The Economic Impact of the University of Northern Colorado's College of Osteopathic Medicine to Colorado

Lightcast

Contents

Executive summary

THE UNIVERSITY OF NORTHERN COLORADO (UNC) is a public doctoral research university based in Greeley, Colorado. The university's just-right size, expert faculty, and tradition of research and hands-on learning give students exceptional opportunities and a personalized education. UNC continues to evolve and grow to meet the needs of its students and state and local communities. As part of this effort, UNC is planning to open a College of Osteopathic Medicine. According to the Health Resources and Services Administration (HRSA), only 34.6% of the state's need for physicians is met. By opening a College of Osteopathic Medicine, UNC will help address this physician shortage. This analysis quantifies the economic impacts from UNC's College of Osteopathic Medicine (UNC COM) on the state economy. Note that the positive impacts from increased access to healthcare and improved healthcare in Colorado as a result of UNC COM are beyond the scope of this analysis.
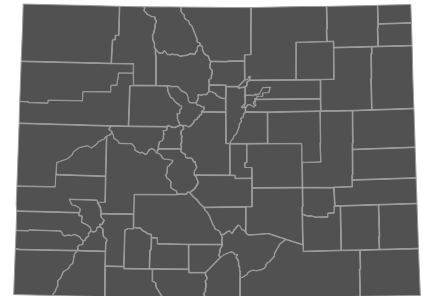
Colorado

> By opening a College of Osteopathic Medicine, UNC will help address this physician shortage.

Economic impact analysis

Short-run capital spending impacts

As the $127.5 million is spent to construct UNC COM, it will create a significant amount of new economic activity that will ripple throughout the Colorado economy. These impacts span from FY 2025, when the capital spending will begin, to FY 2027, when the capital spending is expected to be completed.

From FY 2025 to FY 2027, the capital spending will create a present value of **$106.3 million** in total added income for Colorado.

Long-run operations spending impacts

Utilizing the capacities of UNC COM will create the demand for added faculty and staff and their associated day-to-day operational expenditures. These operations spending impacts began in FY 2023, when UNC COM employees were first hired and UNC COM planning expenses occurred.

Across a 20-year timeframe, from FY 2023 to FY 2042, the operations spending resulting from UNC COM will create a present value of **$356.7 million** in total added income.

Long-run visitor spending impacts

Out-of-state visitors will be attracted to Colorado for events at UNC COM such as new student orientations and white coat and graduation ceremonies. These visitors will bring new dollars to the economy through their spending at hotels, restaurants, gas stations, and other state businesses.

Between FY 2026, when visitors are first expected for new student orientations, and FY 2042, the spending from out-of-state visitors will add approximately **$4.1 million** in income for the Colorado economy.

Long-run student spending impacts

UNC COM is expected to start serving students in FY 2027. Many of these students will relocate from outside the state. Some students from Colorado may leave the state if not for UNC COM. The money that these students will spend toward living expenses in Colorado is attributable to UNC COM.

From FY 2027, when the first UNC COM students enroll, to FY 2042, the students' spending will create a present value of **$202.6 million** in total added income.

Long-run alumni impacts

UNC COM alumni will represent a significant increase in the stock of human capital available to the Colorado economy, more specifically and importantly the college will fill some of the need for physicians in the state. They will begin to positively impact the state economy in FY 2034, when the first graduates become active in the state workforce, accounting for an enrollment ramp-up period and time spent completing their residency training in their chosen specialty. The higher earnings and increased productivity of these alumni will create long-run impacts across the state economy.

By FY 2042, UNC COM will have produced 1,741 physicians, an estimated 409 of whom will actively work in the Colorado workforce. From FY 2034 to FY 2042, the alumni will create a present value of **$691.2 million** in total added income to the Colorado economy.

Total impact

From FY 2023 to FY 2042, the present value of short- and long-run impacts created by UNC COM will generate a total economic impact on the Colorado economy of **$1.4 billion** in total added income.

By FY 2028, **5.4 years** after the start of this project, it is expected that the impacts generated by UNC COM will have grown significantly enough to recover the costs of not only the initial capital investment, but the annual costs of keeping UNC COM operational.

The implicit multiplier is the present value of added income divided by the present value of the initial capital investment in UNC COM and the long-run operational costs of the college. From FY 2023 to FY 2042, every dollar spent on UNC COM will create a present value of **$3.30** in added income throughout Colorado.

Total impact from FY 2023 to FY 2042

Values do not account for inflation and are undiscounted.

Source: Lightcast impact model.

Net cash flow from FY 2023 to FY 2042

Values do not account for inflation and are undiscounted.

Source: Lightcast impact model.

Annual impacts

The economic impacts discussed thus far are those summed across the analysis years of FY 2023 to FY 2042 and discounted to present value terms. However, each of the four long-run types of impacts will create an annual impact. These break down as follows:

- **Operations spending annual impact:** UNC COM will increase UNC's operational spending. By FY 2032, when operations stabilize, increased operations spending will add around **$23.5 million** in total income on an annual basis, equivalent to supporting **176 jobs** per year.

- **Visitor spending annual impact:** UNC COM will attract visitors to the state who would otherwise not have visited Colorado. Once the expected number of out-of-state visitors stabilize in FY 2031, the visitors will add **$309.3 thousand** in income per year, supporting **five jobs** annually, as a result of their spending in the state.

- **Student spending annual impact:** Once the number of students UNC COM is able to serve stabilizes at 632 students in FY 2032, **$15 million** in income will be added per year, supporting **83 jobs** annually, as a result of spending from retained and relocated students in the state.

- **Alumni annual impact:** UNC COM will produce more alumni every year, who will then accumulate in the state workforce. By FY 2042, the last year of this analysis, alumni are estimated to add **$158.4 million** in total income to the economy per year, supporting **3,987 jobs** annually. This annual impact is expected to increase every year for many years as UNC COM continues to serve more students and they enter the state workforce.

The total annual impact from UNC COM will be at least **$197.2 million** in added income. This is equivalent to supporting **4,161 jobs** every year.

Taxpayer benefits analysis

Between FY 2023 and FY 2042, state and local taxpayers will receive an estimated present value of $83.3 million in added tax revenue stemming from the spending from UNC COM's capital and operations spending and the spending of its visitors and students as well as the alumni higher earnings. Savings to the public sector add another estimated $929.2 thousand in benefits due to a reduced demand for government-funded social services in Colorado. Across the 20-year timeframe, total taxpayer benefits amount to $84.2 million, the present value sum of the added tax revenue and public sector savings.

Taxpayer benefits from FY 2023 to FY 2042*

Y-axis: Tax revenues and savings (millions). X-axis: Fiscal year
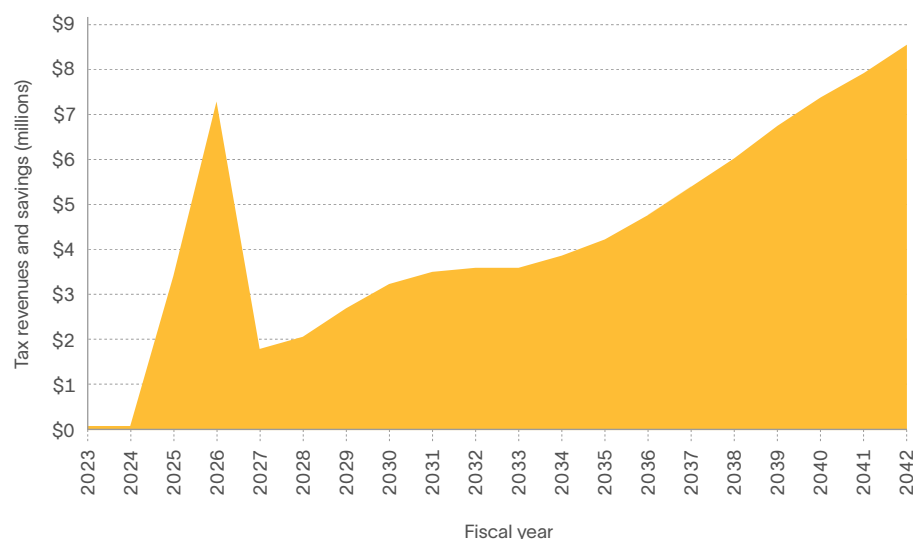
* These values do not account for inflation and are undiscounted.

Source: Lightcast impact model.

Introduction

THE UNIVERSITY OF NORTHERN COLORADO (UNC) is a public doctoral research university based in Greeley, Colorado. Established in 1889, and made a university in 1970, UNC serves around 9,000 students every year and offers more than 200 undergraduate and graduate programs, many of which are nationally recognized. The university's just-right size, expert faculty, and tradition of research and hands-on learning give students exceptional opportunities and a personalized education. The university boasts a 14:1 student-to-faculty ratio. UNC graduates join a strong network of over 140,000 alumni living and working in 50 states and 90 countries who help build communities that save and transform lives.

UNC continues to evolve and grow to meet the needs of its students and state and local communities. As part of this effort, UNC is planning to open a College of Osteopathic Medicine, a not-for-profit entity within the university. According to the Health Resources and Services Administration (HRSA), only 34.6% of the state's need for physicians is met. The HRSA also identifies that 59 of the 63 counties in the state contain regions designated as health professional shortage areas in primary care. By opening a College of Osteopathic Medicine, UNC will help address this physician shortage. With 40 accredited colleges of osteopathic medicine in the U.S.—only seven of which are at public colleges and universities—UNC COM would be joining a select group of DO colleges that will attract students from not just Colorado and the region, but across the country.

Osteopathic Medicine is a philosophy and practice of care with a distinct whole-person approach and focus on prevention and wellness. Doctors of Osteopathic Medicine (DOs) partner with their patients and work toward achieving optimal health with community and population health playing key roles in successful outcomes

UNC President, Andy Feinstein said, "I am excited about the possibility of UNC stepping up to meet the need of producing more physicians in service to our community and region. The creation of an osteopathic medical college at UNC would establish a pipeline of additional physicians to provide high-level care to others, including to individuals in underserved areas. A new medical college would be a win for Greeley, Weld County, the State of Colorado, and UNC."

The Founding Dean of the College of Osteopathic Medicine is Beth Longenecker, DO, MS, FACOEP, FACEP. Dr. Longenecker brings 20 years of experience in medical education to her leadership role. She began in her position as Founding Dean of the University of Northern Colorado's proposed College of Osteopathic Medicine (UNC COM) in June 2022.

This analysis will quantify the new economic activity created by UNC COM in the short-run and long-run in addition to the long-run state and local taxpayer benefits. The analysis spans 20 years, from FY 2023, when expenses for UNC COM first began, to FY 2042. The impacts are broken down into five types of impacts:

- **Short-run capital spending impacts:** The initial spending for the construction of UNC COM will span from FY 2025 to FY 2027 and total $127.5 million. As this money is spent, it will create new economic activity that will ripple throughout the Colorado economy.

- **Long-run operations spending impacts:** UNC COM will create the demand for added faculty and staff and their associated day-to-day operational expenditures. These operations spending impacts began in FY 2023 when the first operational expenditures occurred. UNC COM's operations spending impacts will continue to grow as expected expenses grow until FY 2032 when the finances are expected to stabilize.

- **Long-run visitor spending impacts:** UNC COM will attract visitors to Colorado for new student orientations and white coat and graduation ceremonies as well as other academic and business events. The Colorado economy will grow as these visitors spend money at restaurants, gas stations, and other businesses. The number of out-of-state visitors is expected to grow to nearly 1,000 by FY 2031.

- **Long-run student spending impacts:** As UNC COM becomes operational, it will begin serving medical students. Many of these students will relocate to the state in order to attend the college and others, originally from the state, will remain in the state because of opportunities provided by UNC COM. These students will spend money on housing, food, and entertainment in the state. This injection of money is attributable to UNC COM, which will begin in FY 2027 when UNC COM expects to start serving students.

- **Long-run alumni impacts:** The added capacities created by UNC COM will help UNC respond to not only the demand of students but also the demands of a growing economy. The impact from UNC COM alumni will begin to accrue in FY 2034, the first year the additional students enter the workforce after graduating and completing their residency training in their chosen specialty. By FY 2042, the final year of this analysis, an estimated 409 physicians will have been produced and working in Colorado as a result of UNC COM. These alumni represent a significant increase in physicians in the Colorado economy. The added earnings and increased productivity of these alumni will create long-run impacts across the state economy.

Even though this analysis spans across the five types of impacts from FY 2023 to FY 2042, the long-run impacts will continue long after the final year of this analysis.

In addition to these state impact, or growth in gross state product, state and local taxpayers will reap benefits from UNC COM. Taxpayers will experience benefits in the form of additional tax revenues stemming from the spending of UNC COM and its visitors and students and higher earnings of alumni as well as government savings.

