An Evaluation of the Kansas Bioscience Authority Economic Impact Measures

Report Prepared for Kansas Bioscience Authority

by

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Executive Summary

In the fall of 2011, the Kansas Bioscience Authority (KBA) requested that the University of Kansas Center for Science, Technology & Economic Policy at the Institute for Policy & Social Research provide a review of KBA's *Direct Outcomes Description and Measurement Policy.* This policy informs KBA's collection of economic impact data and frames KBA's policies more generally in light of technology evaluation. This report responds to KBA's request and addresses the following topics: 1) general challenges of technology evaluation; 2) the scope of KBA's technology programs; 3) the contributions of KBA's current measures to overall program evaluation; 4) measures that might be added or enhanced in the future; and 5) a comparison of this review to other efforts to evaluate KBA.

This report discusses the inherent difficulty of measuring long-term scientific investments with short-term indicators of future economic impact. KBA has several programs designed to increase bioscience research, foster commercial development, and attract new ventures to the state of Kansas. Each of these activities requires different metrics to evaluate its overall impact. We reviewed these metrics and compared them to those being collected by similar state agencies as well as the federal STAR METRICS program. Our review shows that KBA collects more metrics than agencies reviewed in other states. KBA also collects many of the indicators used in the federal STAR METRICS program. We recommend that KBA enhance its measures by including additional STAR METRICS measures such as patent citations, scientific publications, and workforce development indicators including students trained in bioscience on KBA funded projects. Although, KBA has been reviewed on two previous occasions, this report provides new information on the quality of the economic impact data they collect. Overall, we find that KBA collects a comprehensive set of outcome measures that span the scope of KBA's mission and provide the basis for understanding the economic impact of their scientific investments.

Challenges of Biotechnology Evaluation – at the National and State Levels

> *"The number one current rationale for extra research investment is that it will generate badly needed economic growth."*

So summarizes a recent article in the journal *Nature.*[1] Yet the article points out the sparseness of hard evidence connecting government research investments to economic progress. The challenges of evaluating biotechnology programs are not unique to KBA or to Kansas. They are in fact shared by all state and federal programs that strive to stimulate innovation and to smooth the path from innovation to commercialization.

Nor are the challenges of evaluation unique to biotechnology, although in an emerging field like biotechnology challenges may be magnified. Challenges include:

[1] Macilwain, Colin. 2010. "Science economics: What science is really worth." Nature, 465, 682-684. June.

- *Accounting for time*. The development of a product or service in the biotechnology industry may take ten or more years to become commercialized.
- *Accounting for risk*. In an emerging field like biotechnology, many well-conceived and well-managed projects or enterprises may still fail.
- *Accounting for synergies and agglomeration effects*. It appears that biotechnology developments benefit by the development of "industry clusters," wherein new projects are stimulated by existing projects in the area. The argument is that biotechnology research induces strong spillover effects that enhance the productivity of other firms in the region[2].
- *Designing appropriate outcome measures*. Are there indicators of project success that go beyond job and income growth?

There is growing demand for economic evaluations of projects that involve taxpayer funds. But no consensus about the appropriate measures and models for evaluation has been reached. *The Science of Science Policy: A Federal Research Roadmap*[3] reviewed federal science funding agencies and found that some agencies had only pilot projects to evaluate research funding while others had well-developed programs for evaluating their portfolios. One federal agency noted: "We need a great deal more outcome data. The data currently available are inadequate for program evaluation purposes."[4]

In response to the dearth of data on the economic impact of federal scientific investments, the STAR METRICS program was developed as a pilot project in 2009 to measure the economic impact of science funding in the American Recovery and Reinvestment Act (ARRA). STAR METRICS is led by the National Institutes of Health (NIH), the National Science Foundation (NSF), and the White House Office of Science and Technology Policy, and it has developed a set of outcome measures for sponsored university research projects (see Appendix 1)[5]. Since its inception the STAR METRICS program has provided a systematic approach to measuring the impact of scientific investments at the federal level[6].

Along another track, the National Institute of Standards and Technology (NIST) and the Department of Energy have undertaken research on evaluation models that extend the use of

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[2] Devol, Ross; Perry Wong, Junghoon Ki, Armen Bedroussian and Rob Koepp. 2004. *America's Biotech and Life Science Clusters: San Diego's Position and Economic Contributions*. Milkin Institute. http://www.milkeninstitute.org/publications.

