

Revitalizing U.S. Pharma: Evaluating the Economic and Social Impacts of Advanced API Manufacturing in Missouri

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Executive Summary

The U.S. pharmaceutical sector has faced considerable challenges due to an overreliance on foreign active pharmaceutical ingredient (API- the primary substance in a drug that produces the intended therapeutic effect) production, which has often led to shortages of critical medicines, quality issues, and heightened national health security risks. These challenges underscore the need for a revitalized approach to pharmaceutical manufacturing that prioritizes domestic capabilities and sustainability.

The drug API Innovation Center (the “Center”), a pioneering nonprofit organization, is dedicated to advancing America's pharmaceutical manufacturing resilience. The Center’s vision is to create a premier pharmaceutical manufacturing innovation center that drives the nation’s transition to health security. The Center’s mission is to drive health security and economic growth for the nation and its citizens through U.S.-based production of medicines. This mission is critical to ensuring that every hospital, pharmacy, and American has access to essential medications produced domestically, thereby enhancing national health security. Situated in Missouri, the Center serves as a vital hub for a diverse network of stakeholders, including major corporations, academic institutions, research entities, and innovative startups. Together with these stakeholders, the Center is committed to transforming the API supply chain and addressing significant vulnerabilities that have surfaced in recent years, particularly those highlighted by global supply chain disruptions.

The objective of this comprehensive study, conducted by a dedicated academic and graduate student research team from Olin Business School under the guidance of the Olin Research Center and the Center for Analytics and Business Insights (CABI), is to thoroughly assess the broad economic and social impacts of re-shoring pharmaceutical manufacturing to the U.S. at an individual molecule level by developing and commercializing it in Missouri. This initiative is aimed at building national resiliency of supply through domestic essential manufacturing capabilities and fostering economic growth, job creation, and technological innovation within the state and the broader region as the potential result of a large-scale investment.

This report presents the findings of the research team, which has analyzed the potential economic impacts of the Center's initiatives. By employing a blend of general methodologies for economic impact assessment and specific data pertaining to Missouri, the study provides insightful projections about job creation, economic activity, and sectoral benefits. Additionally, it offers a detailed comparison with analogous investments both within and outside the state to contextualize the expected outcomes.

Through strategic analysis and targeted research, this report delivers a comprehensive overview of how leveraging advanced manufacturing technology to develop APIs in Missouri could address existing pharmaceutical supply chain challenges while enhancing the state’s economic and social landscape.

Key Research Findings

1. Significant Economic Impact

The development and commercialization of a generic drug in Missouri are projected to generate significant economic benefits, including job creation and increased economic growth. It supports direct, indirect, and induced economic activities, bolstering both the local and regional economies. The initiative to build national resiliency is projected to generate \$49 million to \$51 million in total economic impact per drug molecule, driven by advanced manufacturing technologies. This includes a direct impact of \$22.2 million to \$23.2 million from job creation and production activities, an indirect impact of \$2.6 million to \$2.7 million from supporting industries, and an induced impact of \$24.1 million to \$25.2 million from local spending by wage earners. With 6 molecules currently under development, the Center is expected to contribute \$306 million to the regional economy, supported by the investment from the Missouri Technology Corporation (MTC) towards molecule development. The Center's long-term goal of reshoring 350 medicines is projected to generate \$17.85 billion in economic activity. In terms of job creation, the Center's future investment will create 125 jobs with an average cost of \$384,000 per job, significantly more efficient than industry leaders like ApiJect and Eli Lilly, whose investments per job exceed \$1 million.

2. Workforce Development & Job Creation

Reshoring manufacturing to the U.S. using advanced manufacturing technology presents a unique opportunity to boost the U.S. economy and create new job classes. The initiative promotes workforce development by offering specialized training and certification programs in pharmaceutical manufacturing and related sectors. This strengthens the local talent pool, creating a skilled, diverse workforce that supports Missouri's expanding industries. The creation of new job classes, particularly in advanced manufacturing technologies, contributes to both local workforce expansion and the overall economic growth of the region.

3. Strategic Regional Impact

Utilizing advanced manufacturing technology for pharmaceutical production in Missouri, this initiative enhances the state's reputation as a biopharmaceutical innovation hub. It attracts further investments and partnerships, fostering a strong sense of community and establishing Missouri as a leader in innovation and economic development.

Background

APIs are the critical components of medications that provide the therapeutic effects essential for patient treatment. However, the U.S. and the global pharmaceutical supply chain have become heavily dependent on foreign API manufacturers, primarily in China and India. Currently, over 80% of APIs used in U.S. medicines are sourced from these two countries.¹ This overreliance has created significant vulnerabilities for the U.S., including frequent drug shortages, drug quality issues, and increased national health security risks. The COVID-19 pandemic starkly exposed the fragility of this system, as supply chain disruptions resulted in severe medication shortages, highlighting the urgent need for a more resilient and self-reliant pharmaceutical infrastructure.²

In a September 2021 report, the Department of Defense Office of Inspector General warned that U.S. reliance on foreign pharmaceutical suppliers poses a "public health, readiness, and national security risk³." Less than 5% of large-scale API manufacturing sites worldwide are located in the U.S., with the majority based in China and India. According to the U.S. Food and Drug Administration's (FDA) Drug Shortages: Root Causes and Potential Solutions report, issued in 2020, 88% of the manufacturing sites producing APIs for the U.S. market were located outside the U.S.⁴ This dependence on overseas manufacturing, compounded by the COVID-19 pandemic, shifting geopolitical landscapes, and extreme weather events impacting manufacturing facilities, has further underscored the risks to the U.S. pharmaceutical supply chain.

An analysis by Anthony Sardella, a WashU Olin Business Professor and founder of the Center, further revealed the extent of this threat. His August 2021 study, published by the Washington University in St. Louis Center for Business Analytics and Insights, found that 75% of COVID-related medicines and 83 of the top 100 generic medicines consumed in the U.S. have no domestic API manufacturing source. Additionally, 97% of the most prescribed antivirals and 92% of antibiotics lack a U.S.-based source for their API. The federal government, through initiatives such as the Bold Goals for U.S. Biotechnology and Biomanufacturing, aims to bring 25% of small molecule API production back to the U.S. within five years.⁵ Achieving this objective requires investments in advanced manufacturing technologies that can lower production costs and increase efficiency,

¹ Sardella, Anthony. The U.S. Active Pharmaceutical Ingredient Infrastructure: The Current State and Considerations to Increase U.S. Healthcare Security, August 2021.

² Ibid.

³ U.S. Department of Defense Inspector General. Evaluation of the Department of Defense's Mitigation of Foreign Suppliers in the Pharmaceutical Supply Chain, September 2021.

⁴ "Drug Shortages: Root Causes and Potential Solutions" FDA Oct 2019,

<https://www.fda.gov/media/131130/download>.

⁵ A Bold Goal: Reshoring 25% of Small Molecule API to the U.S. in 5 Years, API Innovation Center, January 2024.

thereby helping domestic manufacturers have the opportunity to compete more effectively with lower-cost foreign producers.⁶

Current State of Manufacturing

Global: The manufacturing industry has encountered various recent challenges, including uncertain geopolitical conflicts, supply chain instability before and after the COVID-19 pandemic, and environmental abnormalities. Despite these obstacles, the industry holds considerable promise as nations seek to make new investments in cutting-edge technology. Developing more efficient processes is increasingly important, with businesses exploring ways to reduce costs.⁷

National: The compound annual growth rate (CAGR) projections for the global manufacturing sector into 2030 vary depending on the specific subsector and region, with general forecasts suggesting a positive trajectory. This growth is driven by substantial federal investments, such as the Infrastructure Investment and Jobs Act⁸, Inflation Reduction Act⁹, and CHIPS and Science Act¹⁰, aimed at modernizing infrastructure and encouraging technological innovation. Advances in automation, Artificial Intelligence, and additive manufacturing production processes are expected to further drive growth, positioning U.S. manufacturers for long-term success for those willing to make the investment.

Missouri: According to the Missouri Chamber of Commerce's recent "Making Missouri a Manufacturing Powerhouse" report, Missouri's manufacturing sector remains a cornerstone of the state's economy, with approximately "8,000 manufacturing establishments" contributing nearly "10% of the state's total earnings." Manufacturers employ more than 287,000 workers, accounting for 11.6% of the state's private sector jobs and generating approximately \$50 billion annually.¹¹ Missouri's manufacturing sector does face challenges however, particularly in workforce development and infrastructure, with the state ranking 28th in manufacturing competitiveness.¹²

⁶ Ibid.