About economic impact analysis

Economic impact analyses use different types of impacts to estimate the results. The impact focused on in this study is the **income impact**, which assesses the change in gross state product, or GSP. Income may be further broken out into the **labor income impact**, which assesses the change in employee compensation; and the **non-labor income impact**, which assesses the change in income business profits. Another way to state the income impact is **jobs**, a measure of the number of full- and part-time jobs that would be required to support the change in income. In the next section, jobs are reported on an annual basis rather than total because jobs are duplicated across the years. Finally, a frequently used measure is the **sales impact**, which comprises the change in business sales revenue in the economy as a result of increased economic activity. It is important to bear in mind, however, that much of this sales revenue leaves the state economy through intermediary transactions and costs.[1] All of these measures—jobs, income, and sales—are used to estimate the economic impact results.

The analysis breaks out the impact measures into different components, each based on the economic effect that caused the impact. The following is a list of each type of effect presented in this analysis:

▪ The **initial effect** is the exogenous shock to the economy caused by the initial spending of money, whether to pay for salaries and wages, purchase goods or services, or cover operating expenses.

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1   See Appendix 2 for an example of the intermediary costs included in the sales impact but not in the income impact.

- The initial round of spending creates more spending in the economy, resulting in what is commonly known as the **multiplier effect**. The multiplier effect comprises the additional activity that occurs across all industries in the economy and may be further decomposed into the following three types of effects:

  - The **direct effect** refers to the additional economic activity that occurs as the industries affected by the initial effect spend money to purchase goods and services from their supply chain industries.

  - The **indirect effect** occurs as the supply chain of the initial industries creates even more activity in the economy through their own inter-industry spending.

  - The **induced effect** refers to the economic activity created by the household sector as the businesses affected by the initial, direct, and indirect effects raise salaries or hire more people.

The terminology used to describe the economic effects listed above differs slightly from that of other commonly used input-output models, such as IMPLAN. For example, the initial effect in this study is called the "direct effect" by IMPLAN, as shown in the table below. Further, the term "indirect effect" as used by IMPLAN refers to the combined direct and indirect effects defined in this study. To avoid confusion, readers are encouraged to interpret the results presented in this section in the context of the terms and definitions listed above. Note that, regardless of the effects used to decompose the results, the total impact measures are analogous.

Lightcast	Initial	Direct	Indirect	Induced
IMPLAN	Direct	Indirect		Induced

Multiplier effects in this analysis are derived using Lightcast's Multi-Regional Social Accounting Matrix (MR-SAM) input-output model that captures the interconnection of industries, government, and households in the state. The Lightcast MR-SAM contains approximately 1,000 industry sectors at the highest level of detail available in the North American Industry Classification System (NAICS) and supplies the industry-specific multipliers required to determine the impacts associated with increased activity within a given economy. For more information on the Lightcast MR-SAM model and its data sources, see Appendix 3.

The economic impact
of UNC COM

THIS ANALYSIS QUANTIFIES the economic impacts associated with UNC COM, an endeavor beginning in FY 2023. In order to open UNC COM, the college will require $127.5 million in funding. Approximately, 99% of the funding is expected to come from the state government. The remaining $1.3 million of funds will originate from other funding sources such as donors (Table 1).

Table 1: Funding sources for UNC COM

Funding source	Amount	% of total
State government	$126,266,608	99%
Other sources of funding	$1,275,420	1%
Total	**$127,542,028**	**100%**

Source: Data provided by UNC COM.

UNC COM has outlined the proportion of funds that would be spent on construction, equipment—such as computers and lab materials—and other needs. Figure 1 outlines the total spending in these categories by year for UNC COM.

Figure 1: Spending by year and function

Values do not account for inflation and are undiscounted.

Source: Data provided by UNC COM.

Impacts created by UNC COM

Short-run capital spending impacts

+

Long-run operations spending impacts

+

Long-run visitor spending impacts

+

Long-run student spending impacts

+

Long-run alumni impacts

Total impacts
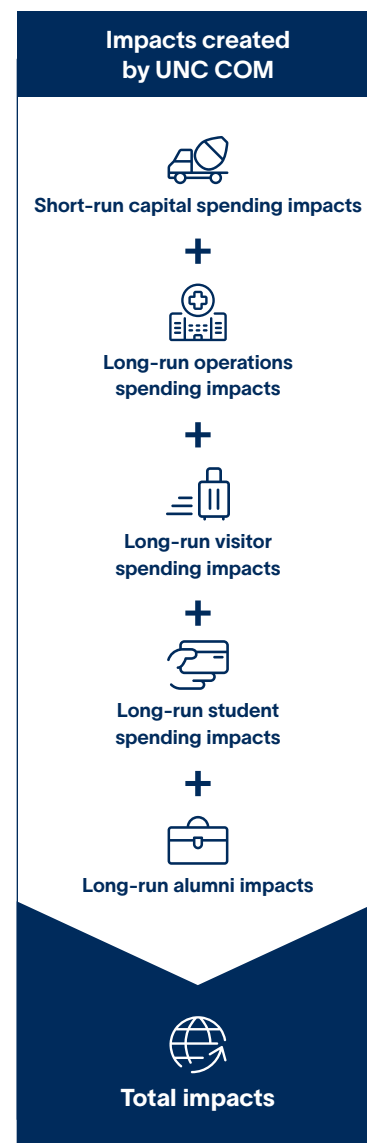
UNC COM will create impacts on the Colorado economy in a variety of ways. The initial capital investments will consist of the construction of the 100,000 square foot state of the art building to deliver the osteopathic medical education, thereby providing short-run capital spending impacts. Once the construction is completed, UNC COM will serve students whom UNC would otherwise not be able to serve. UNC COM will create new jobs for faculty and staff and will increase the day-to-day operational supply chain purchases from local businesses. UNC COM will draw out-of-state visitors to the state for new student orientations and white coat and graduation ceremonies, and these visitors will spend their money at state businesses, growing the state economy. Additionally, UNC COM will attract more students to the state and retain students in the state that would have left, thus positively impacting the state economy through the students' spending. This will provide a steady stream of long-run spending impacts year after year. Lastly, as the students graduate as physicians, they will create long-run benefits within the state.

In this section, we estimate these impacts under five headings: 1) the short-run capital spending impact from the spending on construction and other purchases; 2) the long-run operations spending impact from UNC COM; 3) the long-run visitor spending impact from the spending of out-of-state visitors; 5) the long-run student spending impact from the day-to-day expenditures of UNC COM students; and 6) the long-run alumni impact from the graduates that UNC COM will be able to produce. For the purpose of this report, UNC COM's service area is Colorado. UNC COM also received summary reports highlighting its expected impact on the local area of Weld County.

Short-run capital spending impacts

The capital spending will primarily be used to construct new state-of-the-art facilities and to purchase equipment to serve students. As outlined in Figure 1, the spending will occur during the course of three years. We refer to this period as the construction phase. Over the course of the construction phase, a total of $127.5 million will be spent. This spending will create a significant increase in the demand for the goods and services that are required to construct UNC COM. The initial spending will create subsequent rounds of spending and corresponding multiplier effects that will generate still more jobs and income throughout the Colorado economy. The short-run capital spending impacts only extend until FY 2027, when the construction phase ends.

> Spending toward UNC COM will create a net total short-run economic impact of **$106.3 million** in added income for Colorado.

The first step in estimating the multiplier effects of the construction spending is to map the three spending categories in Figure 1—construction, equipment, and other—to the approximately 1,000 industries of the Lightcast MR-SAM model. We assume UNC's spending patterns on UNC COM approximately match national averages for those three categories and apply national spending patterns for NAICS 902612 (Colleges, Universities, and Professional Schools (State Government)).

The next step is to estimate the portion of these expenditures that occur inside the state. The expenditures occurring outside the state are known as leakages. We estimate in-state expenditures using regional purchase coefficients (RPCs), a measure of the overall demand for the commodities produced by each sector that is satisfied

by Colorado suppliers, for each of the approximately 1,000 industries in the MR-SAM model. For example, if 40% of the demand for NAICS 52410 (Insurance carriers) is satisfied by UNC COM's suppliers, the RPC for that industry is 40%.

The remaining 60% of the demand for NAICS 52410 is provided by suppliers located outside Colorado. The spending is multiplied, industry by industry, by the corresponding RPC to arrive at the in-state spending. Of the $127.5 million spent during the course of the construction phase, we estimate $112.7 million will be spent within Colorado and $14.9 million will be spent on out-of-state goods and services (Table 2). Finally, in-state spending is entered, industry by industry, into the MR-SAM model's multiplier matrix, which in turn provides an estimate of the associated multiplier effects on labor income, non-labor income, total added income, and sales.

Table 2:   Spending by year and place of occurrence

Year	In-state (thousands)	Out-of-state (thousands)	Total (thousands)
FY 2025	$30,394	$4,287	$34,681
FY 2026	$77,040	$9,470	$86,510
FY 2027	$5,234	$1,117	$6,351
Total	**$112,668**	**$14,874**	**$127,542**

Values do not account for inflation and are undiscounted.

Source: Data provided by UNC COM and the Lightcast impact model.

Table 3 and Figure 2 present the short-run economic impacts of UNC COM by year. The first row under each year in the table represents the initial effect of that year's construction spending. Results appear in the section labelled multiplier effect in the table. Adding the initial effect and the multiplier effects yields the gross impact.

UNC COM estimates that 15% of the funds being raised will originate from state sources. The state government may be the direct funding for UNC COM's capital projects; however, the state government is expected to raise 85% of these funds from sources outside Colorado. Had the 15% of funds originating from Colorado been spent on other projects, other economic impacts would be created. This scenario is commonly known as a counterfactual; i.e., what has not happened but what would have happened if a given event—in this case, UNC COM receiving these funds—had not occurred. In economic analysis, impacts that occur under counterfactual conditions are used to offset the impacts that actually occur in order to derive the true impact of the event under analysis.

We estimate this counterfactual by simulating a scenario where public monies are instead spent on consumer goods and savings. This simulates the public monies being returned to the taxpayers and being spent by the household sector. Our approach is similar to that described above. We map these public funds to the detailed industries of the MR-SAM model using national household expenditure coefficients, use the industry RPCs to estimate in-state spending, and run the in-state spending through the MR-SAM model's multiplier matrix to derive multiplier effects. The results of this

exercise are shown as negative values in the row labelled "Less alternative uses of funds" in Table 3. The total net impacts of the construction spending are equal to the total gross impacts less the impacts of the alternative uses of funds.

Since construction is so labor intensive, most of the added income stems from labor income as opposed to non-labor income. As a result, the non-labor impacts associated with spending in the non-construction sectors are larger than in the construction sectors, so the net non-labor impact of construction spending is negative. This means that had the construction money instead been spent on consumer goods, more non-labor income would have been created at the expense of less labor income. The total net impact is still positive and substantial.

Table 3:   Short-run capital spending impacts by year

	Labor income (thousands)	Non-labor income (thousands)	Total added income (thousands)	Sales (thousands)
FY 2025				
Initial effect	$0	$0	$0	$34,681
Multiplier effect				
Direct effect	$12,687	$3,796	$16,483	$30,394
Indirect effect	$4,393	$1,287	$5,680	$10,738
Induced effect	$9,783	$2,970	$12,752	$23,082
Gross impact	**$26,862**	**$8,053**	**$34,915**	**$98,896**
Less alternative uses of funds	-$1,625	-$1,397	-$3,021	-$4,182
Net impact	**$25,238**	**$6,656**	**$31,894**	**$94,714**
FY 2026				
Initial effect	$0	$0	$0	$86,510
Multiplier effect				
Direct effect	$31,683	$6,192	$37,876	$77,040
Indirect effect	$10,989	$2,141	$13,130	$26,732
Induced effect	$22,412	$4,385	$26,796	$54,465
Gross impact	**$65,084**	**$12,718**	**$77,802**	**$244,746**
Less alternative uses of funds	-$4,053	-$3,484	-$7,536	-$10,432
Net impact	**$61,031**	**$9,235**	**$70,266**	**$234,314**
FY 2027				
Initial effect	$0	$0	$0	$6,351
Multiplier effect				
Direct effect	$2,143	$432	$2,574	$5,234
Indirect effect	$742	$149	$890	$1,814
Induced effect	$1,516	$306	$1,822	$3,698
Gross impact	**$4,401**	**$886**	**$5,287**	**$17,097**
Less alternative uses of funds	-$298	-$256	-$553	-$766
Net impact	**$4,103**	**$631**	**$4,734**	**$16,331**

Values do not account for inflation and are undiscounted.

Source: Lightcast impact model.