[3] National Science and Technology Council. 2008. The Science of Science Policy: A Federal Research Roadmap. Accessed online 4/25/12 at http://www.whitehouse.gov/files/documents/ostp/NSTC%20Reports/39924_PDF%20Proof.pdf

[4] National Science and Technology Council. 2008. The Science of Science Policy: A Federal Research Roadmap, p.17. Accessed online 4/25/12 at http://www.whitehouse.gov/files/documents/ostp/NSTC%20Reports/39924_PDF%20Proof.pdf

[5] National Academies of Science. 2012. "Star Metrics Working Group." http://sites.nationalacademies.org/PGA/fdp/PGA_057189. Accessed 01/23/2012.

[6] Lane, Julia and Lou Schwarz. 2012. Creating New Administrative Data to Describe the Scientific Workforce: The STAR METRICS Program. American Institutes for Research.

outcome measures[7]. The models try to answer questions such as "what is the benefit-cost ratio of a project?" These two federal initiatives indicate that sound outcome measures are a necessary precondition before the use of evaluation models can be even considered.

At the state level, evaluation data and evaluation models are much less developed. KBA provided us with a list of six agencies with somewhat comparable missions (see Appendix 2). We contacted these agencies by email, but only Georgia responded. We were able to find some information on data collection on the websites of the Ohio, Texas and Maryland biotechnology agencies. Information from these states is included in our evaluation of KBA. We contacted the Ben Franklin Technology Partners in Pennsylvania and were told that they did not collect economic impact information. Our repeated calls and emails to the Pittsburgh Life Sciences Greenhouse were unanswered.

Before discussing the Kansas Bioscience Authority's evaluation procedures, we first review KBA's mission and the scope of its programs.

KBA's Technology Programs

KBA operates a portfolio of programs addressing various stages in the life-cycle of biotechnology research and commercialization (Table 1). Some programs focus on Kansas universities and on emerging research areas. Other programs focus on the private sector and on bringing products to market. Each of these programs has specific goals and criteria for the participation of a researcher or firm.

It is important to note that KBA's programs span the life cycle of biotechnology development. KBA stimulates basic research and start-up firms that are in the early stages of commercialization. But KBA also devotes resources to attracting mature biotechnology enterprises to the state. KBA encourages synergies between basic science, early stage product development, and mature commercialization.

The broad range of KBA's activities require a broad range of data for evaluation, as we discuss in later sections of this report. Many of KBA's activities can be classified as investments in the ***future*** growth of biotechnology. Therefore, evaluation measures must consider not only current outcomes (such as current jobs and income), but also expected future outcomes. Despite the difficulties associated with evaluating the impact of bioscience investments discussed above, KBA has tracked several outcome metrics used in STAR METRICS and by other state agencies.

[7] Ruegg, Rosalie and Irwin Feller. 2003. A Toolkit for Evaluating Public R&D Investment Models, Methods, and Findings from ATP's First Decade. Advanced Technology Program, National Institute of Standards and Technology.

Table 1. Inventory of KBA Programs

Program	Description	Focus	Life Cycle Stage
Kansas Bioscience Eminent Scholars	Recruit and support distinguished bioscience researchers at Kansas universities and encourage their commercialization efforts.	Universities	Basic research
Kansas Bioscience Rising Stars	Support and retain up-and-coming University researchers in bioscience fields and encourage their commercialization efforts.	Universities	Basic research
Kansas Bioscience Matching Fund	1) Grant-matching funds: provide required matching funds for federal and private research grants. 2) Technology development funds: match firms' investments in the commercialization of new products and technologies.	Universities Private sector	Basic and applied research Early-stage commercialization
Kansas Bioscience Centers of Innovation	Develop world-class bioscience research centers that may include public-private collaborations.	Universities and private sector partners	Applied research and early to mid–stage commercial development
Kansas Bioscience R&D Voucher	Provide early-stage financing and commercialization support.	Private sector	Early commercial development
Kansas Bioscience Grant Writing Voucher Program	Assist Kansas small biotechnology businesses in winning obtaining federal SBIR/STTR (Small Business Innovation Research/Small business Technology Transfer) and other federal and foundation grants.	Private sector	Applied research and early commercial development
Heartland Bioventures	Help early stage firms become stronger business entities through assistance with management and other issues. The goal is to make the firms more attractive for private venture capital funding.	Private sector	Early commercial development
Direct Equity Investment	Make equity investments in Kansas firms alongside private sector venture capitalists and other investors.	Private sector	Early to mid–stage commercial development
The Drug Development Program	Support relatively late-stage drug development projects that are close to regulatory filing.	Universities and private sector	Mid-stage commercialization. Products close to regulatory filing.
Kansas Bioscience Expansion & Attraction	Provide financial incentives for the expansion and attraction of bioscience companies with strong growth potential in partnership with Kansas Department of Commerce and local development agencies.	Private sector	Mid to mature commercialization