⁷ Statista. "Manufacturing - Worldwide." Statista, <https://www.statista.com/outlook/io/manufacturing/worldwide>.

⁸ <https://www.congress.gov/bill/117th-congress/house-bill/3684>

⁹ <https://www.congress.gov/bill/117th-congress/house-bill/5376/text>

¹⁰ <https://www.congress.gov/bill/117th-congress/house-bill/4346>

¹¹ Making Missouri a Manufacturing Powerhouse", Missouri Chamber of Commerce and Industry, 2024.

¹² Ibid

The Challenges and Opportunities in Pharmaceutical Manufacturing

Challenge: The generic pharmaceutical sector, including the API production space, faces unique opportunities, if underlying challenges can be addressed. KPMG's Generics 2030: Three Strategies to Curb the Downward Spiral report indicates that the sector is caught between increasing demand and a highly unstable economic environment. Patent expiries totaling nearly \$8 billion in U.S. annual sales opened significant opportunities for generics in 2019, and more expirations are expected in the coming years. However, accordingly to the report, the industry's reliance on "low-cost offshore manufacturing" has introduced significant quality control issues and supply chain vulnerabilities.¹³

The U.S. API manufacturing industry has been in decline for several years, with the number of domestic facilities dropping by 18% between 2014 and 2019.¹⁴ According to Sardella's *US Generic Pharmaceutical Industry Economic Instability*, the industry's economic instability is further complicated by price erosion and consolidation among buyers, which has driven profit margins lower, creating a "race to the bottom" for manufacturers. Today, more than 80% of APIs for essential medicines, as defined by the FDA, are produced outside the U.S., primarily in China and India, leaving the U.S. pharmaceutical supply chain vulnerable. Missouri's manufacturing sector, while strong, reflects these national challenges. Despite its size and significance, the state's infrastructure and workforce development capacity require further enhancement to keep pace with the demands of modern pharmaceutical manufacturing.¹⁵

The Opportunity: Advanced manufacturing technologies represent a significant growth opportunity for Missouri, particularly in the API and generic pharmaceutical sectors. Utilizing advanced technologies such as continuous flow chemistry, automation, and 3D printing, Missouri can significantly reduce production costs, increase efficiency, and improve product quality by condensing processes that once took months into mere days, optimizing production, and minimizing waste and environmental impact. Manufacturing already presents an industry where Missouri maintains a competitive advantage. It also presents an area where the state has experienced resiliency and now growth compared to the rest of the country. Further, manufacturing holds impressive potential as an export opportunity, especially chemical exports which came in over \$3 billion in 2022. This potential further highlighting the sectors' ability to strengthen the national position where the United States is currently running national trade deficits. Finally, it is worth noting the average wage being paid in the manufacturing sector in Missouri is over \$67,000, higher than the state private sector average by around ten percent.

¹³ <https://kpmg.com/kpmg-us/content/dam/kpmg/pdf/2023/generics-2030-final.pdf>

¹⁴ <https://apicenter.org/wp-content/uploads/2023/07/US-Generic-Pharmaceutical-Industry-Economic-Instability.pdf>

¹⁵ Ibid

The Drug API Innovation Center

The Center, located in Missouri, is at the forefront of tackling these challenges and seizing these opportunities. The Center's commitment to establishing advanced API manufacturing capabilities within the U.S. significantly mitigates the risk of reliance on foreign API sources. This strategic initiative enhances national health security by ensuring a stable, reliable supply of essential medications, thus reducing potential shortages and safeguarding public health at a national level. By utilizing cutting-edge manufacturing technologies, the Center aims to revolutionize the API supply chain and reinforce the nation's and Missouri's healthcare preparedness. This initiative not only reduces the risks of foreign dependency but also opportunistically drives economic growth and job creation in Missouri. Advanced manufacturing techniques, such as continuous flow chemistry, significantly lower production costs and improve quality control, positioning Missouri as a leader in pharmaceutical innovation.

Why does the API Innovation Center exist and what is its purpose?

- *Lead* national efforts to drive Bold Goal towards US-based manufacturing of 25% of small-molecule APIs (~300) within five years to overcome the price erosion, industry consolidation and manufacturing offshoring dynamics impacting Americans' reliable access to generic medications.
- *Grow* and deploy US biomanufacturing industrial base and enhance economic growth of Missouri through creation of DEI employment opportunities contributing greater than \$1.3B in economic growth to the region
- *Drive* innovation with its research and industry partners to ensure international economic competitiveness in US industrial biomanufacturing base, accelerate our national resiliency and decrease drug shortage risk scores by 50% in five years through production of APIs and the key starting materials (KSMs) used to make them, as well as finished drug products.

What does the API Center do and how does it create impact?

- *Invests* in pioneering research to develop innovative manufacturing technologies for production of APIs. Technologies allow for cost efficiencies, higher throughput and yield, improved quality, smaller footprint, and decreased human and environmental hazards.
- *Modernizes* existing idle US pharmaceutical manufacturing capacity through facility investments (*i.e.*, equipment and processes) to produce KSMs, APIs and partner to product drug product at economically viable and sustainable levels.

- *Commercializes* high quality, US-based medicines through forward and reverse integration, and disruptive distribution capabilities, including formation of margin sharing partnerships with drug product manufacturers to ensure economic sustainability of supply.

The Missouri ICP (Invest-Contract-Partner) public-private partnership and operating model created by the St. Louis-based Center is also receiving significant national attention as a model for building national resiliency.¹⁶ Their groundbreaking work has been cited in pharmaceutical industry publications and their analysis and guidance has been shared in recent White House listening sessions with various federal agencies and the US House Energy & Commerce Oversight and Investigation Subcommittee.

The Center’s ICP public-private model fosters investment, contracting and partnership to seamlessly transition from early API development to an FDA-approved cGMP (current Good Manufacturing Practice) facility, accelerating the speed to market and mitigating the hurdles faced by pharmaceutical manufacturers.