Table 3 and Figure 2 present undiscounted year-by-year impacts. In order to understand the total impact from FY 2025 to FY 2027, we must discount all future impacts to their present value in 2023 dollars. This is done using a discount rate of 0.2%, the three-year average of the real Treasury interest rate reported by the Office of Management and Budget for long-term investments.[2] Once the future impacts are discounted, we sum the present value of each year's impacts to reach a total net impact of UNC COM's construction spending from FY 2025 to FY 2027. Results are presented in Table 4. Spending toward UNC COM will create a total short-run economic impact of $106.3 million in added income for Colorado.

Figure 2:   Short-run capital spending impact by year

Values do not account for inflation and are undiscounted.

Source: Lightcast impact model.

Table 4: Present value of short-run capital spending impacts, total from FY 2025 to FY 2027

	Labor income (thousands)	Non-labor income (thousands)	Total added income (thousands)	Sales (thousands)
FY 2025 – FY 2027				
Initial effect	$0	$0	$0	$126,836
Multiplier effect				
Direct effect	$46,255	$10,365	$56,621	$112,045
Indirect effect	$16,035	$3,558	$19,593	$39,067
Induced effect	$33,525	$7,620	$41,145	$80,798
Gross impact	**$95,816**	**$21,543**	**$117,358**	**$358,746**
Less alternative uses of funds	-$5,942	-$5,108	-$11,050	-$15,294
Net impact	**$89,874**	**$16,435**	**$106,309**	**$343,451**

Source: Lightcast impact model.

Discount rate

The discount rate is a rate of interest that converts future values to present values. For example, $1,000 in future expenses spent 10 years in the future is worth much less than $1,000 in the present. The selection of an appropriate discount rate, however, can become an arbitrary and controversial undertaking. As suggested in economic theory, the discount rate should reflect the investor's opportunity cost of capital, i.e., the rate of return one could reasonably expect to obtain from alternative investment schemes. In this study we use a 0.2% discount rate as provided by the Office of Management and Budget.

Note that this is a real discount rate, not nominal. When a bank promises to pay a certain rate of interest on a savings account, it employs an implicitly nominal rate. Bonds operate in a similar manner. If it turns out that the inflation rate is higher than the stated rate of return, then money is lost in real terms. In contrast, a real rate of return is on top of inflation. For example, if inflation is running at 3% and a nominal percentage of 5% is paid, the real rate of return on investment is only 2%.

Long-run operations spending impacts

UNC COM will create a new wave of economic activity that will include payroll for new faculty and staff and spending on other supplies (e.g., office supplies and medical supplies). In this section, we estimate the economic impact of these new rounds of operations spending that will occur. These economic impacts will continue annually as long as UNC COM is operational. We estimate the operational impacts between FY 2023—when expenses first began for employees and planning UNC COM—and FY 2042—the final year of this analysis.

To begin this analysis, we consider the revenue and spending needed to operate UNC COM per year. UNC COM provided information regarding the estimated revenues and operations spending required. The college spent $583.8 thousand for payroll and

Spending towards UNC COM employees and other purchases will generate **$356.7 million** in added income for Colorado between FY 2023 and FY 2042.

Figure 3:   Revenue by year and source
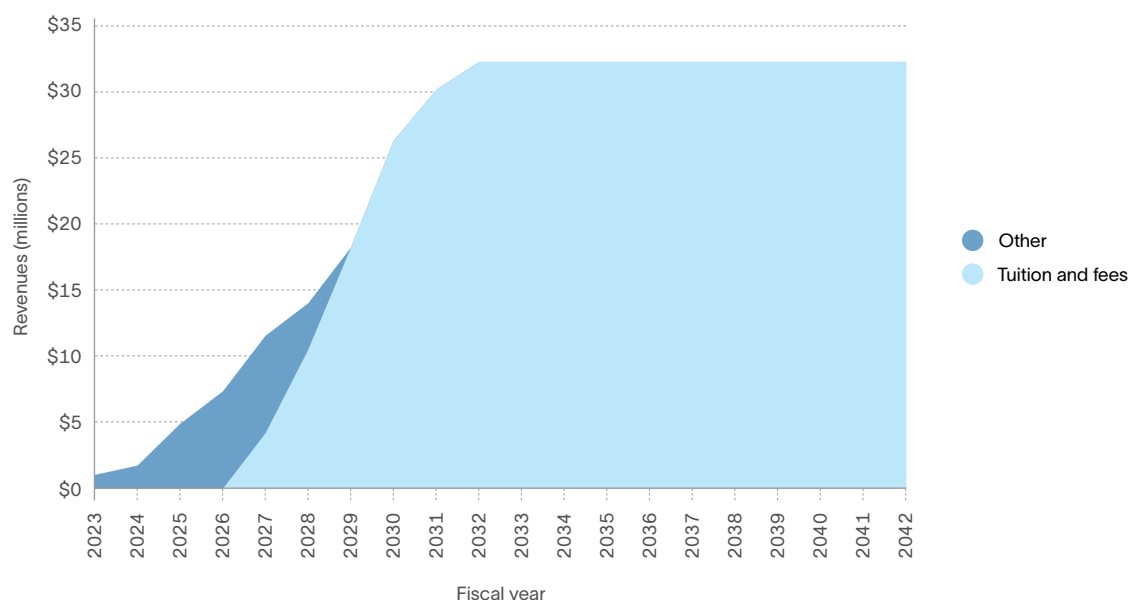
Values do not account for inflation and are undiscounted.
Source: Data provided by UNC COM.

$498.3 thousand for non-pay expenditures on UNC COM in FY 2023. The spending will grow over time until, once stabilized around the 10th year of operations, UNC COM will spend $18.3 million per year for its operations (excluding depreciation and interest). To fund these operations the college estimates it will receive an additional $32.1 million in revenues once stabilized, which is expected to occur in FY 2032. Figure 3 and Figure 4 outline the operations revenue and expenditures, respectively, by year and type.

Figure 4: **Expenditures by year and type (excluding depreciation & interest)**
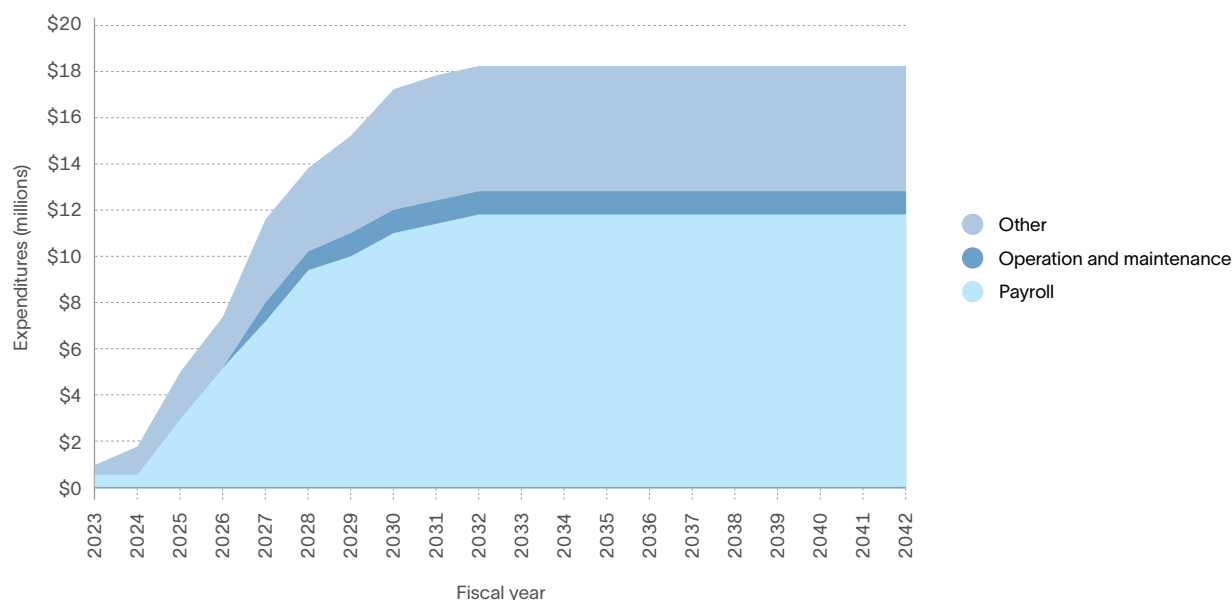
Values do not account for inflation and are undiscounted.
Source: Data provided by UNC COM.

The first step in estimating the operations spending impacts is to map these categories to the approximately 1,000 industries of the Lightcast MR-SAM model. Again, assuming that the spending patterns of UNC COM's personnel approximately match those of the average consumer, we map payroll to spending on industry outputs using national household expenditure coefficients supplied by Lightcast's national SAM. For the other expenditure category, we assume the spending patterns approximately match national averages and apply the national spending coefficients for NAICS 902612 (Colleges, Universities, and Professional Schools (State Government)).

We now have two vectors of expenditures: one for payroll and another for UNC COM's purchases of supplies and services. Using the RPCs, we estimate the portion of these expenditures that occur inside the state. The vectors of expenditures are multiplied, industry by industry, by the corresponding RPC to arrive at the in-state expenditures associated with the 100,000 square foot state of the art building to deliver osteopathic medical education. Finally, in-state spending is entered, industry by industry, into the MR-SAM model's multiplier matrix, which in turn provides an estimate of the associated multiplier effects on labor income, non-labor income, total added income, sales, and jobs.

Table 5 presents the economic impact of UNC COM's operations for the first year of operations, FY 2023, and the last year, FY 2042, whereas Figure 5 presents the impact every year. For each year, the top row shows the initial effects of UNC COM's operations in terms of labor income, non-labor income, total added income, and sales. However, the funding for these operations had to come from somewhere. Consequently, we must account for any alternate uses of these funds. This is similar to the counterfactual we considered in the short-run capital spending impacts section. However, we also consider that the majority of student tuition will be paid by federal loans, representing an immediate new injection of money into the state economy that would not have been there without UNC COM. For the alternative uses of funds, we only consider tuition and other revenue sources coming from state sources. The results of this exercise are shown as negative values in the row labeled "Less alternative uses of funds" in Table 5.

Table 5: Operations spending impacts, first and last year of analysis

	Labor income (thousands)	Non-labor income (thousands)	Total added income (thousands)	Sales (thousands)
FY 2023				
Initial effect	**$584**	**$0**	**$584**	**$1,082**
Multiplier effect				
Direct effect	$99	$70	$169	$279
Indirect effect	$39	$23	$62	$109
Induced effect	$265	$215	$480	$802
Gross impact	**$987**	**$308**	**$1,295**	**$2,272**
Less alternative uses of funds	-$224	-$192	-$416	-$576
Net impact	**$763**	**$116**	**$879**	**$1,696**
...				
FY 2042				
Initial effect	**$11,773**	**$0**	**$11,773**	**$18,262**
Multiplier effect				
Direct effect	$1,474	$851	$2,325	$4,000
Indirect effect	$563	$286	$849	$1,521
Induced effect	$4,874	$3,856	$8,729	$14,725
Gross impact	**$18,684**	**$4,992**	**$23,676**	**$38,509**
Less alternative uses of funds	-$120	-$103	-$223	-$309
Net impact	**$18,564**	**$4,889**	**$23,453**	**$38,199**

Values do not account for inflation and are undiscounted.

Source: Lightcast impact model.

Table 5 and Figure 5 present undiscounted year-by-year operations spending impacts. The total impacts, summed across FY 2023 to FY 2042 and discounted to 2023 dollars, are presented in Table 6. From FY 2023 to FY 2042, the present value of increased operations spending resulting from UNC COM will create $356.7 million in total added income.

Figure 5: Operations spending impacts by year
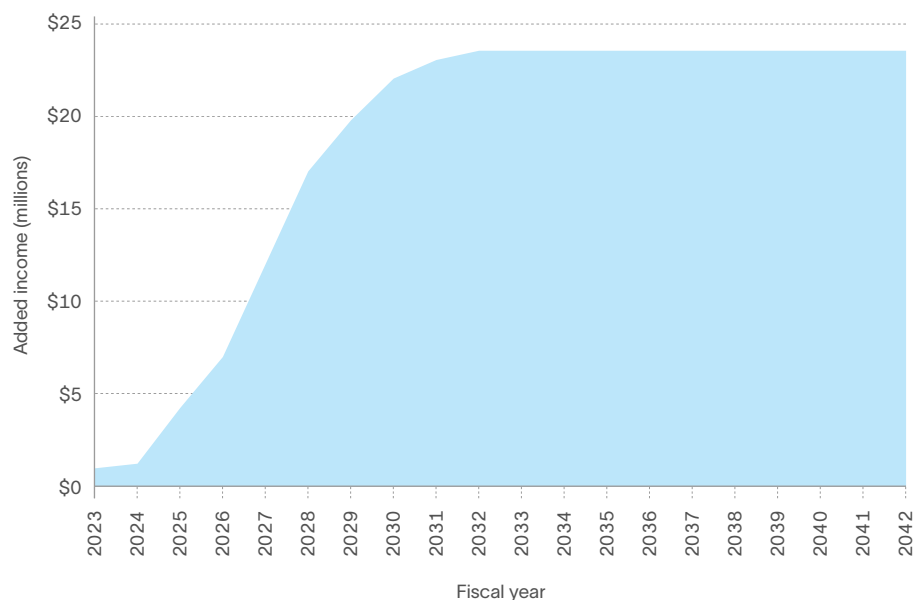
Values do not account for inflation and are undiscounted.