The Contributions of KBA's Current Measures to Overall Program Evaluation

KBA collects and reports data on four primary outcomes. KBA also collects data on ten additional indicators, which, for this report, we call secondary indicators (see table 2). Secondary indicators include those particular to technology and those measuring financial health. KBA also has a formal policy, the *Direct Outcomes Description and Measurement Policy*, that we reviewed and found suitable for evaluation purposes. We believe that each of these program components informs the public's understanding of KBA's contribution to the state. We discuss each outcome indicator in light of some of the challenges of biotechnology evaluation—does the indicator attempt to measure current, medium-term, or long-term economic development? Does the indicator take risk into account? Does the indicator demonstrate the emergence of synergies? We ask whether the ***mix*** of data collected by KBA sufficiently captures the range of KBA's contributions.

Primary Indicator: Jobs and Wages
As stated in a memo from Governor Brownback to the Kansas public:

> "The ultimate goal of Kansas' economic development system is the prosperity of the state's citizens. A sound economic development process enhances prosperity through enhanced business-sector productivity; it creates, sustains, and renews economic opportunity for families by creating a vibrant business sector."[8]

Clearly, jobs and wages provide the core measure of economic development of the average citizen. Jobs and wages fluctuate with the success of the biotechnology enterprise. When jobs and wages maintain an upward trend, they indicate the potential for medium-term and even long-term economic success. As the number of jobs in biotechnology firms increases, so does the potential for synergistic growth.

Primary Indicator: Equity Investments
Investments in biotechnology are inherently risky. As mentioned earlier, the commercialization process is lengthy. Early-stage developments are subject to scientific risk (for example, the product under development might not work out). Later stage developments are subject to regulatory risk (the product may fail FDA approval) and market risk (consumers may simply not purchase much of a new drug that enters the market). Private equity investment is the market's verdict that the potential rewards outweigh the risks. Not only does the equity investment allow further advances toward commercialization, it also serves as an external signal that the biotech firm is on the right track.

[8] Brownback, Sam (Governor) and Lieutenant Governor Jeff Colyer. 2011. Memo to All Kansans re: Our Administration's Economic Development Strategic Plan. February. http://governor.ks.gov/frontpagenews/2011/02/10/economic-development-strategic-plan. Accessed 01/24/2012.

Primary Indicator: External Research Funding

KBA stimulates biotechnology development at its earliest stages: basic and applied research at Kansas universities and other research institutions. Just as equity investment signals that a commercial development has a high potential reward, so external research funding signals that research *ideas* are innovative and have high potential payoffs. Experts rigorously review funding proposals to federal agencies such as the National Institutes of Health (NIH) and the National Science Foundation (NSF); only research plans with sound ideas and sound methods for testing those ideas are likely to make it through the review process. Both the equity measure and the funding measure provide assessments of risks and rewards from outside the KBA organization itself. External research funding also stimulates cooperation among multiple universities and private sector research partners, who are often included as subcontractors as part of the research award.

Primary Indicator: Capital Expenditures

Capital expenditures build the infrastructure of universities and businesses. In the short run, physical capital allows firms to undertake production. In the longer run, investments in research equipment and facilities enhance research productivity and make university researchers more competitive for future external funding. Capital investment indicates a long-term commitment to research and development in Kansas. Earlier we discussed how bioscience attracts more bioscience. Capital investments in equipment and buildings signal to potential innovators that Kansas has a core of bioscience activity that is likely to persist into the future. The availability of lab space may also attract developing firms.