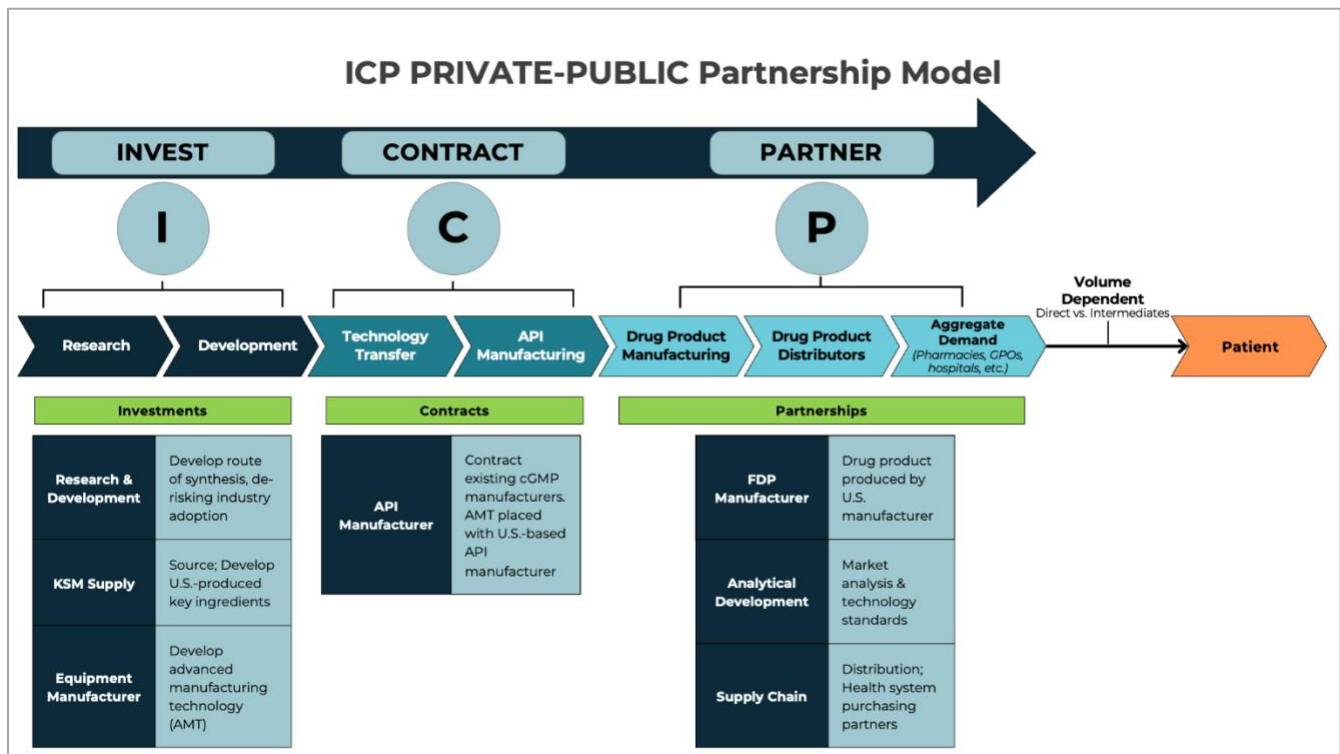


Figure 1. API Innovation Center’s ICP Private-Public Partnership Model

¹⁶ <https://aspr.hhs.gov/newsroom/Pages/Biden-Harris-Funds-DPA.aspx>

Economic and Social Impacts on Missouri

Missouri, particularly the St. Louis region, boasts a robust pharmaceutical ecosystem, making it an ideal location to become a national leader in reshoring API production. Missouri's world-class healthcare services, academic research institutions, innovation centers, and a well-established pharmaceutical sector create a thriving environment for API manufacturing. The United States Pharmacopeia (USP) ranks Missouri first in the nation for the number of API manufacturers producing essential medicines and third for the number of commercially active API Drug Master Files with the FDA. This existing infrastructure provides a substantial foundation for Missouri to lead the national effort to strengthen the domestic API manufacturing sector and secure the country's pharmaceutical supply chain.

Reshoring API production using advanced manufacturing technology has the potential to generate significant economic and social benefits for Missouri. Economically, the development of an advanced API manufacturing sector will create new job opportunities both within the pharmaceutical industry and across the broader supply chain. This will include roles in research, development, manufacturing, and quality control, fostering a growing high-tech workforce in the state. Additionally, the increased demand for local goods and services will further stimulate regional economic growth.

On a social level, this initiative will contribute to workforce development by offering specialized training and certification programs, helping residents acquire valuable skills in advanced manufacturing. This will enhance the local talent pool and create a more inclusive, diverse workforce, promoting long-term socioeconomic growth. Furthermore, by stabilizing the supply of critical medications, this initiative will strengthen Missouri's public health infrastructure, improving the state's ability to respond to health emergencies and ensuring the well-being of its communities.

By reshoring API production through adopting innovative manufacturing technologies, Missouri is positioned to become a critical hub for pharmaceutical innovation, benefiting both its economy and its citizens.

Research Purpose & Methodology

The Center is focused on revitalizing the U.S. pharmaceutical industry by advancing essential drug manufacturing capabilities to Missouri. This study seeks to evaluate the economic and social impacts of reshoring API production through advanced manufacturing technology, enhancing Missouri's role in safeguarding the U.S. pharmaceutical sector from foreign dependencies and supply chain disruptions. By fostering technological advancements and innovation in pharmaceutical manufacturing, the initiative seeks to position Missouri as a leader in both economic growth and national health security, while providing a foundation for future investment in the state's biopharmaceutical sector.

Specific Objectives:

- **Assess Economic Benefits:** Evaluate the economic advantages of establishing API manufacturing in Missouri, including job creation and economic growth.
- **Analyze Social Impacts:** Examine the broader social effects on the local community and broader region, focusing on community well-being and engagement.
- **Evaluate Technological Innovation:** Identify the potential for technological advancements, such as continuous flow chemistry, to enhance production efficiency and innovation within the pharmaceutical industry.
- **Outline Relevant Metrics:** Define and outline the key metrics necessary for assessing the impact of advanced API manufacturing, such as direct, indirect, and induced economic activities, job creation, and wage growth.

Methodology:

This comprehensive study, carried out by a dedicated team from Olin Business School under the guidance of the Center for Analytics and Business Insights (CABI), used a combination of advanced economic analysis tools, data collection, and qualitative research. The analysis focused on measuring both economic, social and environmental impacts within Missouri and the broader U.S. pharmaceutical landscape.

The methodology included the following key components:

- **IMPLAN Analysis:** This economic impact software was instrumental in organizing and analyzing the data provided by the Center. It allowed for a detailed breakdown of the direct, indirect, and induced economic contributions of API manufacturing to Missouri, including job creation, increased regional economic activity, and ripple effects across related industries.

- **Lightcast Analytics:** Labor market data provided by Lightcast supplied industry-specific multipliers for Missouri's pharmaceutical sector. This data was crucial in estimating broader economic effects such as wage growth, employment trends, and future job demands driven by API production.
- **Research and Interviews:** Extensive research was conducted, including case studies of analogous investments in API manufacturing outside Missouri. Interviews with key stakeholders, such as corporate leaders, policymakers, and academic partners, provided insights into the challenges and opportunities of reshoring API manufacturing. These interviews, coupled with a detailed literature review, ensured that the analysis considered relevant external factors and broader trends in the global pharmaceutical industry.
- **Case Study Comparisons:** To contextualize the results, the study compared Missouri's API manufacturing initiative with similar projects across the U.S. and internationally. This provided a benchmark for evaluating Missouri's competitiveness and the potential long-term impacts on the state's economy and healthcare infrastructure.
- **Social Impact Metrics:** The study also included a thorough examination of the social benefits, such as workforce training programs, the development of a diverse and inclusive talent pipeline, and public health improvements. These metrics were used to assess how the project could positively influence community well-being, health security, and Missouri's ability to respond to future health emergencies.

The study leveraged a wide range of data sources, including industry reports, government statistics, labor market data, interviews with key stakeholders, and analogous case studies. This comprehensive data-driven approach provided a thorough analysis of the economic and social benefits that advanced API manufacturing could bring to Missouri, ensuring the findings are both precise and meaningful.

Research Results

The findings highlight the significant economic benefits and positive social impacts of establishing advanced API manufacturing in Missouri. The initiative promises substantial job creation, economic growth, and technological innovation, while also enhancing community well-being and sustainability

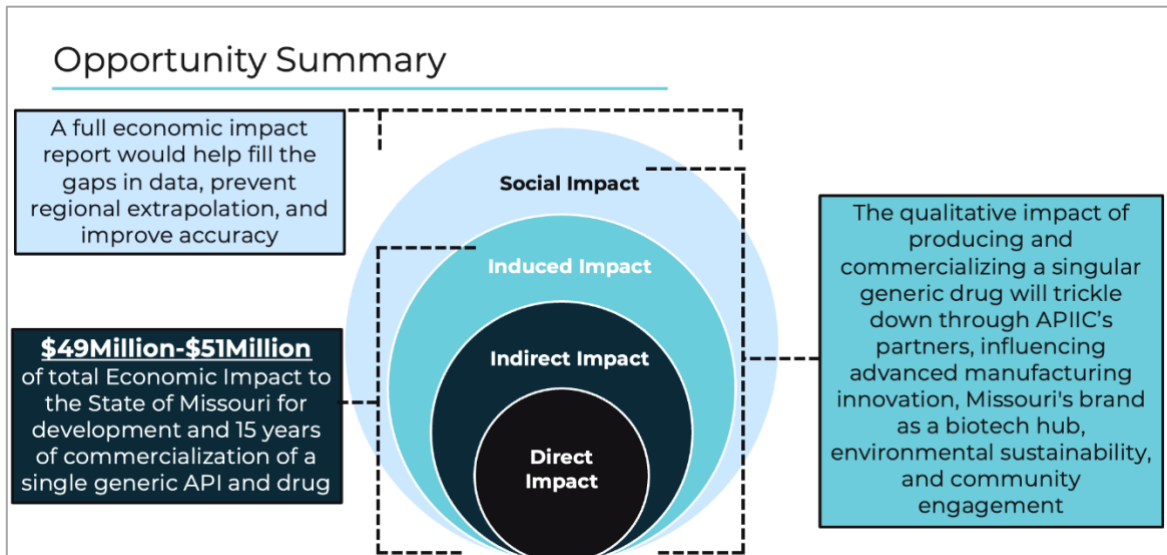


Figure 2. Layers of Economic Impact

Economic Impact:

Total Economic Impact - \$49 million to \$51 million for the development and commercialization of a single API and generic drug.