Source: Data provided by UNC COM.

Table 6: Present value of operations spending impacts, total from FY 2023 to FY 2042

	Labor income (thousands)	Non-labor income (thousands)	Total added income (thousands)	Sales (thousands)
FY 2023 – FY 2042				
Initial effect	$183,926	$0	$183,926	$285,241
Multiplier effect				
Direct effect	$22,971	$13,304	$36,275	$62,373
Indirect effect	$8,778	$4,463	$13,241	$23,732
Induced effect	$76,100	$60,243	$136,343	$229,963
Gross impact	$291,774	$78,010	$369,784	$601,309
Less alternative uses of funds	-$7,010	-$6,026	-$13,036	-$18,044
Net impact	$284,764	$71,984	$356,748	$583,265

Source: Lightcast impact model.

Annual operations spending impacts

While the total impacts that occur from FY 2023 to FY 2042 are relevant because of the temporal nature of UNC COM's operations spending, it is critical to understand that there will be a recurring annual operations spending impact. These are the true long-run operations spending impacts. Without making any assumptions for growth beyond the first 20 years of analysis, the Colorado economy will enjoy an annual impact of **$23.5 million** in total added income. This is equivalent to supporting **176 jobs** every year.

Long-run visitor spending impacts

Hundreds of out-of-state visitors are expected to visit UNC COM to attend various events, including new student orientations and white coat and graduation ceremonies. UNC COM estimated that 150 visitors will attend events hosted in FY 2026 and of those 60 will come from outside Colorado. Table 7 presents the average expenditures per person-trip for accommodation, food, transportation, and other personal expenses (including shopping and entertainment).

Table 7: Average spending per visitor in Colorado

Accommodation	$156
Food and dining	$195
Transportation	$15
Personal expenses	$30
Total expenses per person per trip	**$396**

The accommodation and transportation costs are adjusted downward to account for the idea that visitors such as family members are most likely sharing those costs. Costs are adjusted for an average of three days stayed in the state.
Source: Data provided by UNC COM.

The accommodation and transportation costs are adjusted downward to account for the idea that visitors will most likely share those costs. Table 8 shows the number of out-of-state visitors and their corresponding spending by year. The visitors spending impacts continue until FY 2042, the cutoff date in this study's time horizon.

Estimating the impacts generated by visitor spending follows a procedure similar to that of the impacts described above. We distribute the spending to the industry sectors of the MR-SAM model, apply RPCs to reflect in-state spending, and run the spending figures through the MR-SAM model to derive multiplier effects. In this case, the initial effect is purely output-oriented and there is no change in labor or non-labor income. The impact of visitor spending thus falls entirely under the multiplier effect. Table 9 outlines this process for the first and last year of the visitor spending impact, FY 2026 and FY 2042.

Table 8:   Visitors and their spending by year

Year	Total visitors*	Out-of-state visitors	Spending per visitor	Total spending* (thousands)
FY 2026	150	60	$396	$24
FY 2027	360	144	$396	$57
FY 2028	636	254	$396	$101
FY 2029	929	372	$396	$147
FY 2030	1,356	542	$396	$215
FY 2031	1,549	620	$396	$245
FY 2032	1,617	647	$396	$256
FY 2033	1,662	665	$396	$263
FY 2034	1,806	722	$396	$286
FY 2035	1,790	716	$396	$284
FY 2036	1,750	700	$396	$277
FY 2037	1,636	654	$396	$259
FY 2038	1,656	662	$396	$262
FY 2039	1,750	700	$396	$277
FY 2040	1,783	713	$396	$282
FY 2041	1,762	705	$396	$279
FY 2042	1,749	700	$396	$277

* Lightcast worked with UNC COM to arrive at the number of visitors. The number of visitors varies depending on the students' year of study, for example graduating students will have visitors for commencement. The number of visitors varies each year in accordance with the varying size of student cohorts.

Values do not account for inflation and are undiscounted. Numbers may not add due to rounding.

Source: UNC COM and Lightcast impact model.

Table 9:   Visitor spending impacts, first and last year of analysis

|	Labor income (thousands)	Non-labor income (thousands)	Total added income (thousands)	Sales (thousands)
FY 2026				
Initial effect	$0	$0	$0	$24
Multiplier effect				
Direct effect	$7	$5	$12	$21
Indirect effect	$3	$2	$5	$9
Induced effect	$6	$4	$10	$17
Total impact	$15	$11	$27	$70
...				
FY 2042				
Initial effect	$0	$0	$0	$277
Multiplier effect				
Direct effect	$80	$60	$140	$245
Indirect effect	$32	$23	$56	$100
Induced effect	$66	$48	$114	$199
Total impact	$178	$131	$309	$821

Values do not account for inflation and are undiscounted.

Source: Lightcast impact model.

Figure 6: Visitor spending impacts by year
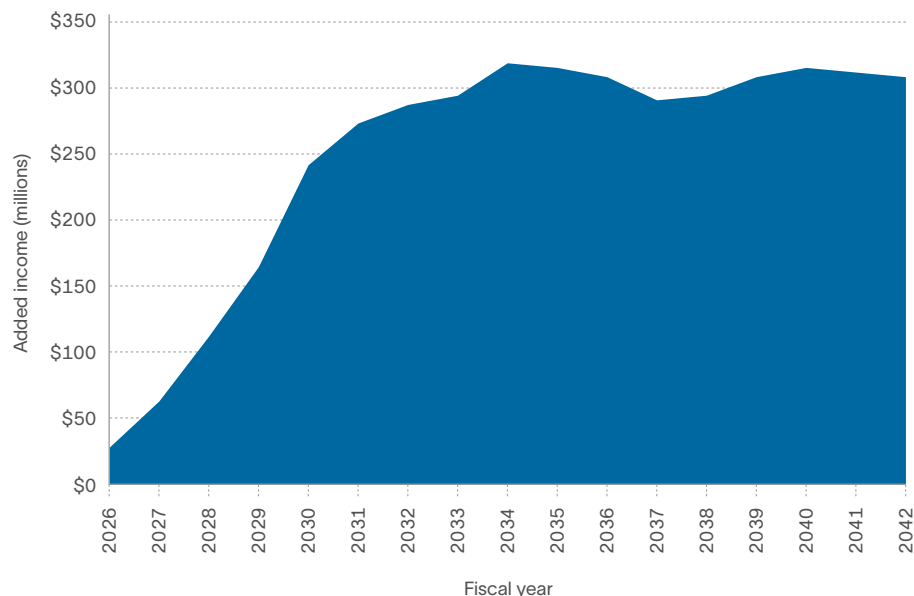
Values do not account for inflation and are undiscounted.

Source: Lightcast impact model.

Annual visitor spending impacts

While the total impacts that occur from FY 2026 to FY 2042 are relevant because of the temporal nature of UNC COM, there will be recurring annual visitor spending impacts as long as the college continues to attract visitors for its events. These are the true long-run UNC COM visitor spending impacts. By FY 2031, once the number of out-of-state visitors stabilizes, the Colorado economy will benefit from an annual impact of **$309.3 thousand** in total added income from the UNC COM visitor spending, which is equivalent to supporting **five jobs** every year.

Table 9 and Figure 6 present the undiscounted visitor spending impacts that accumulate year-by-year between FY 2026 and FY 2042. The total visitor spending impacts, summed across those years and discounted to 2023 dollars, are presented in Table 10. From FY 2026 to FY 2042, the visitor spending from UNC COM will add $4.1 million in total added income.

Table 10: Present value of visitor spending impacts, total from FY 2026 to FY 2042

	Labor income (thousands)	Non-labor income (thousands)	Total added income (thousands)	Sales (thousands)
FY 2026 – FY 2042				
Initial effect	$0	$0	$0	$3,699
Multiplier effect				
Direct effect	$1,073	$795	$1,868	$3,276
Indirect effect	$429	$313	$742	$1,335
Induced effect	$877	$643	$1,520	$2,655
Total impact	**$2,379**	**$1,751**	**$4,130**	**$10,965**

Source: Lightcast impact model.

Between FY 2026 and FY 2042, visitors for UNC COM events will add **$4.1 million** to the Colorado economy.

Long-run student spending impacts

Students will contribute to the economic impact of UNC COM. Approximately 40% of UNC COM students will originate from outside the state. Many of these students will relocate to the state in order to attend the college. These students will bring monies with them to spend on living arrangements, food, transportation, and so forth.

Once stabilized, of the 632 additional students served each year, an estimated 379 of them will be from Colorado. However, not all of them will remain in the state if not for UNC COM. We apply an assumption that 80% of these students will leave Colorado for other education opportunities if UNC COM does not exist. The money that these students, called retained students, will spend on groceries, accommodation, transportation, and so on will now remain in the state.

> Once stabilized in FY 3032, UNC COM expects to serve **632 students** each year.

The spending of these relocated and retained students while they attend the college can be attributed to UNC COM. The student spending impacts are expected to start in FY 2027, when the first students will be served, and last until FY 2042, the final year of this analysis. The average costs for students appear in Table 11, equal to $28,500 per student.

Table 12 outlines the total number of students UNC COM expects to serve each year. By multiplying the expenses per student by the number of relocated and retained students and adjusting for monies paid to student workers, we arrive at a net total of $14.9 million in annual sales, once stabilized.[3] The student spending impacts continue until FY 2042, the cutoff date in this study's time horizon.

3   Numbers may not match by multiplying due to rounding.

Table 11: Average annual student spending

Room and board	$19,000
Personal expenses	$6,063
Transportation	$3,437
Total expenses per student*	**$28,500**

* Numbers may not add due to rounding.

Source: Data provided by UNC COM.

Table 12: Added students and total sales by year

Year	Students	Relocated students*	Retained students	Net sales* (thousands)
FY 2027	80	32	38	$2,002
FY 2028	201	80	96	$5,036
FY 2029	359	142	170	$8,883
FY 2030	515	201	241	$12,539
FY 2031	593	227	272	$14,166
FY 2032	632	240	288	$14,950
FY 2033	632	238	286	$14,863
FY 2034	632	237	285	$14,794
FY 2035	632	239	286	$14,864
FY 2036	632	239	286	$14,873
FY 2037	632	238	286	$14,856
FY 2038	632	238	286	$14,850
FY 2039	632	237	285	$14,798
FY 2040	632	238	286	$14,851
FY 2041	632	239	286	$14,871
FY 2042	632	238	286	$14,858

* The number of relocated and retained students do not stabilize because student state residency changes in students' third year of enrollment and the makeup of the student cohorts during each analysis year continues to fluctuate.

Values do not account for inflation and are undiscounted.

Source: Data provided by UNC COM and the Lightcast impact model.

Estimating the impacts generated by the student spending follows a procedure similar to that of the other impacts previously described. We distribute the sales to the industry sectors of the MR-SAM model, apply RPCs to reflect in-state spending, and run the sales figures through the MR-SAM model to derive multiplier effects. Unlike the previous subsections, the initial effect is purely sales-oriented and there is no change in labor or non-labor income. The impact of student spending thus falls entirely under the multiplier effect. Table 13 outlines the annual impacts for FY 2027, when the first students enroll in UNC COM, and FY 2042, the final year of our analysis. Figure 7 outlines the impact for every year of the analysis.

Table 13: Student spending impacts, first and last year of analysis

	Labor income (thousands)	Non-labor income (thousands)	Total added income (thousands)	Sales (thousands)
FY 2027				
Initial effect	$0	$0	$0	$2,002
Multiplier effect				
Direct effect	$392	$555	$947	$1,592
Indirect effect	$138	$189	$327	$563
Induced effect	$317	$426	$743	$1,242
Total impact	**$847**	**$1,170**	**$2,017**	**$5,399**
...				
FY 2042				
Initial effect	$0	$0	$0	$14,858
Multiplier effect				
Direct effect	$2,907	$4,123	$7,030	$11,818
Indirect effect	$1,027	$1,402	$2,429	$4,181
Induced effect	$2,355	$3,162	$5,517	$9,223
Total impact	**$6,288**	**$8,687**	**$14,975**	**$40,081**

Values do not account for inflation and are undiscounted.

