7
Burlington, VT	33,500,000	3,399,230	(30,100,770)	n/a	n/a	9
Provo, UT	39,500,000	2,118,521	(37,381,479)	n/a	n/a	7

* Project financed entirely by the electric power division and/or grants.

More than half of the fifteen projects (53%) are not on track to generate a positive NPV, and thus breakeven, by the maturity date of their initial debt financing. Of these, three projects (20%) have already ceased operations and thus no longer have any opportunity to make up their deficits. One project (7%) generated negative CFO and fell even further behind in recent years

(UTOPIA). The remaining seven projects (47%) generated positive discounted CFO but will have to improve their operations substantially in order to break-even.

Of the seven projects (47%) that are on track to break-even under NPV, one project (7%), Jackson, has already generated positive NPV and continued to generate positive discounted CFO over the past three fiscal years. The remaining six projects (40%) should generate positive NPV well before the maturity dates of their initial debt. Notably, two of the projects with the largest deficits as of 2019, Lafayette at ($53.4 million) and Chattanooga at ($52.1 million), generated sufficient discounted CFO in recent years to put them on track to break even in just a few years.

5.3 Synthesis of the three approaches to analyzing viability

Combining the three approaches to analyzing cash flow provides a robust assessment of these projects' viability, with the results summarized in Table 7.

Table 7:
Synthesis of the two approaches to analyzing cash flow

Project	Actual performance: short-run viability	Actual performance: long-run viability	Theoretical performance: long-run viability
Chattanooga, TN		X	X
Wilson, NC		X	X
Clarksville, TN			X
Jackson, TN			X
Lafayette, LA			X
Morristown, TN			X
Tullahoma, TN			X
Pulaski, TN			
Salisbury, NC			
UTOPIA, UT			
Windom, MN			
Monticello, MN			
Burlington, VT			
Dunnellon, FL			
Provo, UT			

None of the fifteen projects satisfied the test for short-run viability and did not require infusions of cash from other sources. In terms of long-run viability, only two projects (14%) satisfied the tests based on both actual and theoretical performance: Chattanooga and Wilson. Five additional projects (33%) failed the long-run test based on actual performance but passed the test based on theoretical performance. Eight projects (53%) failed both the tests of long-run viability based on actual and theoretical performance.

5.4 Internal details of project performance

Closer analysis of the internal details of these fifteen projects' financial performance provides additional insights. Table 8 provides an overview of which projects required external funding, used refinancing to defer aspects of their debt service, saw a significant downgrade to their bond rating defaulted on their debt, or were sold to other entities at a loss.

Table 8:
Internal details of project performance

Project	External funding		Backing with taxing power	Refinance deferrals		Bond rating downgrade	Default	Disposal
	Tax dollars	Interfund loans		Principal repayment	Maturity date			
Jackson, TN		X		X	X	X		
Provo, UT	X	X				X		X
Windom, MN		X			X			
UTOPIA, UT	X		X		X			
Burlington, VT	X	X		X		X	X	X
Morristown, TN		X	X	X	X	X		
Pulaski, TN			X					
Clarksville, TN		X						
Wilson, NC		X						
Lafayette, LA		X						
Tullahoma, TN			X					
Chattanooga, TN		X						
Monticello, MN	X	X					X	
Salisbury, NC	X	X		X		X		
Dunnellon, FL	X		X				X	X

Despite the fact that all fifteen projects were supposed to be self-sustaining, fourteen projects (93%) received additional funds from outside sources, with the sole exceptions being Tullahoma and Pulaski. This additional funding took on different forms, with some cities relying on more than one source. Six projects (40%) received contributions supported by tax dollars (Burlington, Dunnellon, Monticello, Provo, Salisbury, and UTOPIA). Eleven projects (69%) received interfund loans from other municipal units. Many projects borrowed significant amounts, with the peak of these loans averaging 37% of the initial debt financing.

Ten projects (67%) declined to back their debt with the cities' taxing power and full faith and credit. Of these, three projects (20%) nonetheless provided support for the municipal fiber projects out of their general funds despite the specific language in the debt instrument protecting these cities from having to do so (Burlington, Monticello, and Salisbury).

Five projects (33%) used refinancing to mitigate their debt obligations. Four projects (27%) deferred the date when repayment of principal was to begin (Burlington, Jackson, Morristown, Salisbury). Four projects (27%) extended the maturity date of the debt (Jackson, Morristown, UTOPIA, and Windom).

Five projects (33%) saw significant downgrades to their bond ratings, although one has since recovered (Burlington). Three projects (20%) have defaulted on their debt (Burlington, Dunnellon, and Monticello). Of these, two projects (13%) stopped servicing their debt just before principal repayments were supposed to begin (Burlington and Monticello). The remaining project (7%) made the necessary payments until it disposed of the project during its fourth year of operations, when it settled its debt for less than its full value (Dunnellon). Three projects (20%) sold their operations at significant losses (Burlington, Dunnellon, and Provo).

6 Analyzing the determinants of viability

The wide variability in outcomes invites further inquiry into what factors drive success and failure. One approach to determining why municipal fiber projects succeed or fail is to compare a project's financial forecast with its actual performance. Three municipal fiber projects included pro forma projections of their financial performance as appendices to their official bond statements: Lafayette, Monticello, and Windom. A summary comparison of the projected versus actual financial performance for these three projects appears in Table 9. Full details are available in Online Appendix B.