- *Direct Impact* - \$22.2 million to \$23.2 million, including job creation and production activities directly related to drug development and commercialization. This impact encompasses the initial changes from economic activity, such as wages and production jobs.

Calculation Methodology: The direct impact figure was calculated by assessing the number of months required for each employee during the development stage, covering both API and finished drug products, as well as the commercialization phase.

Employee wages were averaged based on their roles across these stages. The total wages for the high and low estimates were then multiplied by economic multipliers provided by Lightcast, which reflect the economic ripple effects generated by salaries and job creation directly related to the project.

- *Indirect Impact* - \$2.6 million to \$2.7 million from industries buying local goods and services, such as development equipment, raw materials, and facility buildout. These expenditures have a multiplier effect, stimulating further economic activity in the region.

Calculation Methodology: The indirect impact numbers were derived by applying industry-standard multipliers (sourced from Lightcast) to the direct impact figures. These multipliers account for the economic activity stimulated by industries purchasing local goods and services, such as raw materials, equipment, and facility buildouts. This approach captures the economic benefits of secondary business activities triggered by the project's operations.

- *Induced Impact* - \$24.1 million to \$25.2 million from spending by wage earners, including household purchases and local business support. This includes ripple effects from wages spent in the community, enhancing the local economy and quality of life.

Calculation Methodology: The induced impact was calculated by applying multipliers specific to wage-earner spending, as provided by Lightcast. These multipliers estimate the economic boost generated by employees spending their wages locally on household purchases and services. The direct impact figures were multiplied by these induced effect multipliers to capture the broader community economic effects driven by increased consumer spending in the region.

Social Impact:

- *Health Security* - reducing reliance on foreign API production, thereby enhancing national health security by ensuring a steady and reliable supply of essential medications.
- *Health Outcomes* - ensuring a steady supply of essential medications, reducing shortages, and making drugs more accessible to the public, thereby improving overall health outcomes.
- *Public Safety and Preparedness* - improving the ability to respond to health crises and emergencies by ensuring a reliable supply of essential medications. Supporting the development of robust public health infrastructure and systems.
- *Enhanced Quality of Life* - contributing to local infrastructure and community development projects, improving the overall quality of life for residents. Boosting local economies through increased spending by employees and businesses associated with the Center.

Strategic Impact:

- *Enhancing Innovation and Sustainability* - promoting advanced manufacturing innovation, improving supply chain efficiency, and encouraging environmental sustainability through the use of cutting-edge manufacturing practices. Beyond economic and social impact, reshoring API manufacturing also brings environmental advantages. According to a recent study by McKinsey, traditional API production methods contribute heavily to greenhouse gas emissions, but new technological advancements such as continuous flow chemistry, green chemistry practices and automation can significantly lower the environmental burden. When engaging with major pharmaceutical companies like Pfizer, the ability to reduce the environmental footprint through green chemistry was identified as one of the primary reasons they would consider working with the Center. By adopting these methods, the Center will help reduce energy consumption, minimize waste, and decrease the overall carbon footprint of pharmaceutical manufacturing.¹⁷
- *Brand Building & Community Engagement* - strengthening Missouri's brand as a biotech hub and enhancing community engagement through partnerships and sustainability initiatives. This includes partnering with community organizations to promote health education and preventive care, as well as supporting local health initiatives and programs aimed at improving public health outcomes.
- *Workforce Development & Job Opportunities* - enhancing educational opportunities through specialized programs and training for students in pharmaceutical and biotech fields. Providing training and upskilling opportunities for the local workforce and preparing them for high-tech jobs in pharmaceutical manufacturing.

Benchmarking the Impact

To further assess the impact of API Innovation Center's initiatives, we benchmarked our efforts against 11 major biopharma projects. This analysis compared the ratio of investment to jobs created, investment per job, and return on investment (ROI) to determine how the Center's initiatives rank in terms of efficiency and return. The results demonstrate that the Center's initiatives rank among the highest in the sector in terms of efficiency of job creation, further validating the significance of this initiative.

We selected North Carolina pharmaceutical projects for benchmarking due to the region's leadership in biopharma manufacturing, having secured over \$2 billion in investments in 2020 alone. North Carolina's projects reflect a variety of scales and advanced technologies, making

¹⁷ McKinsey & Company. (2023). Decarbonizing API manufacturing: Unpacking the cost and regulatory requirements. <https://www.mckinsey.com/industries/life-sciences/our-insights/decarbonizing-api-manufacturing-unpacking-the-cost-and-regulatory-requirements>

them highly comparable to our own efforts. Additionally, the state's focus on reshoring drug manufacturing aligns with our goals at the Drug API Innovation Center.

By benchmarking against a region known for its significant job creation and investment efficiency, we can more accurately evaluate how our initiatives stand within the broader U.S. pharmaceutical landscape.

The analysis of investments and job creation across pharmaceutical and biotech companies reveals that Center demonstrates strong efficiency in utilizing capital to generate employment. The Center's Forthcoming Investments stands out with an investment per job created of \$384,000, which is significantly more efficient compared to industry giants like ApiJect and Eli Lilly, where investments per job exceed \$1 million. Even the Center's current investment, with an investment per job of \$645,714, remains competitive and far more efficient than many larger companies. Larger firms, such as Thermo Fisher and ApiJect, require over \$1 million per job created, reflecting the heavier capital demands of large-scale operations. In contrast, the Center's more focused and targeted investment approach yields a higher return in terms of job creation¹⁸. The ROI on job creation for the Center's forthcoming project projections highlights that it will generate jobs at a lower cost than most companies in the analysis, with only a few exceptions like Huvepharma, which operates on a much smaller scale. Overall, the Center's strategic investments are highly effective in creating jobs, positioning it as a competitive player in the biopharma industry with the ability to deliver a high impact on employment with relatively lower capital investment and efficient use of funding.

¹⁸ <https://www.ncbiotech.org/news/north-carolina-books-over-2b-drug-manufacturing-expansions-2020>

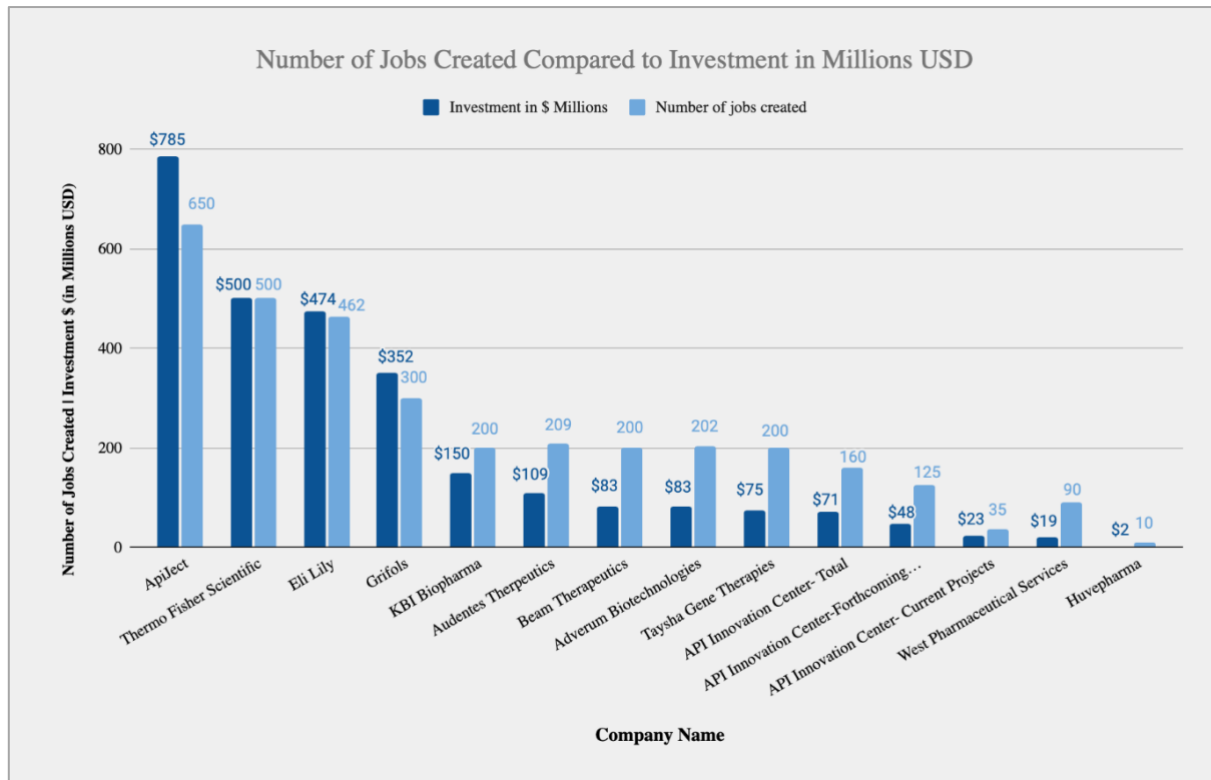


Figure 3. Number of jobs created compared to investment in millions USD, per company.