Source: Lightcast impact model.

Figure 7: Student spending impacts by year
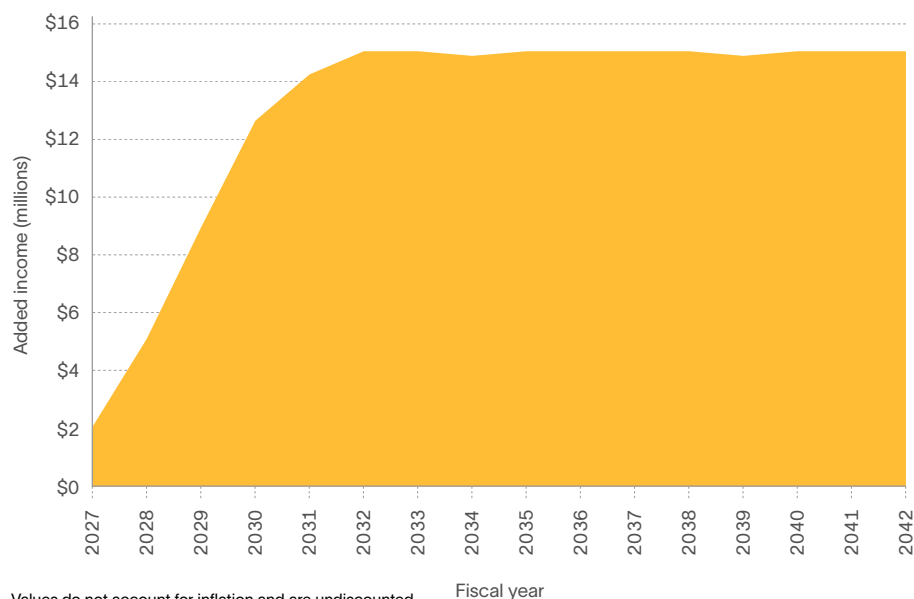
Values do not account for inflation and are undiscounted.

Source: Lightcast impact model.

The total long-run student spending impacts, summed across those years and discounted to 2023 dollars, are presented in Table 14. From FY 2027 to FY 2042, UNC COM students will add $202.6 million in total added income for the Colorado economy.

Table 14: Present value of student spending impacts, total from FY 2027 to FY 2042

	Labor income (thousands)	Non-labor income (thousands)	Total added income (thousands)	Sales (thousands)
FY 2027 – FY 2042				
Initial effect	$0	$0	$0	$200,978
Multiplier effect				
Direct effect	$39,318	$55,771	$95,089	$159,859
Indirect effect	$13,889	$18,963	$32,852	$56,551
Induced effect	$31,849	$42,771	$74,620	$124,753
Total impact	**$85,056**	**$117,505**	**$202,561**	**$542,140**

Source: Lightcast impact model.

Annual student spending impacts

While the total impacts that occur from FY 2027 to FY 2042 are relevant because of the temporal nature of the student spending, there will be recurring annual student spending impacts as long as UNC COM serves students. These are the true long-run UNC COM student spending impacts. The Colorado economy will benefit from an annual impact of **$15 million** in total added income from student spending activities, which is equivalent to supporting **83 jobs** annually.

Long-run alumni impacts

While UNC COM will create economic impacts through capital, operations, visitor, and student spending, the real mission and purpose of UNC COM is to educate students to become physicians. By FY 2042, an estimated 1,741 alumni will have graduated from UNC COM to continue on to their residency, an estimated 409 of whom will be active in the state workforce.[4]

UNC COM's medical students will receive knowledge, skills, and abilities that will increase their productivity and allow them to command a higher wage once they enter the workforce. But the reward of increased productivity does not stop there. Talented professionals make capital, such as buildings, production facilities, and equipment, more productive too. The employers of UNC COM's alumni enjoy the fruits of this increased productivity in the form of additional non-labor income (i.e., higher profits). In this section, we estimate the economic impacts stemming from the higher labor income of these alumni in combination with the increased productivity that will be enjoyed by their future employers. The time horizon for this portion of the analysis falls between FY 2034 and FY 2042—the earliest point in time when the additional alumni will be working in the Colorado workforce (accounting for a three-to-six-year delay in receiving physician earnings because of residency training in their chosen specialty) and the final year of this anal-

> By FY 2042, an estimated **1,741 additional alumni** will have graduated from the college as a result of UNC COM.

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4   Lightcast worked with UNC COM to determine the expected number of additional alumni, including their workforce settlement rates.

ysis. Note that, unlike the alumni impact in the economic impact study conducted by Lightcast for UNC for FY 2018, for this analysis, only those students that graduated with a degree are measured. The analysis uses 4- and 6-year graduation rates as provided by UNC COM.

There is an important difference between the alumni impact and the impacts estimated in the previous sections. Whereas the short- and long-run spending impacts stem from an injection of new sales into the state economy, the alumni impact stems from the increased human capital that will accumulate in the Colorado workforce as a result of UNC COM. The initial effect of alumni is comprised of two main components. The first and largest of these is the added labor income of physician graduates. The second component is the added non-labor income of the businesses that will employ these additional alumni.

To estimate the added labor income created each year, we use the number of alumni produced and their *incremental* added labor income stemming from their educations. The number of alumni is calculated using the enrollment as outlined in the student spending impact (Table 12) and multiplying them by the graduation rate. The incremental labor income is the difference between the earnings of physicians and the earnings at the level of education the students had when entering UNC COM. Since UNC COM will be serving additional students seeking a professional degree and the majority of these students will enter with a bachelor's degree, the incremental added labor income associated with an alumnus with a professional degree is the difference between the average earnings for someone with a professional degree and someone with a bachelor's degree. The average earnings in Colorado associated with each level of educational attainment are found in Table 15 and Figure 8. The added labor income created each year is equal to the sum of the incremental earnings of each year's new alumni working in the state workforce.

Table 15: Average annual earnings by education level in Colorado at career midpoint

	Annual earnings	Increase in earnings	Once stabilized, annual graduates
Bachelor's degree in healthcare	$57,800	n/a	n/a
Professional degree in Osteopathic Medicine	$265,600	$207,800	147

Source: Lightcast impact model.

Figure 8: Average annual earnings by education level in Colorado at career midpoint
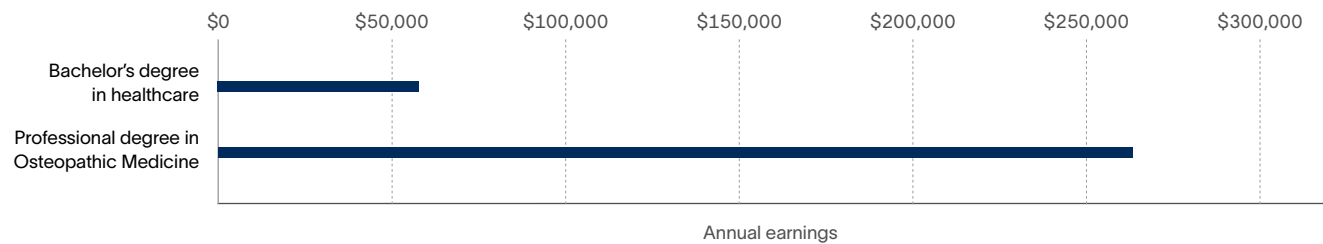
Source: Lightcast impact model.

Because we only want to consider alumni that would graduate as a result of UNC COM, there are two counterfactuals we must consider. First, there are alternative education opportunities. In the scenario where UNC COM does not exist, a portion of these additional alumni may receive an alternative comparable education elsewhere and work post-graduation in Colorado. The incremental labor income that accrues to these students cannot be counted towards the added labor income created by UNC COM. We assume 5% of these alumni would receive an alternative comparable education and work in Colorado post-graduation. This means that 5% of the added labor income from the alumni would be generated in the Colorado economy anyway, even without the added capacities from UNC COM.

Second, we need to account for the importation of labor. Suppose UNC COM is not built. These alumni would not graduate and there would be fewer physicians in Colorado. However, businesses could still satisfy some of their need for skilled labor by recruiting from outside Colorado. We refer to this as the labor import effect. Lacking information on its possible magnitude, we assume 20% of the jobs that students fill at state businesses could be filled by physicians recruited from outside the state.

As seen in Table 16, the average wage increase per additional alumnus is $187,084. This differential was dampened to adjust for "ability bias" to account for other factors besides education that influence individual behavior. After accounting for the two above counterfactual scenarios, the net wage increase per alumnus is $140,313.

Table 16: Earnings increase per additional alumnus

Average wage increase per alumnus	$187,084
Alternative education variable	5%
Labor import effect	20%
Net wage increase per alumnus	**$140,313**

Source: Lightcast impact model.

It is important to understand that the alumni impacts are cumulative as more alumni are produced. For example, for the purposes of this analysis we use a 100% time to complete graduation rate (4 years) as well as a 150% time to complete graduation rate (6 years) for those that did not graduate in 4 years. The first alumni graduate at the end of FY 2030, four years after the first students are enrolled. Then, students begin their residency training in their chosen specialty, which can last between three and six years. Thus, the earliest year of completion of their degree and residency is FY 2033. The added labor income from FY 2030 cohort of students will begin in FY 2034 when those alumni become active in the state workforce, the year following the completion of their residency training. Alumni are also produced in FY 2031 from the second cohort of students, who are now able to gain their degree as a result of UNC COM. The total incremental added labor income in FY 2035 will equal the sum of the alumni added labor income who graduated in FY 2034 and FY 2035. This continues until FY 2042, the cutoff date in this study's time horizon. These alumni are then adjusted for various measures of attrition such as unemployment and migration to determine how many

are active in the state workforce. Table 17 shows the accumulation of alumni. Using these active alumni, we then calculate added labor income by year.

Table 17: Additional alumni and labor income by year

Fiscal year	Graduates	Cumulative alumni working in state*	Added labor income (thousands)**
FY 2030	68	0	$0
FY 2031	106	0	$0
FY 2032	114	0	$0
FY 2033	152	0	$0
FY 2034	156	20	$2,477
FY 2035	148	56	$6,809
FY 2036	145	97	$11,948
FY 2037	119	151	$18,727
FY 2038	147	208	$25,979
FY 2039	147	263	$33,057
FY 2040	147	316	$40,014
FY 2041	147	359	$45,960
FY 2042	147	409	$52,690
Total	**1,741**	**409**	**$237,660**

* Alumni will not receive most of the higher earnings until after they complete their residency training in their chosen specialty and then following next fiscal year when they become active in the state workforce.

** The added labor income is calculated using the annual alumni after applying a graduation rate.

Values do not account for inflation and are undiscounted.

Source: Data provided by UNC COM and the Lightcast impact model.

Now that we have the labor income portion of our initial effect, we estimate the non-labor income portion of the initial effect. As discussed earlier in this section, businesses that employ alumni from UNC COM enjoy higher profits as a result of the increased productivity of their capital assets. To estimate this additional income, we allocate the initial increase in labor income to the six-digit NAICS industry sectors where students are most likely to be employed. We do so by using inverse staffing patterns, which break down the industries in which physicians are most likely to be employed. Finally, we apply a matrix of wages by industry and by occupation from the MR-SAM model to map the occupational distribution of the initial labor income effects to the detailed industry sectors in the MR-SAM model.[5]

Once these allocations are complete, we apply the ratio of non-labor to labor income provided by the MR-SAM model for each sector to our estimate of initial labor income. This computation yields the non-labor income attributable to UNC's additional alumni. Summing initial labor and non-labor income together provides the total initial effect of

5   For example, if the MR-SAM model indicates that 65% of wages paid to workers in SOC 29-1062 (Family and General Practitioners) occur in NAICS 621111 (Offices of Physicians, except Mental Health Specialists), then we allocate 65% of the initial labor income effect under SOC 29-1062 to NAICS 621111.

these alumni in the Colorado economy, as represented by the "Total added income" column. We now have a complete initial effect from which we can derive the multiplier effects. To do so, we convert the industry-specific income figures generated through the initial effect to sales using sales-to-income ratios from the MR-SAM model. We then run the values through the MR-SAM's multiplier matrix, as described at the beginning of this section. Table 18 outlines this process in detail for FY 2034, when the first graduates from UNC COM enter the state workforce, and FY 2042, the final year of the analysis. Figure 9 presents the impacts every year of the analysis.