Secondary Technology Indicators Overview: Innovation and Synergies

Additional indicators address the special nature of biotech. Biotechnology is knowledge intensive. Knowledge spreads from firm to firm, between universities and firms, and between firms, universities, and government laboratories. The flows of knowledge are not one way. Innovation at universities spreads out as new ventures commercialize products. The practical experience of business ventures rekindles ideas at knowledge centers. These indicators provide measurements of knowledge creation and diffusion.

Secondary Technology Indicator: Number of Strategic Partners

In a paper presented in 2000, Maryann Feldman described strategic partnering in bioscience:

> "There are basically three important actors in biotech research alliances, universities, small entrants and large incumbent firms…Strategic research alliances are formed to bring these actors' complementary competencies together with the goals of advancing the technology and introducing commercial products to the market."[9]

[9] Feldman, Maryann. "Strategic Research Partnerships in Biotechnology." 2001. In National Science Foundation, Division of Science Resources Studies. *Strategic Research Partnerships: Proceedings from an NSF Workshop.* NSF 01-336.

Feldman goes on to review the academic literature: in summary, partnerships appear to increase firm growth and enhance knowledge spillovers. Overall, strategic partnerships measure whether KBA is fueling the kind of activities that might take off to higher levels of growth.

Secondary Technology Indicator: Number of Invention Disclosures and Patents
Patents and their precursors, invention disclosures, contribute to KBA's outcome measures in two ways. First, they signal that innovative activity actually has taken place. Second, they indicate that a Kansas entity will have the right to profit from that innovative activity, bringing potential income and jobs to Kansas in the future. The patent indicator could be expanded by examining patent citations in addition to patent counts. We discuss this in a later section.

Secondary Technology Indicator: New Start-up Companies Created
According to research sponsored by the Kauffman Foundation[10], business startups account for about three percent of total US employment. All of these jobs are new jobs that did not exist before the firms came into existence. The Kauffman research indicates that job growth in the US would consistently be negative if it were not for the emergence of new firms. In short, new firms = new jobs. An additional indicator that KBA might consider is the survival of new firms. If new firms survive several years, the jobs they create become permanent.

Secondary Technology Indicator: Number of Commercial Products or Services Created
New commercial products or services provide another measure of research success. The acceptance of new products by the marketplace generally means that the products meet an unfulfilled need of customers—for example, a need for a new or improved medical treatment. The new products or services provide a potential source of future income and employment.

Secondary Indicators of Financial Health
Several of KBA's secondary indicators report the financial health of biotechnology firms that operate in Kansas. The indicators are likely to be highly correlated. That is, a firm with expanding revenue will probably have expanding income and, as a consequence, increased income tax liabilities. Of the financial indicators, net income is probably the most important. An operation with positive net income in Kansas is likely to survive into the future, continue to provide jobs and wages, and reinvest in the state. Similarly, positive net income for the firm as a whole (for firms that have operations in both Kansas and elsewhere) serves as a survival factor. Note however that net income is likely to be negative in the early years of a firm's operation.

The last column of Table 2 compares KBA metrics to other state agencies and STAR METRICS. Of the five state agencies we reviewed, KBA collects the most data. Several of KBA's measures

[10] Haltiwanger John; Ron Jarmin; and Javier Miranda. 2009. *Jobs Created from Business Startups in the United States.* Kauffman Foundation. January. http://www.kauffman.org/research-and-policy/business-dynamics-statistics.aspx. Accessed 01/24/2012.

are also collected by STAR METRICS; however, it does not collect secondary measures of financial health.