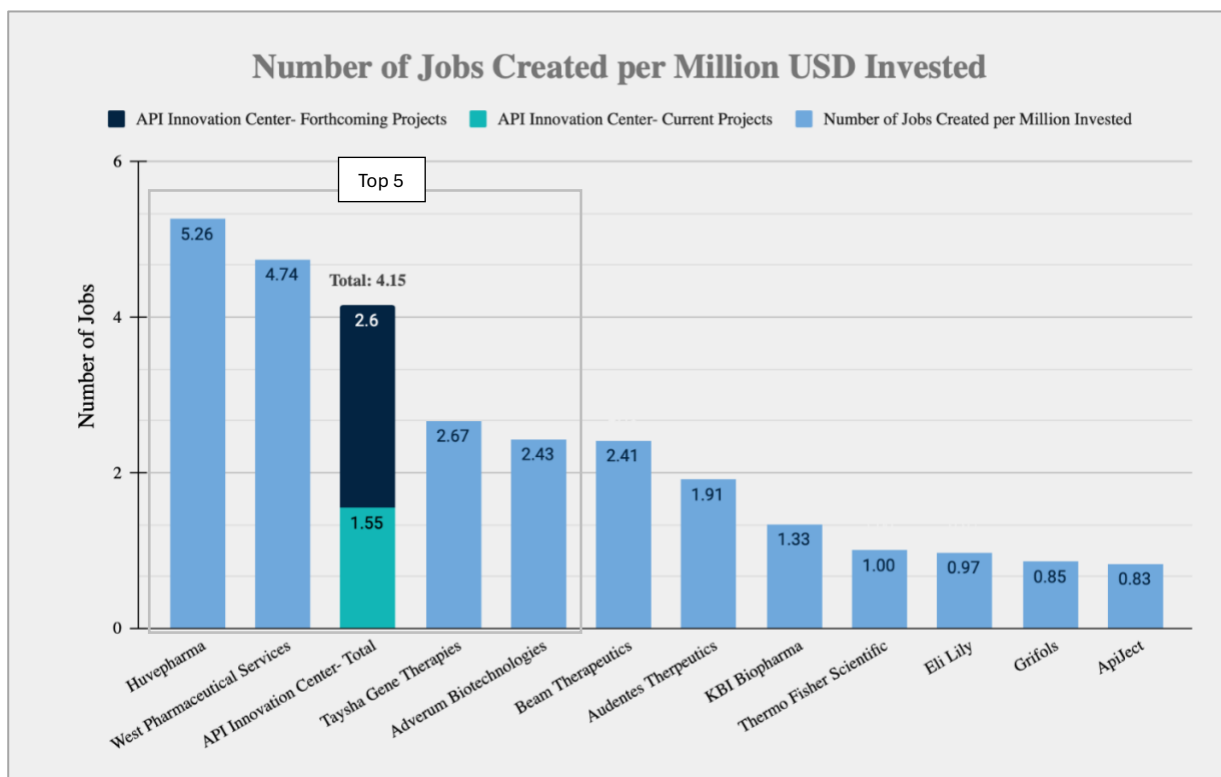


Figure 4. Number of jobs created per million USD invested, per company

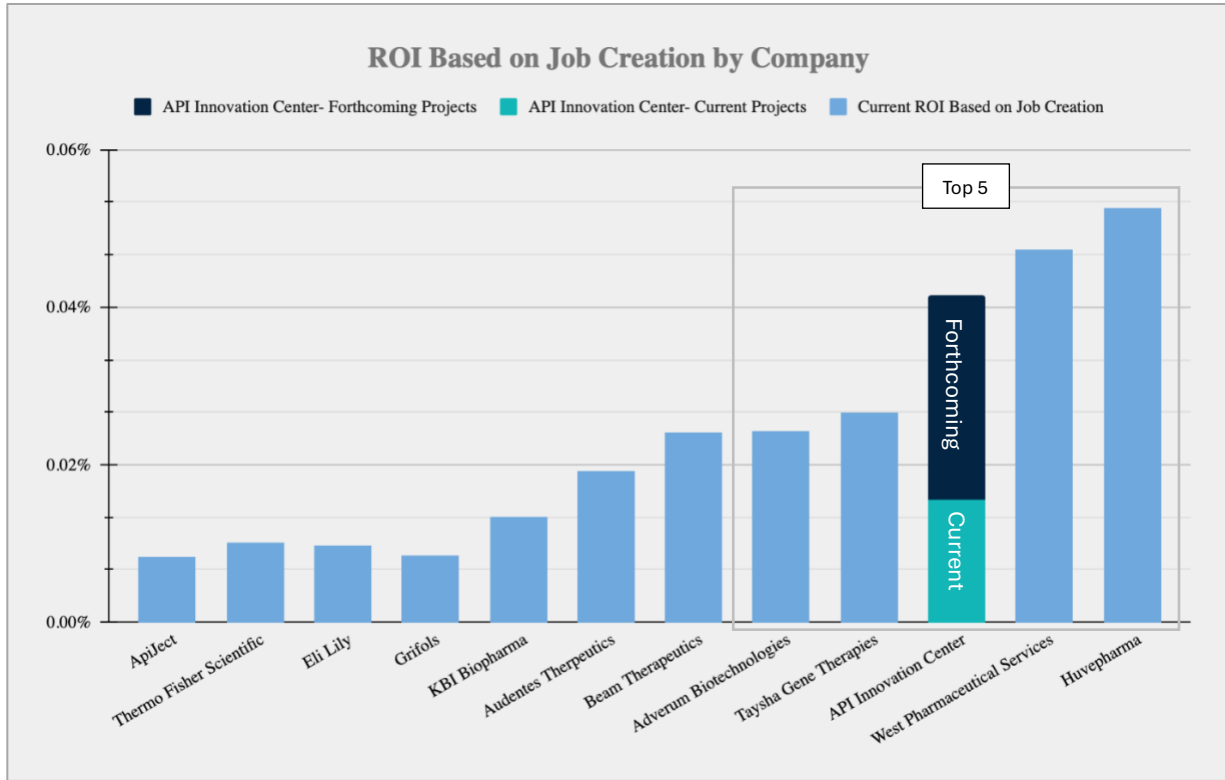


Figure 5. Return on Investment (ROI) % for job creation by company

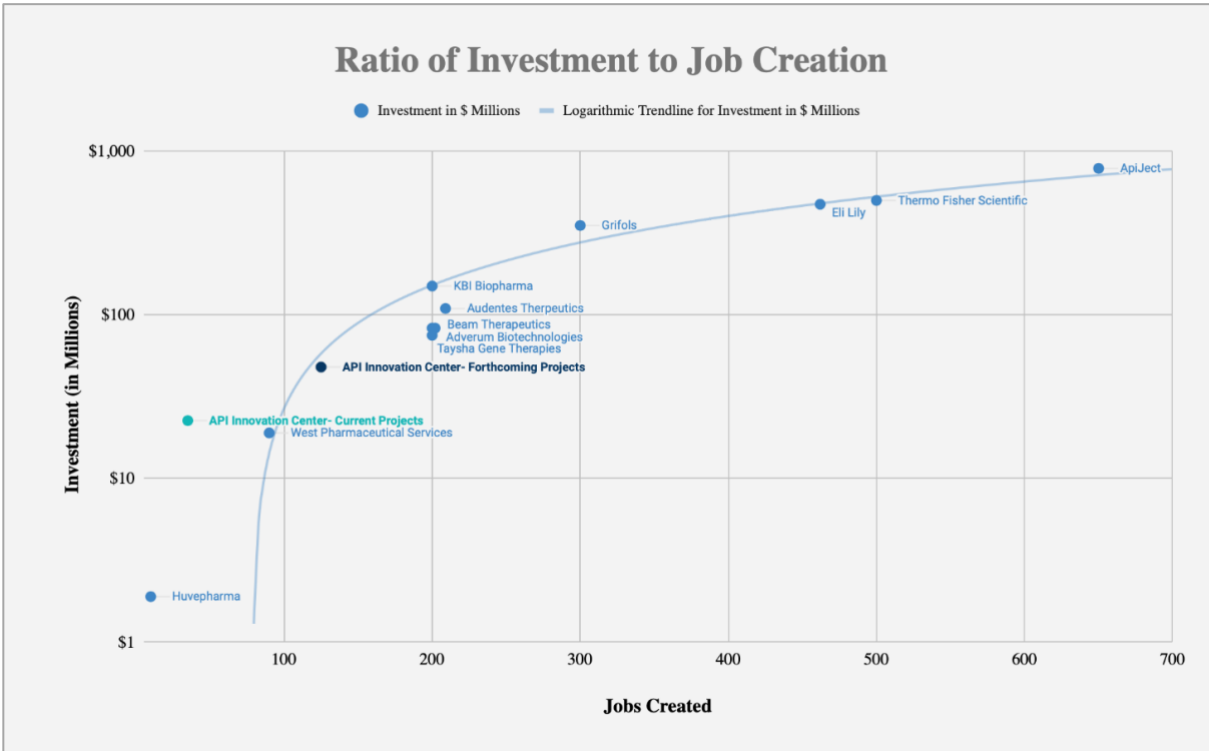


Figure 6. Ratio of investment to job creation trendline, by company

The graph highlights the Center as highly efficient in job creation relative to its investment. In its current phase, the Center's results are similar to West Pharmaceutical Services, demonstrating a strong return on investment with relatively low capital. The forthcoming phase maintains a competitive edge, with job creation efficiency comparable to larger companies like Eli Lilly and Thermo Fisher, despite significantly lower investment. Overall, the Center excels in creating jobs with minimal financial outlay, indicating strong potential for cost-effective growth in the biopharma sector.

Workforce Development and Employment Impact – A Unique Opportunity:

The development of advanced manufacturing in Missouri presents a unique opportunity to revitalize the state's economy and transform its workforce in a manner that is accessible to all members of our community, fostering a diverse and inclusive workforce that draws on the full spectrum of talent. Lessons from the biotechnology industry underscore the importance of this approach. Currently, non-White employees make up slightly more than one-third (38%) of the biotech workforce, yet this diversity diminishes at higher levels, with 24% of executives and 28% of CEOs being people of color. Additionally, Black professionals represent just 6% of the biotech workforce, with even lower representation in senior roles.

To ensure that Missouri's growth in advanced manufacturing benefits everyone, it is crucial to implement strategies that address these challenges. Building a diverse workforce begins with early outreach and education, particularly in underserved communities, where programs that expose students to careers in STEM fields can inspire a new generation of professionals. Additionally, mentorship and training programs tailored to underrepresented groups are vital for providing the support and resources needed to succeed in these industries. The Center's investment will serve as a catalyst in this effort by creating diverse and new job classes for the sector