Table 18: Alumni impacts, first and last year of analysis

	Labor income (thousands)	Non-labor income (thousands)	Total added income (thousands)	Sales (thousands)
FY 2034				
Initial effect	**$2,477**	**$820**	**$3,297**	**$5,092**
Multiplier effect				
Direct effect	$517	$313	$830	$1,294
Indirect effect	$230	$134	$364	$571
Induced effect	$1,837	$1,119	$2,956	$4,557
Total impact	**$5,061**	**$2,386**	**$7,447**	**$11,514**
...				
FY 2042				
Initial effect	**$52,690**	**$17,444**	**$70,134**	**$108,327**
Multiplier effect				
Direct effect	$11,002	$6,659	$17,661	$27,538
Indirect effect	$4,895	$2,851	$7,747	$12,139
Induced effect	$39,074	$23,808	$62,882	$96,942
Total impact	**$107,661**	**$50,763**	**$158,424**	**$244,946**

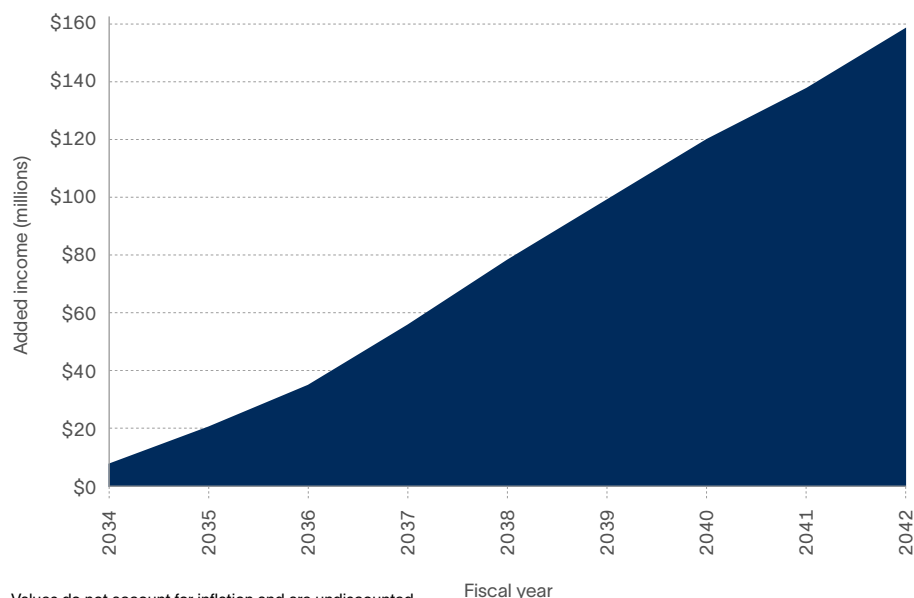Values do not account for inflation and are undiscounted.

Source: Lightcast impact model.

Table 18 and Figure 9 present the undiscounted alumni impacts that accumulate year-by-year between FY 2034 and FY 2042. The total long-run alumni impacts, summed across those years and discounted to 2023 dollars, are presented in Table 19. From FY 2034 to FY 2042, the additional alumni will add $691.2 million in total added income.

Figure 9:   Alumni impacts by year

Values do not account for inflation and are undiscounted.

Source: Lightcast impact model.

Table 19:   Present value of alumni impacts, total from FY 2034 to FY 2042

	Labor income (thousands)	Non-labor income (thousands)	Total added income (thousands)	Sales (thousands)
FY 2034 – FY 2042				
Initial effect	$229,893	$76,111	$306,004	$472,642
Multiplier effect				
Direct effect	$48,001	$29,055	$77,057	$120,153
Indirect effect	$21,359	$12,441	$33,800	$52,962
Induced effect	$170,485	$103,877	$274,361	$422,968
Net impact	$469,738	$221,485	$691,222	$1,068,724

Source: Lightcast impact model.

Annual alumni impacts

Similar to the long-run spending impacts, recurring alumni impacts will continue as long as UNC COM serves students. However, unlike the long-run spending impacts, the alumni impacts will continue to accumulate as more and more alumni are produced and as long as these alumni remain in Colorado. UNC COM expects to graduate 147 alumni per year once stabilized. Many of these students will work in the state. By FY 2042, the accumulation of alumni will create an annual impact of **$158.4 million** in total added income. This is equivalent to supporting **3,897 jobs** per year for Colorado. This annual impact is expected to increase every year for many years as UNC COM continues to graduate more students and they enter the state workforce.

Total economic impacts from UNC COM

In this analysis, we estimate five types of economic impacts created by UNC COM: short-run capital spending impacts and long-run operations spending impacts, visitor spending impacts, student spending impacts, and alumni impacts. Given each type of impact has different timelines, they occur at different points in time across our analysis timeframe of FY 2023 to FY 2042. Figure 10 presents the undiscounted year-by-year totals of the five impacts. Note that the positive impacts from increased access to

Figure 10:   Total impacts by year
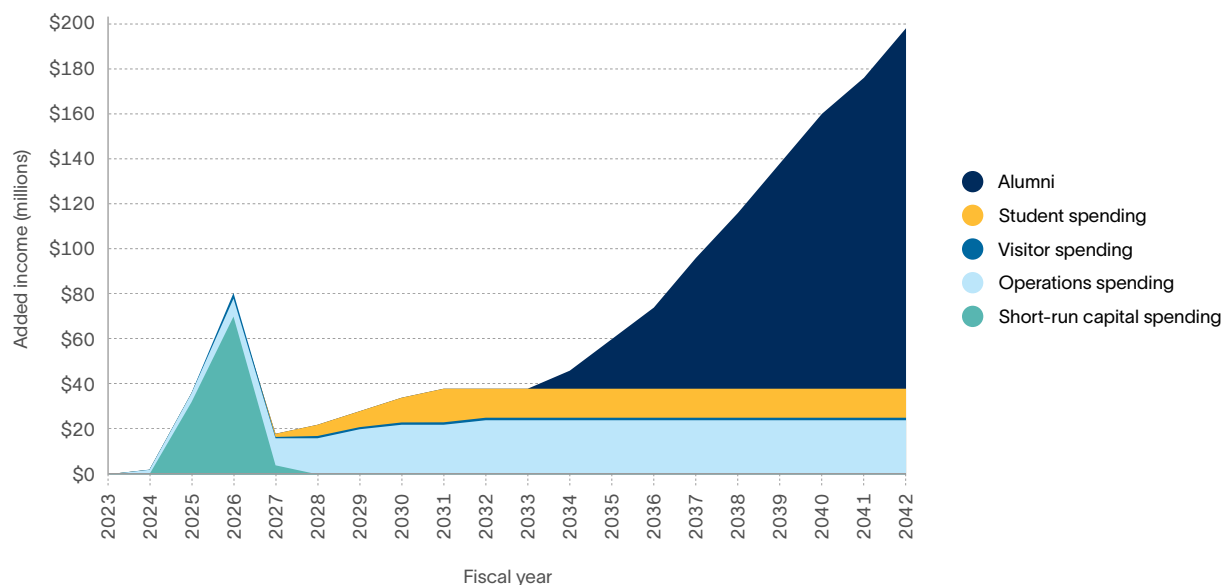
Values do not account for inflation and are undiscounted.

Source: Lightcast impact model.

healthcare and improved healthcare in Colorado as a result of UNC COM are beyond the scope of this analysis.

To understand what these impacts mean in present value terms, we discount them back to 2023 dollars using a discount rate of 0.2%. From FY 2023 to FY 2042, the discounted short-run and long-run impacts created by UNC COM will provide a total economic impact on the Colorado economy of $1.4 billion in total added income. Table 20 presents the present value sum of the total impacts from FY 2023 to FY 2042.

By FY 2028, 5.4 years after the start of this project, it is expected that the impacts generated by UNC COM will have grown significantly enough to recover the costs of not only the initial capital investment, but the annual costs of keeping UNC COM operational (Figure 11).

Table 20: Present value total impacts from FY 2023 to FY 2042

	Labor income (thousands)	Non-labor income (thousands)	Total added income (thousands)	Sales (thousands)
FY 2023 – FY 2042				
Initial effect	**$413,818**	**$76,111**	**$489,929**	**$1,085,697**
Multiplier effect				
Direct effect	$157,619	$109,290	$266,909	$454,457
Indirect effect	$60,491	$39,738	$100,228	$172,323
Induced effect	$312,835	$215,154	$527,989	$858,504
Gross impact	**$944,763**	**$440,293**	**$1,385,056**	**$2,570,981**
Less alternative uses of funds	-$12,952	-$11,133	-$24,085	-$33,338
Net impact	**$931,811**	**$429,160**	**$1,360,971**	**$2,537,642**

Source: Lightcast impact model.

Figure 11: Net cash flow from FY 2023 to FY 2042

Fiscal year
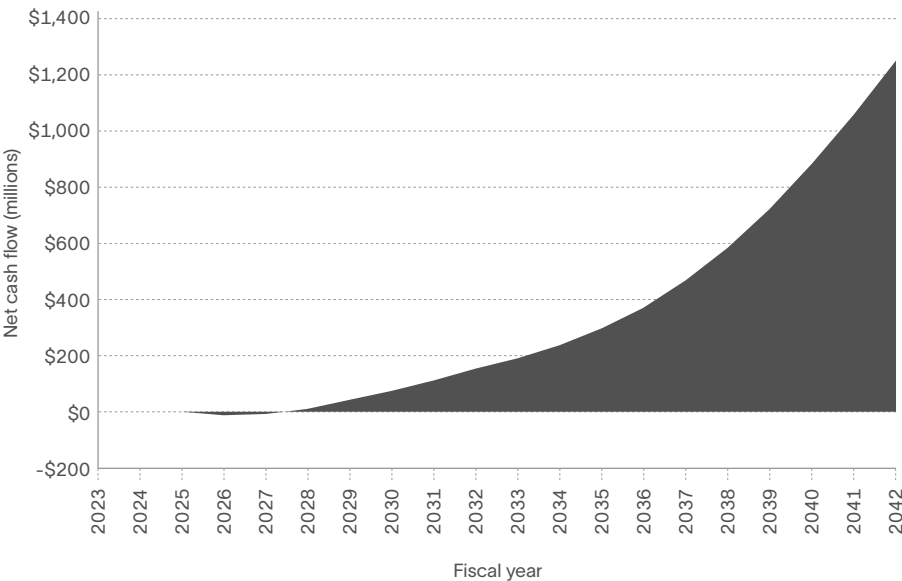
Values do not account for inflation and are undiscounted.

Source: Lightcast impact model.

Implicit multiplier

The implicit multiplier is the present value of added income divided by the present value of the initial capital investment in UNC COM and the long-run operational costs of the college. From FY 2023 to FY 2042, every dollar spent on UNC COM will create a present value of **$3.30** in added income throughout Colorado.

Annual impacts

The economic impacts discussed thus far are those summed across the analysis years of FY 2023 to FY 2042 and discounted to present value terms. However, each of the four long-run types of impacts will create an annual impact. These break down as follows:

- **Operations spending annual impact:** UNC COM will increase UNC's operational spending. By FY 2032, when operations stabilize, increased operations spending will add around **$23.5 million** in total income on an annual basis, equivalent to supporting **176 jobs** per year.

- **Visitor spending annual impact:** UNC COM will attract visitors to the state who would otherwise not have visited Colorado. Once the expected number of out-of-state visitors stabilize in FY 2031, the visitors will add **$309.3 thousand** in income per year, supporting **five jobs** annually, as a result of their spending in the state.

- **Student spending annual impact:** Once the number of students UNC COM is able to serve stabilizes at 632 students in FY 2032, **$15 million** in income will be added per year, supporting **83 jobs** annually, as a result of spending from retained and relocated students in the state.

- **Alumni annual impact:** UNC COM will produce more alumni every year, who will then accumulate in the state workforce. By FY 2042, the last year of this analysis, alumni are estimated to add **$158.4 million** in total income to the economy per year, supporting **3,897 jobs** annually. This annual impact is expected to increase every year for many years as UNC COM continues to serve more students and they enter the state workforce.

The total annual impact from UNC COM will be at least **$197.2 million** in added income. This is equivalent to supporting **4,161 jobs** every year.

Taxpayer benefits
from UNC COM

T O DETERMINE THE BENEFITS to taxpayers as a direct result of UNC COM, the pivotal step is to determine the public benefits that will specifically accrue to the state government. For example, benefits resulting from earnings growth are limited to increased state tax payments. Similarly, savings related to improved health, reduced crime, and fewer welfare and unemployment claims, discussed below, are limited to those received strictly by the state government. In all instances, benefits to private residents, local businesses, or the federal government are excluded.