Table 9:
Projected versus actual performance for Lafayette, Monticello, and Windom

		Lafayette 2007–2016	Monticello 2008–2015	Windom 2004–2011
Customers in the final year of the forecast period*	Projected	29,555	2,543	1,188
	Actual	17,686	1,487	1,073
	Difference	-11,869	-1,056	-115
	Pct. difference	-40%	-42%	-10%
Operating revenue	Projected	367,113,147	37,699,878	12,814,000
	Actual	186,314,498	10,567,972	11,329,437
	Difference	(180,798,649)	(27,131,906)	(1,484,563)
	Pct. difference	-49%	-72%	-12%
Average revenue per user (ARPU)	Projected	12,421	14,825	10,786
	Actual	10,535	7,107	10,559
	Difference	-1,887	-7,718	-228
	Pct. difference	-15%	-52%	-2%
Operating expense	Projected	(207,828,869)	(33,114,151)	(11,300,991)
	Actual	(94,216,489)	(19,471,147)	(14,606,820)
	Difference	113,612,380	13,643,004	(3,305,829)
	Pct. difference	-55%	-41%	+29%
Operating expenses / operating revenue	Projected	-57%	-88%	-88%
	Actual	-51%	-184%	-129%
	Difference	6%	-96%	-41%
	Pct. difference	11%	-110%	-46%
Operating income	Projected	159,284,278	4,585,727	1,177,349
	Actual	(32,509,994)	(8,903,175)	(3,277,383)
	Difference	(191,794,272)	(13,488,902)	(4,454,732)
	Pct. difference	-120%	-294%	-378%
Additions to plant	Projected	(97,907,643)	(20,356,614)	(8,376,101)
	Actual	(127,387,523)	(15,178,684)	(9,481,853)
	Difference	(29,479,880)	5,177,930	(1,105,752)
	Pct. difference	+30%	-25%	+13%
CFO	Projected	155,182,418	3,999,509	666,910
	Actual	28,011,729	(7,095,414)	1,384,598
	Difference	(127,170,689)	(11,094,923)	717,688
	Pct. difference	-82%	-277%	+108%
Debt service	Projected	(62,777,862)	(12,331,000)	(4,609,570)
	Actual	(53,849,276)	(13,766,869)	(4,607,735)
	Difference	8,928,586	(1,435,869)	1,835
	Pct. difference	-14%	+12%	+0%

* Includes only data customers for Monticello and Windom; includes combined data, telephone, and cable television customers for Lafayette

Of these three projects, Windom is the only project to exceed its CFO expectations, with such expectations exceeded by +$0.7 million. Contrast this with Lafayette's ($127.2 million) and Monticello's ($11.1 million) CFO shortfall.

The primary driver of Windom's positive results appears to be its relative success in acquiring customers. Its customer total in 2011 fell only -10% short of projections, which was much smaller than Lafayette's -40% or Monticello's -42% shortfall. As a result, Windom's revenue fell short of projections by only -12%, compared to -49% for Lafayette and -72% for Monticello. This shortfall clearly resulted from the number of customers, rather than the amount of revenue generated from each customer, as Windom and Lafayette generated similar ARPU of roughly +$10,500, with Monticello only slightly behind.

Operating efficiency appears to have played a less significant a role. The ratio of Windom's operating expenses to operating revenue underperformed expectations by -46%. Similarly, Monticello's operating efficiency was -110% versus expectations. This did not prevent either Windom or Monticello from outperforming Lafayette in terms of CFO, despite Lafayette's +11% improvement in operating efficiency as compared to expectations.

The role of capital expenses is similarly unclear. The fact that Windom's additions to plant exceeded projections by +13% did not prevent it from meeting expectations in terms of CFO. Conversely, Monticello's -25% lower expenditures on additions to plant compared with projections did not lift its performance above Windom's. Interestingly, Lafayette's forecast allocated no funding to "Additions to plant" after the fourth year of the project. This ignores the need to invest capital to attach new customers to the network and to expand and upgrade the transmission equipment and other attached electronics needed to run the network, all of which require ongoing investments of capital.

7 Conclusion

To date, debates over municipal fiber have been long on rhetoric and short on systematic empirical assessment of financial performance. This analysis fills that void and provides cities weighing whether to initiate a municipal fiber project with hard data based on the actual performance of existing municipal fiber projects to inform their decisions whether to proceed.

An examination of the actual performance of the fifteen projects for which complete data since 2011 are available reveals that none of them satisfied the standard test of short-run financial viability, which required them to receive with infusions of additional cash from outside sources or obtain some form of debt relief. In terms of long-run viability, again measured by actual performance, thirteen projects (87%) generated insufficient ANCF to put them on track to repay their debt by the date their initial debt is scheduled to mature. Moreover, eleven projects (73%) have either already defaulted or generated negative cumulative ANCF over the past three fiscal years, which leaves them poorly positioned unless they substantially improve their operations. An assessment of theoretical, best-case performance based on the NPV of CFO reveals that, even if these projects had achieved optimal performance for capital expenditures and debt service, the majority of the projects (53%) generated insufficient discounted CFO to cover their project costs.

Closer analysis of the projects in our study reveals further problems. Although all fifteen were expected to be self-sustaining, thirteen (87%) received further infusions of cash. Six of the projects (40%) received such infusions from general revenue even though three of those (20%) declined to back their initial debt with their general taxing power. Five projects (33%) used refinancing to defer the due date of principal repayment or to extend the maturity date of the debt. Five projects (33%) saw significant downgrades to their bond ratings. Three projects

(20%) have defaulted on their debt. Three projects (20%) have already been liquidated at significant losses.

An analysis of the reasons for success and failure suggests that the ability to generate revenue played the most significant role. Efficiency in capital costs and operating efficiency appear to have exerted influence over the overall results.

These results suggest that decisionmakers should carefully assess the possibility that a municipal fiber network might struggle and include the costs associated with dealing with that outcome when deciding whether to initiate such a project. At a minimum, due diligence would seem to require an analysis of whether the current project more closely resembles projects that succeeded or failed and a consultation with the leadership of prior projects that struggled.

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