including non-degree certificate program employment opportunities in the pharmaceutical manufacturing sector through Quality Assurance/Quality Control (QA/QC) jobs. It also opens up pathways for a wide range of individuals for roles such as QA Specialist, Validation Engineer, and Compliance Specialist which are crucial for maintaining safety and regulatory standards, strengthening Missouri's pharmaceutical capabilities. These certifications also have broad applicability across other key industries where Missouri and the greater St. Louis region have a strong presence, including but not limited to:

- Medical Device Manufacturing - as companies like Bausch + Lomb expand their operations, there will likely be increased demand for Compliance Specialists, Quality Engineers, and Process Validation Experts. These roles are essential for ensuring that medical devices meet stringent FDA regulations.
- Chemical Manufacturing - companies like Bayer depend on Quality Control Chemists and Compliance Officers to uphold product quality and safety, supporting sustained economic growth and environmental responsibility in the region.
- Healthcare & Clinical Research - with institutions like BJC Healthcare and Washington University School of Medicine, the need for Clinical Quality Assurance Auditors and Compliance Specialists is critical. These roles support the integrity of clinical trials and the quality of healthcare delivery.

As Missouri seeks to establish itself as a hub for advanced manufacturing, further research and collaboration with local stakeholders will be essential to fully realize these opportunities. The combined direct and indirect impacts of this initiative, supported by ongoing validation and strategic partnerships, will ensure that Missouri remains at the forefront of innovation, job creation, and economic vitality.

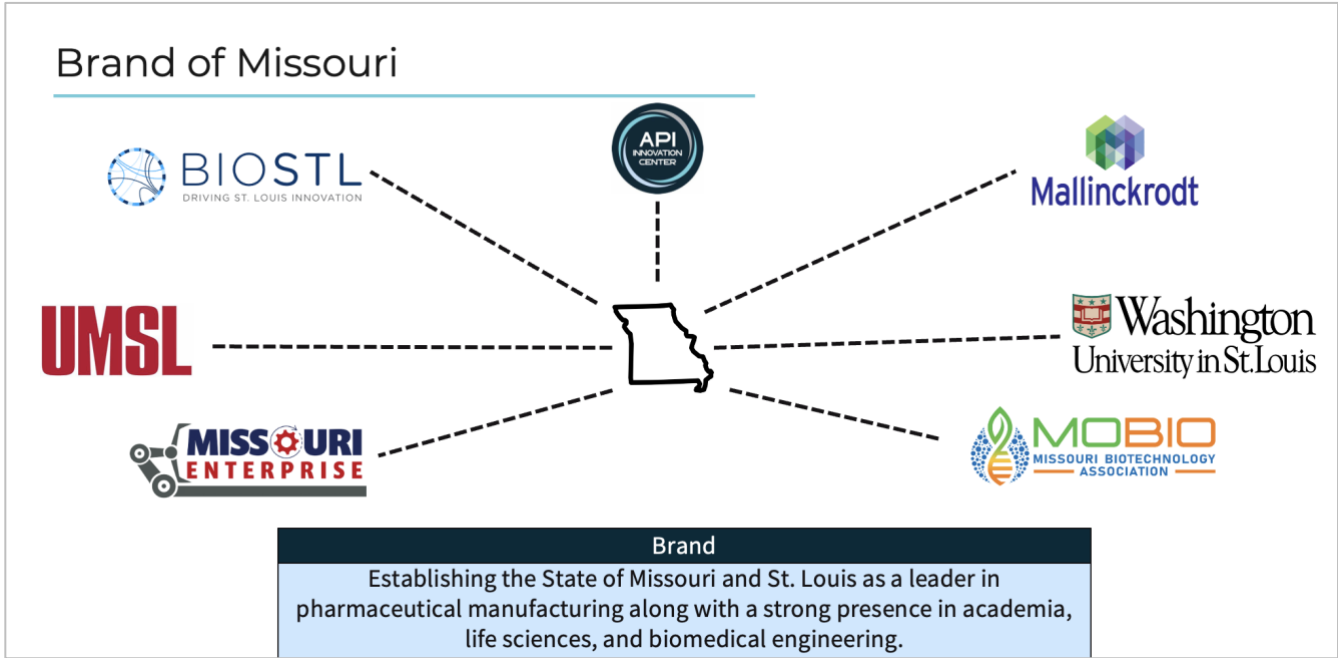


Figure 7. The Brand of Missouri- key players in the region

Conclusion

The economic impact of the Center's reshoring initiative is both substantial and transformative. Their current focus on developing 25 essential medicines is projected to contribute a remarkable \$1.2 billion in regional economic growth. This large-scale effort represents a significant opportunity to bolster Missouri's economy and the St. Louis region's profile while also reducing the nation's dependence on foreign APIs.