Growth in tax revenues

As a result of their time at UNC COM, alumni will earn more because of the skills they learned while attending the college, and businesses will earn more because alumni skills make capital more productive (buildings, machinery, and everything else). This in turn raises profits and other business property income. Together, increases in labor and non-labor (i.e., capital) income are considered the effect of a skilled workforce. These in turn increase tax revenues since the state government is able to apply tax rates to increased income.

Estimating the effect of UNC COM alumni on increased tax revenues begins with the present value earnings of the alumni who work in the state. To these higher earnings, we apply a multiplier derived from Lightcast's MR-SAM model to estimate the added labor income created in the state as alumni and businesses spend their higher earnings.[6] As labor income increases, so does non-labor income, which consists of monies gained through investments. To calculate the growth in non-labor income, we multiply the increase in labor income by a ratio of the Colorado gross state product to total labor income in the state. We also include the spending impacts that were created from capital, operations, visitor, and student spending. To each of these, we apply the prevailing tax rates so we capture only the tax revenues attributable to state and local government from this additional revenue.

Not all of these tax revenues may be counted as benefits to the state, however. Some alumni will leave the state during the course of their careers, and the higher earnings they receive as a result of their education leaves the state with them. To account for this dynamic, we combine an alumni settlement data from the college with data on migration patterns from the Internal Revenue Service and UNC COM to estimate the number of alumni who will leave the state workforce over time.

Taxpayer benefits

Increased tax revenue

Avoided costs to
state/local government

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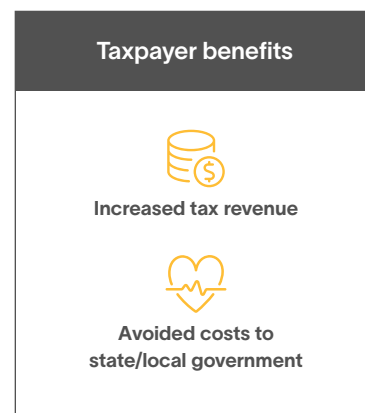
6   For a full description of the Lightcast MR-SAM model, see Appendix 3.

We apply another reduction factor to account for the students' alternative education opportunities. This is the same adjustment that we use in the calculation of the alumni impacts and is designed to account for the counterfactual scenario where UNC COM does not exist. The assumption in this case is that any benefits generated by students who could have received an education even without the college cannot be counted as new benefits to state and local taxpayers. For this analysis, we assume an alternative education variable of 5%, meaning that 5% of the student population at UNC COM would have generated benefits anyway even without the college.

After adjusting for attrition and those students who will graduate anyway, we calculate the present value of the future added tax revenues that will occur in the state from FY 2023 to FY 2042, equal to $83.3 million. The present value represents the sum of the future benefits that accrue each year over the 20-year period of this analysis, discounted to current year dollars to account for the time value of money. We use the discount rate of 0.2%. This is the three-year average of the real Treasury interest rate recommended by the Office of Management and Budget (OMB) for 30-year investments.[7]

Government savings

In addition to the creation of higher tax revenues to the state and local government, education is statistically associated with a variety of lifestyle changes that generate social savings, also known as external or incidental benefits of education. These represent the avoided costs to the government that otherwise would have been drawn from public resources absent the education provided by CSUCI. Government savings appear in Figure 12 and Table 21 and break down into three main categories: 1) health savings, 2) crime savings, and 3) income assistance savings. Health savings include avoided medical costs that would have otherwise been covered by state and local government. Crime savings consist of avoided costs to the justice system (i.e., police protection, judicial and legal, and corrections). Income assistance benefits comprise avoided costs due to the reduced number of welfare and unemployment insurance claims.

The model quantifies government savings by calculating the probability at each education level that individuals will have poor health, commit crimes, or claim welfare and unemployment benefits. Deriving the probabilities involves assembling data from a variety of studies and surveys analyzing the correlation between education and health, crime, and income assistance at the national and state level. We multiply the marginal differences by the number of students who achieved a professional degree. The sum of these marginal differences counts as the upper bound measure of the number of students who, due to the education they received at the college, will not have poor health, commit crimes, or demand income assistance. We dampen these results by the ability bias adjustment discussed earlier to account for factors (besides education) that influence individual behavior. We then multiply the marginal effects of education times the associated costs of health, crime, and income assistance. Finally, we apply the

7   Office of Management and Budget. "Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses." Real Interest Rates on Treasury Notes and Bonds of Specified Maturities (in Percent). https://www.whitehouse.gov/wp-content/uploads/2022/06/M-22-13-Discount-Rates.pdf. Last revised March 15, 2022.

same adjustments for attrition and alternative education to derive the net savings to the government. Total government savings appear in Figure 12 and sum to $929.2 thousand.

Table 21 displays all benefits to taxpayers. The first row shows the added tax revenues created in the state, equal to $83.3 million, from UNC COM's construction and operations spending, the spending of its visitors and students, and UNC COM alumni's higher earnings. The sum of the government savings and the added income in the state is $84.2 million, as shown in the bottom row of Table 21. These benefits are limited to those that will be received as a direct result of UNC COM and is limited to the 20-year timeframe of this analysis.

Figure 13 presents the benefits to state and local taxpayers from UNC COM each year from FY 2023 to FY 2042. These benefits will continue long after the final year of this analysis. After FY 2042, state and local taxpayers will annually see at least $8.5 million of additional benefits because of UNC COM.

Table 21:   Present value of added state tax revenue and government savings from UNC COM, FY 2023 to FY 2042 (thousands)

Added tax revenue	**$83.3 million**
Government savings	
Income assistance savings	$106.6 thousand
Health-related savings	$659.2 thousand
Crime-related savings	$163.4 thousand
Total government savings	**$929.2 thousand**
Total taxpayer benefits	**$84.2 million**

Source: Lightcast impact model.

Figure 12:   Present value of government savings from UNC COM

Health
$659.2 thousand

Crime
$163.4 thousand

$929.2 thousand
Total government savings

Income assistance
$106.6 thousand
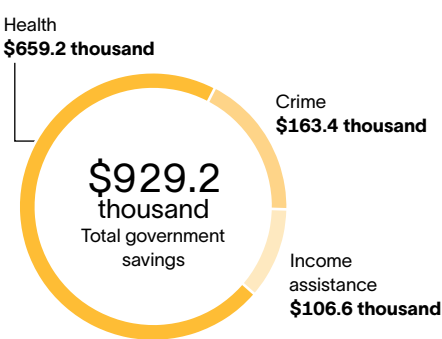
Source: Lightcast impact model.

Figure 13:   State and local taxpayer benefits from UNC COM, FY 2023 to FY 2042
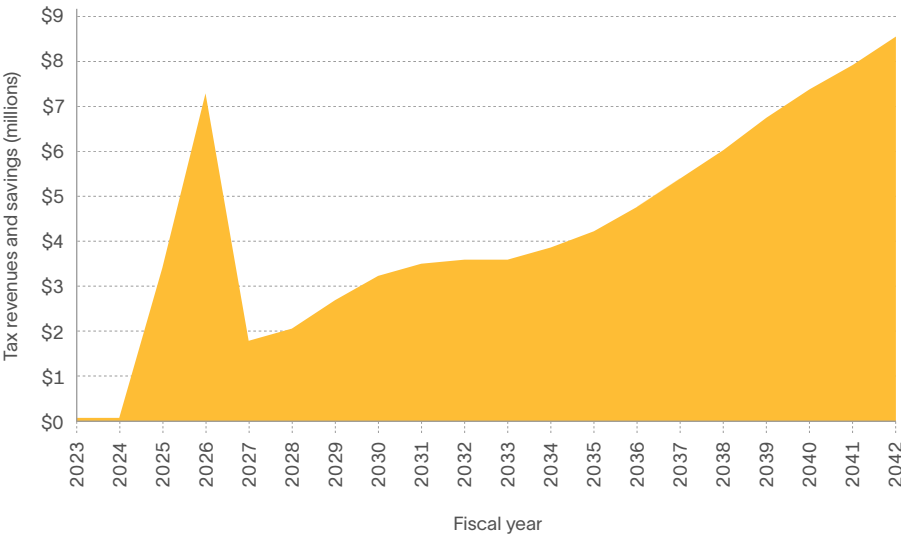
Values do not account for inflation and are undiscounted.

Source: Lightcast impact model.

Conclusion

THE RESULTS OF THIS STUDY demonstrate that UNC COM will create value for the Colorado economy through many avenues. From the very beginning, its construction phase of the 100,000 square foot state of the art building will positively impact the state economy. UNC COM will bring money into the state, generating additional spending impacts. UNC COM will attract out-of-state visitors to attend new student orientations and white coat and graduation ceremonies, and these visitors will spend money at state businesses, growing the state economy. UNC COM will allow UNC to serve more students, helping meet the growing student demand and Colorado's physician needs. These students' daily spending will grow the state economy. Finally, as these students graduate from UNC COM, they will help meet the needs of the state economy and add to the productivity of the state workforce.

UNC COM is expected to generate a total economic impact of **$1.4 billion** in total added income for the state economy between the 20-year period of FY 2023 to FY 2042. This represents the sum of several different impacts, including the college's:

- Short-run capital spending impact (**$106.3 million**);

- Long-run operations spending impact (**$356.7 million**);

- Long-run visitor spending impact (**$4.1 million**);

- Long-run student spending impact (**$202.6 million**);

- Long-run alumni impact (**$691.2 million**).

After FY 2042, the total annual impact from UNC COM will be at least **$197.2 million** in added income. This is equivalent to supporting **4,161 jobs** every year. Note that the positive impacts from increased access to healthcare and improved healthcare in Colorado as a result of UNC COM are beyond the scope of this analysis.

In addition, state and local taxpayers will benefit from UNC COM. Between FY 2023 and FY 2042, state and local taxpayers will receive an estimated present value of $83.3 million in added tax revenue stemming from the spending from UNC COM's construction and operations and the spending of its visitors and students as well as the alumni higher lifetime earnings. Savings to the public sector add another estimated $929.9 thousand in benefits due to a reduced demand for government-funded social services in Colorado. Total taxpayer benefits amount to **$84.2 million**, the present value sum of the added tax revenue and public sector savings.

Lightcast

Lightcast provides colleges and universities with labor market data that help create better outcomes for students, businesses, and communities. Our data, which cover more than 99% of the U.S. workforce, are compiled from a wide variety of government sources, job postings, and online profiles and résumés. Hundreds of institutions use Lightcast to align programs with regional needs, drive enrollment, connect students with in-demand careers, track their alumni's employment outcomes, and demonstrate their institution's economic impact on their region. Visit lightcast.io/solutions/education to learn more or connect with us.

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Appendix 1: Glossary of terms

Alternative education: A "with" and "without" measure of the percent of students who would still be able to avail themselves of education if the college under analysis did not exist. An estimate of 10%, for example, means that 10% of students do not depend directly on the existence of the university in order to obtain their education.

Alternative use of funds: A measure of how monies that are used to fund UNC COM might otherwise have been used if UNC COM does not exist.

Attrition rate: Rate at which students leave the workforce due to out-migration, unemployment, retirement, or death.

Counterfactual scenario: What would have happened if a given event had not occurred. In the case of this economic impact study, the counterfactual scenario is a scenario where the university's UNC COM do not exist.

Demand: Relationship between the market price of education and the volume of education demanded (expressed in terms of enrollment). The law of the downward-sloping demand curve is related to the fact that enrollment increases only if the price (tuition and fees) is lowered, or conversely, enrollment decreases if price increases.

Discounting: Expressing future revenues and costs in present value terms.

Earnings (labor income):   Income that is received as a result of labor; i.e., wages.

Economics: Study of the allocation of scarce resources among alternative and competing ends. Economics is not normative (what ought to be done), but positive (describes what is, or how people are likely to behave in response to economic changes).

Externalities: Impacts (positive and negative) for which there is no compensation. Positive externalities of education include improved social behaviors such as improved health, lower crime, and reduced demand for income assistance. Educational institutions do not receive compensation for these benefits, but benefits still occur because education is statistically proven to lead to improved social behaviors.

Gross state product: Measure of the final value of all goods and services produced in a state after netting out the cost of goods used in production. Alternatively, gross state product (GSP) equals the combined incomes of all factors of production; i.e., labor, land and capital. These include wages, salaries, proprietors' incomes, profits, rents, and other. Gross state product is also sometimes called value added or added income.

Initial effect: Income generated by the initial injection of monies into the economy through the payroll of the university and the higher earnings of its students.

Input-output analysis: Relationship between a given set of demands for final goods and services and the implied amounts of manufactured inputs, raw materials, and labor that this requires. When educational institutions pay wages and salaries and spend money for supplies in the state, they also generate earnings in all sectors of the economy, thereby increasing the demand for goods and services and jobs. Moreover, as students enter or rejoin the workforce with higher skills, they earn higher salaries and wages. In turn, this generates more consumption and spending in other sectors of the economy.