Table 2: Biotechnology Outcome Measures

Measure	Applicable time horizon	Addresses Risk	Addresses synergies and agglomeration	Used by other agencies
Primary indicators collected by KBA				
Full and part time jobs and wages	Mainly current, some implications for medium-term and long-term success		A region's biotechnology industry is often measured by jobs and wages. As the size of the industry grows, the region becomes more attractive to additional biotech firms.	Georgia Maryland (incubators) Ohio[11] Texas STAR Metrics
Equity investments	Medium and long-term	Private equity investment is the market's verdict that potential rewards outweigh the risks.		Georgia Maryland Ohio Texas
External research funding	Medium and long-term	External research funding signals that research ideas are innovative and have high potential payoffs.	External research funding helps to build a core of scientists and other researchers who often work cooperatively with the private sector.	Ohio STAR Metrics
Capital expenditures	Current, medium and long-term	Investment in physical capital may indicate that the biotech enterprise has staying power.		STAR metrics
KBA secondary technology indicators				
Strategic partnerships	Medium and long-term	Risk diversified over members of partnership.	Directly measures cooperation among firms and other organizations.	
Invention disclosures and patents	Medium and long-term			Georgia Ohio STAR Metrics
Number of start-ups	Medium and long-term	Many start-ups fail in the marketplace. Risk is diversified by creating a large portfolio of start-ups.	The success of new firms in a geographic region may signal that the area is a good place to start business.	Georgia Maryland Ohio Texas
Number of products commercialized	Medium and long-term	Many new products fail on the market. Risk is diversified by creating a large portfolio of new products.		

[11] BioOhio. (2010). Ohio Bioscience Growth Report 2010. Accessed online 4/25/12 at www.bioohio.com/pdfs/growthreport10.aspx

Table 2: Biotechnology Outcome Measures (continued)

Measure	Applicable time horizon	Addresses Risk	Addresses synergies and agglomeration	Used by other agencies
KBA secondary indicators of financial health				
Firm revenue from in-state operations	Short to medium-term			Georgia Maryland (incubators) Texas
Net income from in-state operations	Short to medium-term			
Income and property tax in state	Short to medium-term			Maryland (incubators) Ohio
Market capitalization	Medium to long-term	Valuation of the firm is based in part upon investors' assessment of risk versus potential reward.		
Firm total revenue	Short to medium-term			Georgia Maryland Ohio Texas
Firm net income	Short to medium-term			Ohio

Summary

Overall, we find that KBA has a comprehensive set of outcome measures that span the scope of KBA's mission. Some measures are general to any economic evaluation: jobs, wages, capital investment, and business income. Other measures are more specific to technology programs: equity investments, particularly venture capital, patents, and strategic partnerships. Still other measures capture the effect of KBA on basic research—particularly the one for external funding. As seen in Table 2, the range of data collected by KBA is much more comprehensive than the data collected by similar state organizations and it compares favorably with measures collected by STAR METRICS. In the next sections, we suggest a few additional measures for future data collection.

Possible Additional Outcome Measures

The national STAR METRICS data collection program includes several measures that KBA could add to its evaluation process. We recommend adding the following measures because they capture information about the synergies of technology development that may be lacking in current data collection. (Note that our examination of data collection by state agencies did not suggest any new measures).

Patent citations and licenses
Citations indicate how important a patent is to future research in the biotechnology field. Are other inventors using the knowledge gained by the initial developer? Are universities and firms licensing KBA-funded discoveries?

Workforce outcomes
Biotechnology development mandates a highly trained and motivated scientific workforce. That workforce exists in part because post-docs, graduate students, and undergraduates gain experience in cutting-edge research activities at universities and research centers. We suggest that KBA track the number of graduate students, postdocs and undergraduates trained on the projects that KBA assists.

Scientific knowledge as measured by publications
Scientific publications are the output and outlet of basic research. Citations by other researchers measure the importance of a scientific contribution. If scientists sponsored by KBA produce widely-cited research, this indicates that Kansas is developing "knowledge assets" that may attract people interested in commercial bioscience development.

Counts of firms and researchers assisted
In addition to reporting on total employment and strategic partnerships, it would be useful to have counts of the total number of firms assisted each year by KBA. Are KBA investments focused on a small percentage of firms relative to the total biotechnology industry in Kansas? What percentage of the KBA budget is assisting public sector (e.g. university) compared to private sector bioscience efforts? Finally, it would be useful to know the number of public and private sector researchers attracted to Kansas as a result of KBA investments.

Comparison to Other Efforts to Evaluate KBA

This review has examined the validity of KBA's measures of the economic impact of scientific investments in the state of Kansas. We find that KBA collects comprehensive indicators of economic impact that compare favorably with those collected by related state agencies and the federal STAR METRICS system. The findings in this review are qualitatively different than previous efforts to evaluate KBA.