As of now, with 6 molecules already underway, the Center is making a direct contribution to the local economy. Each molecule is projected to generate \$51 million in economic stimulus, meaning that the work is currently injecting \$306 million into the region's economy. This impressive impact has been supported by an initial investment of \$6.83 million from the Missouri Technology Corporation for molecule development, along with an additional \$14 million from the BioMAP consortium. Together, these contributions are helping to drive the reshoring efforts, demonstrating a substantial return on investment and proving the viability and value of revitalizing U.S.-based pharmaceutical manufacturing.

Looking ahead, the Center's long-term goal is even more ambitious. By targeting the reshoring of 350 medicines, the Center anticipates generating \$17.85 billion in economic activity, a figure that showcases the transformative potential of this initiative not only for Missouri but also for the broader U.S. pharmaceutical landscape.

Through the use of advanced manufacturing technology, this initiative is not only revitalizing domestic pharmaceutical production but also creating new, high-quality job opportunities. The ROI, combined with the potential for job creation, technological innovation, and local workforce development, positions the Center and Missouri as critical players in securing the nation's health security and economic future.

The Multiplier Effect of State Investment in Pharmaceutical Manufacturing

State investment in pharmaceutical manufacturing has proven to be a powerful multiplier, directly contributing to Missouri's economic growth and attracting additional federal funding. This includes critical investments from the Biopharmaceutical Manufacturing Preparedness Consortium (BioMAP) and the broader Industrial Base Management and Supply Chain (IBMSC) initiatives. These investments position Missouri as a national leader in reshoring pharmaceutical manufacturing and have drawn significant private-sector interest, particularly from healthcare organizations and pharmaceutical companies. Moreover, this public-private partnership strengthens the domestic supply chain, ensuring preparedness and resilience for future health emergencies, in line with the priorities outlined by ASPR.

The Center's ROI ranks among the highest for state-supported projects. When benchmarked against 11 major biopharma projects, the Center demonstrates a competitive investment-to-jobs ratio and cost per job created, outperforming larger projects in terms of efficiency. This makes the Center one of the top contributors to economic growth and job creation within the state, offering a clear path forward for further investment.

The economic benefits of this program are also amplified by its ability to create non-degree job opportunities, providing high-paying jobs to individuals without advanced degrees. This contributes to a more inclusive labor market while addressing workforce shortages in the pharmaceutical sector.

Given these significant returns and the Center's pivotal role in the pharmaceutical reshoring movement, it is recommended that the state continue to fund, if not increase funding for, the Center. Increased state support will further strengthen Missouri's position as a leader in the pharmaceutical manufacturing space and enable the state to capitalize on future federal funding and private sector investments.

Furthermore, MTC has set a successful precedent in the state by investing \$44 million into over 135 companies, which resulted in over \$1 billion in private capital and \$11 million in returns. The Center demonstrates an even higher ROI, underscoring the effectiveness of state-backed initiatives in driving economic growth and job creation.

By leveraging state investments and adopting advanced manufacturing technologies, the Center is well-positioned to continue delivering strong economic returns, creating jobs, and fostering long-term sustainability in Missouri's pharmaceutical manufacturing ecosystem

Recommendations

The insights from the study led to several key recommendations that provide a strategic roadmap for the Center to maximize its economic and social impacts. By investing, contracting available cGMP facilities and partnering with drug manufacturers, the Center can foster partnerships, promote sustainability, and conduct comprehensive research to achieve its mission of revitalizing U.S. pharmaceutical manufacturing, create regional economic growth and build the nation's drug supply chain resiliency.

- *State Investment* - encourage the state of Missouri to invest in the API Innovation Center to stimulate economic growth and technological innovation. The Center has already demonstrated a remarkable return on investment from its initial MTC funding, so ensuring the approved and committed funding continues is essential to current momentum.

Leverage the multiplier – over the past several years state government leaders have been both innovative and aggressive at using state funds to leverage federal dollars, this approach coupled with the profound economic multiplier effect in advanced manufacturing should continue to be prioritized at the state level.

- *Partnerships and Collaborations* - foster collaborations with local universities, research institutions, and industry partners to drive innovation and community engagement.

Direct Placements – work to align existing workforce programming with industry needs across a full spectrum of opportunities and education levels with a specific focus on reaching more underrepresented communities and lead directly to a job placement.

- *Sustainability Initiatives* - promote environmental sustainability through the use of green chemistry and responsible sourcing, as well as consciously seek collaborations that increase diversity and inclusion within the Center's operations and partnerships.

Promote the Ecosystem – Missouri and St. Louis are fortunate to have strength in several economic sectors, work with tangential industries to promote one another, increase awareness, and tout the potential of a vibrant region.

- *Longitudinal Studies* - undertake longitudinal studies to track the long-term impacts of the Center's initiatives that help better understand the healthcare supply chain, process improvements and new technology in advanced manufacturing, and pharmaceutical drug development, on the local economy and community.
- *Sector-Specific Research* - focus on specific sectors within the pharmaceutical industry such as Quality Assurance (QA), Quality Control (QC), inventory management, and national security risks to identify targeted opportunities for growth and innovation.

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Appendices

Appendix I: Analogous Use Cases

The following case studies provide detailed analyses of similar initiatives in other regions, offering valuable insights and comparative data to contextualize the potential impacts of the Center in Missouri. These case studies highlight successful strategies and lessons learned from analogous investments, demonstrating the feasibility and transformative potential of advanced API manufacturing.

Secretariat BioPharma

Secretariat BioPharma is a leading organization focused on enhancing the pharmaceutical manufacturing industry through rigorous economic modeling and strategic investments. Their impact report provides valuable insights into the economic benefits of localized pharmaceutical production.

- The approach utilized an input-output model to calculate direct impacts from labor income, inputs, and value-added activities. This approach ensures a comprehensive understanding of how the investment translates into economic benefits.
- The methodology emphasized the importance of detailed economic data and specific regional factors in accurately measuring impact. This includes leveraging localized data to reflect the unique economic environment of the area.
- The report demonstrated how a focus on detailed economic modeling can lead to better resilience planning and more targeted economic strategies.
- In the report they highlighted the need for long-term growth data, value-added metrics, and tax contributions to provide a complete picture of economic impact.

Applying a similar rigorous economic model in Missouri can help accurately predict the long-term benefits and identify key growth areas specific to the region's economic landscape.

Virginia BioPharma

Virginia BioPharma is a prominent biopharmaceutical company that has significantly contributed to local economies through extensive job creation and infrastructure development. Their initiatives serve as a model for the potential impacts of API manufacturing in Missouri.

Employment and Job Creation:

- Sustaining Jobs - successfully sustains over 148,000 jobs, illustrating the significant employment potential of large-scale biopharma investments.
- Support for Local Suppliers - promotes the growth of local suppliers and infrastructure, showing how investment in API manufacturing can create a broad economic ripple effect.

Infrastructural Development:

- Water and Wastewater Upgrades - initiates local water and wastewater system upgrades, leading to improved public health infrastructure and creating additional demand across various sectors.
- Multiplier Effects - demonstrated how infrastructural improvements can generate further economic activities, such as construction and maintenance jobs, thereby contributing to overall economic development.

Investing in local infrastructure in Missouri can have similar ripple effects, enhancing public services and supporting broader economic growth.

APM vs. EVs (Tesla Comparison)

The comparison between Advanced Pharmaceutical Manufacturing (APM) and Tesla's disruption of the automotive industry offers a compelling perspective on how innovation in manufacturing can transform an entire sector. This analogy provides insights into the potential for APM to revolutionize pharmaceutical production.

Disruption and Transformation:

- *Industry Disruption* – there are parallels between Tesla's disruption of the automotive industry and the potential of Advanced Pharmaceutical Manufacturing (APM) to transform the pharmaceutical sector. Just as Tesla innovated with electric vehicles, APM can innovate with sustainable pharmaceutical production.
- *Innovation Leadership* – there is value in being a leader in innovation and the economic benefits of pioneering new technologies and manufacturing processes.

Economic Contributions:

- *Job Creation* – BEV technology development has driven significant job creation, both directly in manufacturing and indirectly through supply chain innovations.
- *Tax Contributions* - tax contributions from new industries, which can support public services and infrastructure.
- *Supply Chain Innovation* - innovations in one sector can lead to improvements and efficiencies across the entire supply chain.

Positioning Missouri as a leader in pharmaceutical manufacturing can have similar transformative effects, driving economic growth and establishing the state as a hub for innovation.