Multiplier effect: Additional income created in the economy as the university and its students spend money in the state. It consists of the income created by the supply chain of the industries initially affected by the spending of the university and its students (i.e., the direct effect), income created by the supply chain of the initial supply chain (i.e., the indirect effect), and the income created by the increased spending of the household sector (i.e., the induced effect).

Non-labor income: Income received from investments, such as rent, interest, and dividends.

Appendix 2: Example of sales versus income

Lightcast's economic impact study differs from many other studies because we prefer to report the impacts in terms of income rather than sales (or output). Income is synonymous with value added or gross state product (GSP). Sales include all the intermediary costs associated with producing goods and services. Income is a net measure that excludes these intermediary costs:

Income = Sales – Intermediary Costs

For this reason, income is a more meaningful measure of new economic activity than reporting sales. This is evidenced by the use of gross domestic product (GDP)—a measure of income—by economists when considering the economic growth or size of a country. The difference is GRP reflects a state and GDP a country.

To demonstrate the difference between income and sales, let us consider an example of a baker's production of a loaf of bread. The baker buys the ingredients such as eggs, flour, and yeast for $2.00. He uses capital such as a mixer to combine the ingredients and an oven to bake the bread and convert it into a final product. Overhead costs for these steps are $1.00. Total intermediary costs are $3.00. The baker then sells the loaf of bread for $5.00.

The sales amount of the loaf of bread is $5.00. The income from the loaf of bread is equal to the sales amount less the intermediary costs:

Income = $5.00 – $3.00 = $2.00

In our analysis, we provide context behind the income figures by also reporting the associated number of jobs. The impacts are also reported in sales and earnings terms for reference.

Lightcast's MR-SAM represents the flow of all economic transactions in a given region. It replaces Lightcast's previous input-output (IO) model, which operated with some 1,000 industries, four layers of government, a single household consumption sector, and an investment sector. The old IO model was used to simulate the ripple effects (i.e., multipliers) in the state economy as a result of industries entering or exiting the region. The MR-SAM model performs the same tasks as the old IO model, but it also does much more. Along with the same 1,000 industries, government, household and investment sectors embedded in the old IO tool, the MR-SAM exhibits much more functionality, a greater amount of data, and a higher level of detail on the demographic and occupational components of jobs (16 demographic cohorts and about 750 occupations are characterized).

This appendix presents a high-level overview of the MR-SAM. Additional documentation on the technical aspects of the model is available upon request.

Data sources for the model

The Lightcast MR-SAM model relies on a number of internal and external data sources, mostly compiled by the federal government. What follows is a listing and short explanation of our sources. The use of these data will be covered in more detail later in this appendix.

Lightcast Data are produced from many data sources to produce detailed industry, occupation, and demographic jobs and earnings data at the local level. This information (especially sales-to-jobs ratios derived from jobs and earnings-to-sales ratios) is used to help regionalize the national matrices as well as to disaggregate them into more detailed industries than are normally available.

BEA Make and Use Tables (MUT) are the basis for input-output models in the U.S. The *make* table is a matrix that describes the amount of each commodity made by each industry in a given year. Industries are placed in the rows and commodities in the columns. The *use* table is a matrix that describes the amount of each commodity used by each industry in a given year. In the use table, commodities are placed in the rows and industries in the columns. The BEA produces two different sets of MUTs, the benchmark and the summary. The benchmark set contains about 500 sectors and is released every five years, with a five-year lag time (e.g., 2002 benchmark MUTs were released in 2007). The summary set contains about 80 sectors and is released every year, with a two-year lag (e.g., 2010 summary MUTs were released in late 2011/early 2012). The MUTs are used in the Lightcast MR-SAM model to produce an industry-by-industry matrix describing all industry purchases from all industries.

BEA Gross Domestic Product by State (GSP) describes gross domestic product from the value added (also known as added income) perspective. Value added is equal to employee compensation, gross operating surplus, and taxes on production and imports, less subsidies. Each of these components is reported for each state and an aggregate group of industries. This dataset is updated once per year, with a one-year lag. The Lightcast MR-SAM model makes use of this data as a control and pegs certain pieces of the model to values from this dataset.

BEA National Income and Product Accounts (NIPA) cover a wide variety of economic measures for the nation, including gross domestic product (GDP), sources of output, and distribution of income. This dataset is updated periodically throughout the year and can be between a month and several years old depending on the specific account. NIPA data are used in many of the Lightcast MR-SAM processes as both controls and seeds.

BEA Local Area Income (LPI) encapsulates multiple tables with geographies down to the county level. The following two tables are specifically used: CA05 (Personal income and earnings by industry) and CA91 (Gross flow of earnings). CA91 is used when creating the commuting submodel and CA05 is used in several processes to help with place-of-work and place-of-residence differences, as well as to calculate personal income, transfers, dividends, interest, and rent.

Bureau of Labor Statistics Consumer Expenditure Survey (CEX) reports on the buying habits of consumers along with some information as to their income, consumer unit, and demographics. Lightcast utilizes this data heavily in the creation of the national demographic by income type consumption on industries.

Census of Government's (CoG) state and local government finance dataset is used specifically to aid breaking out state and local data that is reported in the MUTs. This allows Lightcast to have unique production functions for each of its state and local government sectors.

Census' OnTheMap (OTM) is a collection of three datasets for the census block level for multiple years. **Origin-Destination (OD)** offers job totals associated with both home census blocks and a work census block. **Residence Area Characteristics (RAC)** offers jobs totaled by home census block. **Workplace Area Characteristics (WAC)** offers jobs totaled by work census block. All three of these are used in the commuting submodel to gain better estimates of earnings by industry that may be counted as commuting. This dataset has holes for specific years and regions. These holes are filled with Census' Journey-to-Work described later.

Census' Current Population Survey (CPS) is used as the basis for the demographic breakout data of the MR-SAM model. This set is used to estimate the ratios of demographic cohorts and their income for the three different income categories (i.e., wages, property income, and transfers).

Census' Journey-to-Work (JtW) is part of the 2000 Census and describes the amount of commuting jobs between counties. This set is used to fill in the areas where OTM does not have data.

Census' American Community Survey (ACS) Public Use Microdata Sample (PUMS) is the replacement for Census' long form and is used by Lightcast to fill the holes in the CPS data.

Oak Ridge National Lab (ORNL) County-to-County Distance Matrix (Skim Tree) contains a matrix of distances and network impedances between each county via various modes of transportation such as highway, railroad, water, and combined highway-rail. Also included in this set are minimum impedances utilizing the best combination of paths. The ORNL distance matrix is used in Lightcast's gravitational flows model that estimates the amount of trade between counties in the country.

Overview of the MR-SAM model

Lightcast's MR-SAM modeling system is a comparative static model in the same general class as RIMS II (Bureau of Economic Analysis) and IMPLAN (Minnesota Implan Group). The MR-SAM model is thus not an econometric model, the primary example of which is PolicyInsight by REMI. It relies on a matrix representation of industry-to-industry purchasing patterns originally based on national data which are regionalized with the use of local data and mathematical manipulation (i.e., non-survey methods). Models of this type estimate the ripple effects of changes in jobs, earnings, or sales in one or more industries upon other industries in a region.

The Lightcast MR-SAM model shows final equilibrium impacts—that is, the user enters a change that perturbs the economy and the model shows the changes required to establish a new equilibrium. As such, it is not a dynamic model that shows year-by-year changes over time (as REMI's does).

National SAM

Following standard practice, the SAM model appears as a square matrix, with each row sum exactly equaling the corresponding column sum. Reflecting its kinship with the standard Leontief input-output framework, individual SAM elements show accounting flows between row and column sectors during a chosen base year. Read across rows, SAM entries show the flow of funds into column accounts (also known as receipts or the appropriation of funds by those column accounts). Read down columns, SAM entries show the flow of funds into row accounts (also known as expenditures or the dispersal of funds to those row accounts).

The SAM may be broken into three different aggregation layers: broad accounts, sub-accounts, and detailed accounts. The broad layer is the most aggregate and will be covered first. Broad accounts cover between one and four sub-accounts, which in turn cover many detailed accounts. This appendix will not discuss detailed accounts directly because of their number. For example, in the industry broad account, there are two sub-accounts and over 1,000 detailed accounts.

Multi-regional aspect of the MR-SAM

Multi-regional (MR) describes a non-survey model that has the ability to analyze the transactions and ripple effects (i.e., multipliers) of not just a single region, but multiple regions interacting with each other. Regions in this case are made up of a collection of counties.

Lightcast's multi-regional model is built off of gravitational flows, assuming that the larger a county's economy, the more influence it will have on the surrounding counties' purchases and sales. The equation behind this model is essentially the same that Isaac Newton used to calculate the gravitational pull between planets and stars. In Newton's equation, the masses of both objects are multiplied, then divided by the distance separating them and multiplied by a constant. In Lightcast's model, the masses are replaced with the supply of a sector for one county and the demand for that same sector from another county. The distance is replaced with an impedance value that accounts for the distance, type of roads, rail lines, and other modes of transportation. Once this is calculated for every county-to-county pair, a set of mathematical operations is performed to make sure all counties absorb the correct amount of supply from every county and the correct amount of demand from every county. These operations produce more than 200 million data points.

Components of the Lightcast MR-SAM model

The Lightcast MR-SAM is built from a number of different components that are gathered together to display information whenever a user selects a region. What follows is a description of each of these components and how each is created. Lightcast's internally created data are used to a great extent throughout the processes described below, but its creation is not described in this appendix.

County earnings distribution matrix

The county earnings distribution matrices describe the earnings spent by every industry on every occupation for a year—i.e., earnings by occupation. The matrices are built utilizing Lightcast's industry earnings, occupational average earnings, and staffing patterns.

Each matrix starts with a region's staffing pattern matrix which is multiplied by the industry jobs vector. This produces the number of occupational jobs in each industry for the region. Next, the occupational average hourly earnings per job are multiplied by 2,080 hours, which converts the average hourly earnings into a yearly estimate. Then the matrix of occupational jobs is multiplied by the occupational annual earnings per job, converting it into earnings values. Last, all earnings are adjusted to match the known industry totals. This is a fairly simple process, but one that is very important. These matrices describe the place-of-work earnings used by the MR-SAM.

Commuting model

The commuting sub-model is an integral part of Lightcast's MR-SAM model. It allows the regional and multi-regional models to know what amount of the earnings can be

attributed to place-of-residence vs. place-of-work. The commuting data describe the flow of earnings from any county to any other county (including within the counties themselves). For this situation, the commuted earnings are not just a single value describing total earnings flows over a complete year but are broken out by occupation and demographic. Breaking out the earnings allows for analysis of place-of-residence and place-of-work earnings. These data are created using Bureau of Labor Statistics' OnTheMap dataset, Census' Journey-to-Work, BEA's LPI CA91 and CA05 tables, and some of Lightcast's data. The process incorporates the cleanup and disaggregation of the OnTheMap data, the estimation of a closed system of county inflows and outflows of earnings, and the creation of finalized commuting data.

National SAM

The national SAM as described above is made up of several different components. Many of the elements discussed are filled in with values from the national Z matrix—or industry-to-industry transaction matrix. This matrix is built from BEA data that describe which industries make and use what commodities at the national level. These data are manipulated with some industry standard equations to produce the national Z matrix. The data in the Z matrix act as the basis for the majority of the data in the national SAM. The rest of the values are filled in with data from the county earnings distribution matrices, the commuting data, and the BEA's National Income and Product Accounts.

One of the major issues that affect any SAM project is the combination of data from multiple sources that may not be consistent with one another. Matrix balancing is the broad name for the techniques used to correct this problem. Lightcast uses a modification of the "diagonal similarity scaling" algorithm to balance the national SAM.

Gravitational flows model

The most important piece of the Lightcast MR-SAM model is the gravitational flows model that produces county-by-county regional purchasing coefficients (RPCs). RPCs estimate how much an industry purchases from other industries inside and outside of the defined region. This information is critical for calculating all IO models.

Gravity modeling starts with the creation of an impedance matrix that values the difficulty of moving a product from county to county. For each sector, an impedance matrix is created based on a set of distance impedance methods for that sector. A distance impedance method is one of the measurements reported in the Oak Ridge National Laboratory's County-to-County Distance Matrix. In this matrix, every county-to-county relationship is accounted for in six measures: great-circle distance, highway impedance, rail miles, rail impedance, water impedance, and highway-rail-highway impedance. Next, using the impedance information, the trade flows for each industry in every county are solved for. The result is an estimate of multi-regional flows from every county to every county. These flows are divided by each respective county's demand to produce multi-regional RPCs.