In 2008, the former state agency, Kansas, Inc., contracted with GSP consulting to conduct an early stage evaluation of KBA.[12] The study focused on the amount of activity within each sub-program and on whether that activity was in line with achieving program goals. The evaluation examined the parts more than the whole; this may be because KBA had only been operational for a few years as of the 2008 evaluation. Nevertheless the Kansas, Inc. evaluation concluded:

[12] GSP Consulting Corporation. 2008. *Evaluation of the Kansas Bioscience Authority: 2004 to 2008.* Kansas, Inc. December.

> "the Kansas Economic Growth Act of 2004 (KEGA) provided a broad mandate and considerable flexibility for assisting the bioscience industry in Kansas…At the current time, the KBA has implemented a range of programs and activities that are making progress toward all of these goals."

On January 23, 2012, results of an independent audit of KBA by BKD Forensic and Valuation Services were released to the public.[13] The audit focused on internal procedures of KBA, oversight, use of funds, and potential and perceived conflicts of interest. The audit was not intended to address KBA's overall role in economic development and was for the most part silent on the question of whether KBA fulfills its economic mission. Therefore, the data collected for the audit procedures were different in nature from the data that potentially could measure KBA's economic contribution.

In summary, neither the Kansas, Inc. report, nor the BKD Forensic audit demonstrates how the entire portfolio of sub-programs developed by KBA affects overall economic development in Kansas. However, the outcome measures developed by KBA provide useful information for communicating KBA's impact to legislators and to the general public.

Conclusions

As discussed throughout this review, the nature of biotechnology development requires outcome measures that go beyond counting current jobs and income. Biotechnology investment by state agencies is an investment in future high-tech growth. Biotechnology paybacks are long term, and the investments made by states are risky. Biotechnology growth attracts additional growth because of synergies among and between firms and universities. Evaluation data must capture both the current payoff of biotechnology programs and their future potential. KBA has taken a "portfolio" approach to data collection, including near term and long run measures, measures of risk, and measures of synergistic growth. The data being collected by KBA is highly suitable to technology programs. Overall, we believe that KBA is collecting appropriate data, but that the data could be enhanced by a few additional measures.

[13] BKD Forensic and Valuation Services. 2011. Kansas Bioscience Authority Forensic Audit. December. http://www.kansasbioauthority.org/about_the_kba/KBA_AuditResults.aspx. Accessed 01/25/2012.

Appendix 1: Features of STAR METRICS Program

The STAR METRICS program collects (or plans to collect) information about the impacts of federal research grants at two conceptual levels (NIH, 2012).

Level 1 impacts include current jobs and income generated by federal grant dollars:

- *Direct jobs and income*: this includes faculty, staff, and students employed directly with grant funding
- *Estimates of employment and income resulting from payments to vendors*: payments to vendors support employment and hence income in sectors where the payments are made
- *Estimates of employment and income from grant sub-contracts*: grant funds often are used to sub-contract with additional universities and with private sector organizations
- *Estimates of employment and income from University overhead funds*: federal grants generally include funding to help maintain university facilities

Level 2 impacts describe the economic, workforce, scientific and social impacts of the grant. Measures under development include:

- *Economic*: firm start ups, patents, and other measures;
- *Workforce*: educational and experiential training of students and other employees;
- *Scientific*: publications, citations, and other measures of scientific recognition;
- *Social*: outcomes such as impacts on health and on the environment.

Appendix 2. Comparable State-Level Bioscience Initiatives

State	Agency	Website
Georgia	Georgia Research Alliance This organization is analogous not to the whole of the KBA but to some of their programs, namely the Eminent Scholar and Rising Star programs.	http://www.gra.org/
Maryland	Maryland Technology Development Corporation	http://www.marylandtedco.org/index.cfm
Ohio	BioOhio	www.bioohio.com
Pennsylvania	Pittsburgh Life Sciences Greenhouse	http://www.pittsburghlifesciences.com/
Pennsylvania	Ben Franklin Technology Partners	http://benfranklin.org/
Texas	Texas Emerging Technology Fund	http://governor.state.tx.us/ecodev/etf