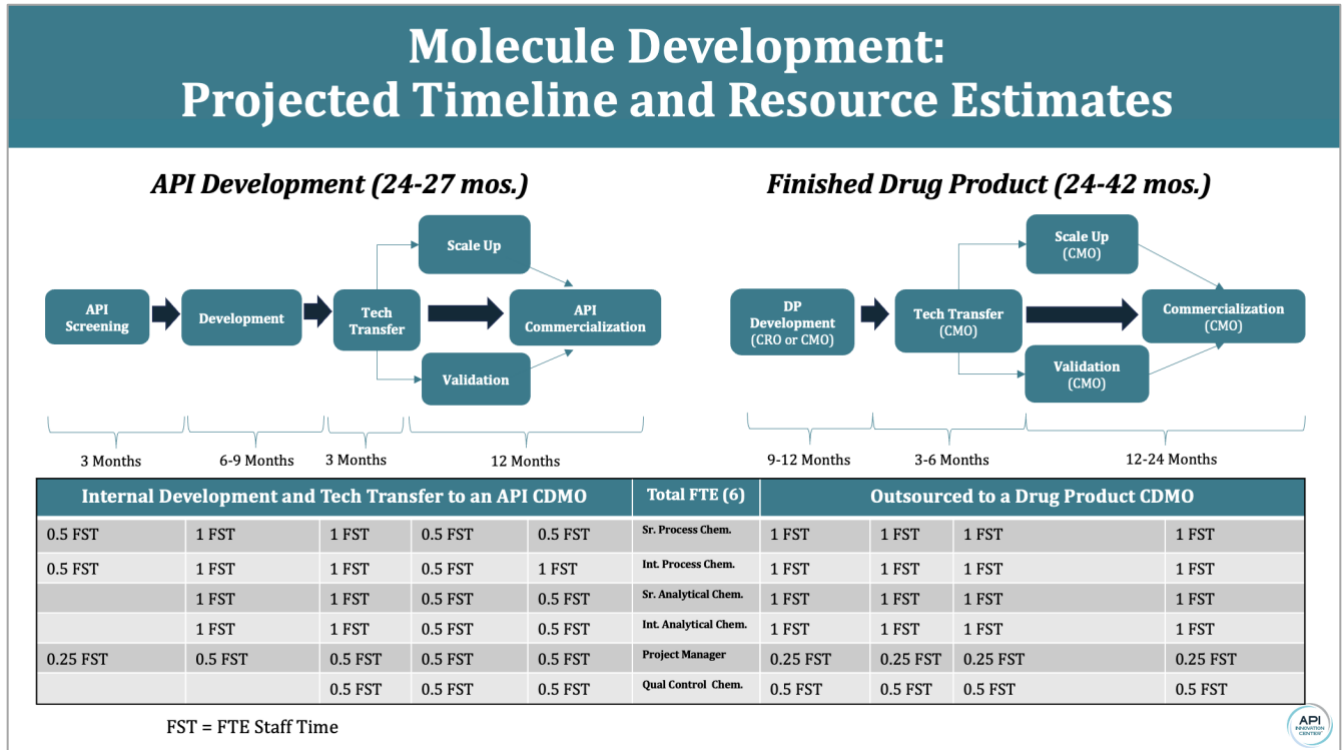
University of Missouri-St. Louis Collaboration

The University of Missouri-St. Louis has collaborated with various partners to address significant public health issues, such as the opioid crisis. Their addiction science team demonstrates the economic and social impacts of targeted health initiatives and innovative solutions.

- *Solving Important Societal Problems* - focuses on the significant economic and social impacts of addressing the opioid crisis through innovative solutions and community engagement.
- *Driving Positive Health Outcomes* - highlights the role of public health initiatives in improving community well-being and fostering a culture of health and safety.
- *Economic and Social Benefits* - shows how targeted health initiatives can lead to broader economic benefits, such as reduced healthcare costs and improved productivity.
- *Collaborative Research* - demonstrates the value of collaboration between universities, research institutions, and industry partners in achieving meaningful health outcomes.

Collaborating with local universities and health organizations in Missouri can drive similar positive outcomes, addressing public health challenges and contributing to economic resilience.

Appendix II: Projected Timeline & Resource Estimates



Appendix III: Detailed Estimate Calculations

Detailed Estimate Calculation

		Multipliers		Low		High				Annual Salary	
Direct Impact	0.27	\$22,189,244.74	\$23,226,170.37	API Development Months of Work Low Range	API Development Months of Work High Range	Finished Drug Product Months of Work Low Range	Finished Drug Product Months of Work High Range	Direct Impact Low	Direct Impact High	Annual Salary	Annual Salary
Indirect Impact	0.15	\$2,620,776.94	\$2,743,248.47								
Induced	1.38	\$24,111,147.83	\$25,237,885.91								
Total		\$48,921,169.50	\$51,207,304.75								
Direct Impact											
Job Title	API Development Months of Work Low Range	API Development Months of Work High Range	Finished Drug Product Months of Work Low Range	Finished Drug Product Months of Work High Range	Direct Impact	Direct Impact	Direct Impact Low	Direct Impact High	Annual Salary	Annual Salary	Annual Salary
Senior Process Chemist	16.5	19.5	24	42	\$314,178.75	\$477,086.25	\$314,178.75	\$477,086.25	\$93,090.00	\$93,090.00	\$93,090.00
Int. Process Chemist	19.5	22.5	24	42	\$337,451.25	\$500,358.75	\$337,451.25	\$500,358.75	\$93,090.00	\$93,090.00	\$93,090.00
Senior Analytical Chemist	15	18	24	42	\$302,542.50	\$465,450.00	\$302,542.50	\$465,450.00	\$93,090.00	\$93,090.00	\$93,090.00
Int. Analytical Chemist	15	18	24	42	\$302,542.50	\$465,450.00	\$302,542.50	\$465,450.00	\$93,090.00	\$93,090.00	\$93,090.00
Project Manager	10.25	11.75	6.75	10.5	\$131,877.50	\$172,604.38	\$131,877.50	\$172,604.38	\$93,090.00	\$93,090.00	\$93,090.00
Quality Control Chemist	7.5	7.5	12	21	\$151,271.25	\$221,088.75	\$151,271.25	\$221,088.75	\$93,090.00	\$93,090.00	\$93,090.00
API Innovation Center Supervisor(3 projects)	8	9	8	14	\$1,663,983.75	\$2,480,460.63	\$1,663,983.75	\$2,480,460.63	\$93,090.00	\$93,090.00	\$93,090.00
Total											
Commercialization (1 year)											
Job Title	API Development Months	Finished Drug Product Months	Direct Impact	Direct Impact	Annual Salary	Annual Salary					
Marketing Manager	6	6	\$127,280.00	\$127,280.00	\$127,280.00	\$127,280.00					
Sales Representative	3	3	\$34,685.00	\$34,685.00	\$69,370.00	\$69,370.00					
Advertising Sales Agents	6	6	\$61,840.00	\$61,840.00	\$61,840.00	\$61,840.00					
Senior Process Chemist	6	12	\$139,635.00	\$139,635.00	\$139,635.00	\$139,635.00					
Int. Process Chemist	12	12	\$186,180.00	\$186,180.00	\$186,180.00	\$186,180.00					
Senior Analytical Chemist	6	12	\$139,635.00	\$139,635.00	\$139,635.00	\$139,635.00					
Int. Analytical Chemist	6	12	\$139,635.00	\$139,635.00	\$139,635.00	\$139,635.00					
Project Manager	6	3	\$69,817.50	\$69,817.50	\$69,817.50	\$69,817.50					
Quality Control Chemist	6	6	\$93,090.00	\$93,090.00	\$93,090.00	\$93,090.00					
API Innovation Center Supervisor(3 projects)	4	4	\$62,060.00	\$62,060.00	\$62,060.00	\$62,060.00					
Total			\$1,053,857.50	\$1,053,857.50	\$1,053,857.50	\$1,053,857.50					
Total(15 year)			\$15,807,862.50	\$15,807,862.50	\$15,807,862.50	\$15,807,862.50					

Detailed Estimate Calculations

Note: Calculations were made from adding up months based on Figure 1 and making the low or high range based on the development time range. Months were then converted to years and multiplied by NAICS mean salaries and multipliers. Direct impact was multiplied by 1.27 to include the initial investment, and an the Center supervisor was added on under the assumption of overseeing 3 projects at once.