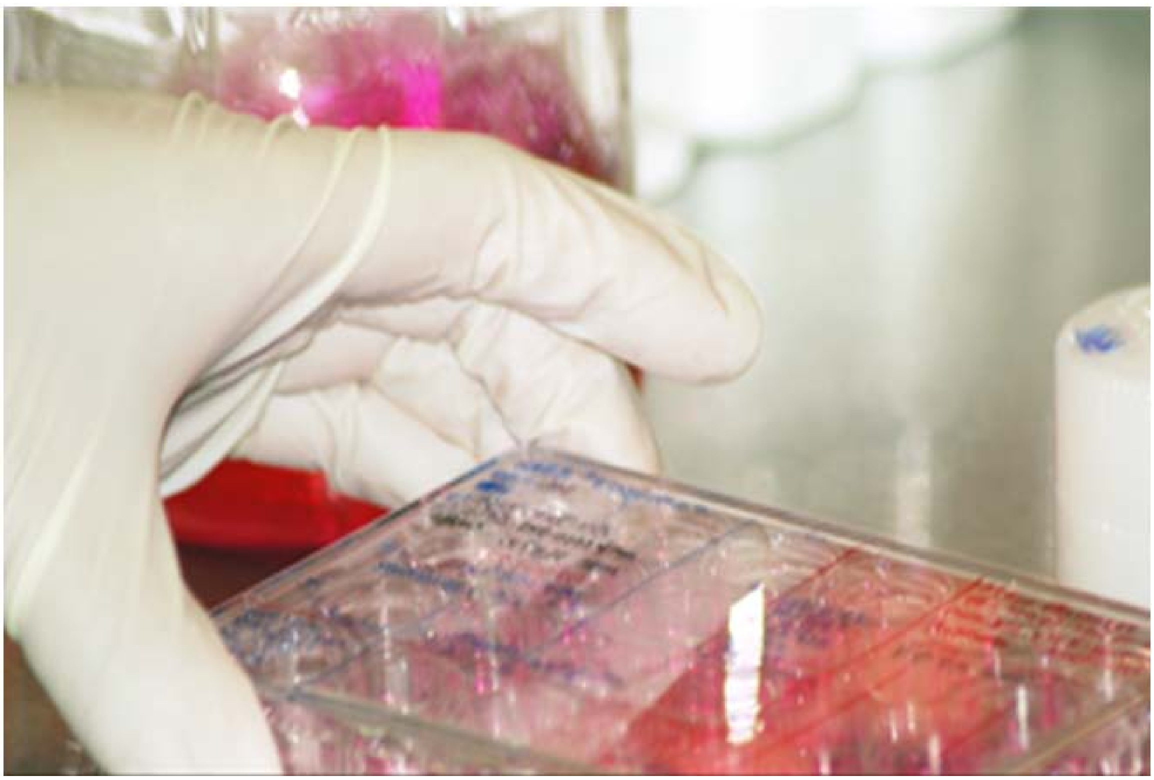
ECONOMIC IMPACT OF RESEARCH FUNDED BY THE

CALIFORNIA INSTITUTE FOR REGENERATIVE MEDICINE



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The conclusions and opinions expressed in this study are those of the author.

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Summary of Findings

In November 2004, Californians voted for the establishment of the California Institute for Regenerative Medicine (CIRM) and authorized the allocation of $3 billion to support stem cell research and other vital medical technologies. CIRM awarded its first grants in April 2006 and, as of July 2010, it had awarded 364 grants worth more than $1 billion to over 50 institutions. In addition, grantees raised $884.3 million from donors and institutional project funds. Recipients of Major Facilities Grants have obtained $3.26 of matching funds for every dollar received from CIRM. Of that $3.25, $2.07 is being used to construct world-class facilities able to accommodate 2,000 scientists. The remaining $1.19 is being used to recruit new researchers to these facilities.

Funds spent in California by CIRM grantees have both **one-time economic impacts** -benefits that last while the grants are being disbursed- and **on-going impacts** that persist and result from structural changes. Building facilities and acquiring equipment have construction impacts while the project is being built and end when the project is complete; so does funding for training and research. On-going impacts accrue directly to patients that have entered remission as they can return to work and thus generate income, and indirectly because of the emergence of competitive business clusters.

We find that the $1.1 billion in CIRM grants committed as of July 2010 – and the $884.3 million in matching funds, will have the following effects during the period 2006-2014:

- The creation of 24,654 FTEs in California, the equivalent of 2,739 jobs per year over the 9 year period; and
- Payment of $157.2 million in tax revenues to the State of California and $44.4 million to local governments.

CIRM grants – including investments in the construction of significant new facilities dedicated to stem cell research - are putting California in a position of leadership in stem cell research leading to the establishment of a biological science and biotechnology infrastructure likely to attract venture capital investment in research and start-up firms. The Cluster Mapping Project at Harvard has identified two fast growing biopharmaceutical clusters in the San Francisco Bay area and around San Diego. CIRM grants have been given to institutions that concentrate in those two areas thus reinforcing the formation of those clusters. Given the size of the facilities that are being built one could reasonably expect the employment of researchers to increase substantially.

I. Introduction

In November 2004, Californians voted for Proposition 71 establishing the California Institute for Regenerative Medicine (CIRM) and authorizing the allocation of $3 billion in public bond funds to support stem cell research and other vital medical technologies. CIRM awarded its first grants in April 2006 and has disbursed over $570 million so far. As of July 2010, the CIRM had awarded 364 grants worth more than $1 billion to over 50 institutions in 18 rounds of funding.[1] In addition, CIRM grantees raised $884.3 million from donors and institutional project funds. Funds spent in California by CIRM grantees – both the grants themselves and the matching funds - have economic benefits some of which are immediate while others are long-lasting. This report estimates both "**one-time impacts**" and "**on-going impacts**" of CIRM grants.

One-time impacts result from the CIRM grants (be they to build new facilities; acquire equipment; fund research projects or train researchers) as well as from the matching funds. Building facilities and acquiring equipment have construction impacts while the project is being built and end – mostly[2] - when the project is complete. Jobs associated with the construction (or renovation) of a site are not "permanent" because they exist only while the project is underway. Even if a project lasts several years, the positions have a termination date. The same argument can be applied to funding used to train individuals or to carry out research.

In addition to the *direct* (one-time) economic impacts of CIRM's grants (jobs gains, tax revenue increases, etc…), there are *indirect* impacts that result from the fact that materials, equipment and supplies need to be produced, and there

[1] http://www.cirm.ca.gov/GrantsSummary
[2] Due to lags in the diffusion of economic impacts, the effects may outlast the exact completion date of the project.

are *induced* impacts given that goods and services need to be manufactured for those workers to consume.

In contradistinction, on-going impacts accrue to Californians for two reasons:

- Directly when CIRM sponsored research results in cheaper and/or more effective therapies. In that case, patients no longer affected by a disease will be able to return to the labor force, bringing about increases in personal income. On the other hand, reductions in the cost of treating patients will benefit both the patients themselves and governments because expenditures are likely to decrease. The evaluation of direct on-going impacts is not part of this report but is the focus of an accompanying study;[3] and
- Indirectly because the emergence of competitive business clusters, which are beneficial for the Californian economy as a whole.

II. Purpose of the Report

Our objective in preparing this analysis is to assist interested parties in evaluating the economic impact of CIRM's grants. The approach used is based on the methodology previously submitted to CIRM included as Appendix I. This report estimates the likely generalized economic impact of those grants, as well as of the commitments that have been made so far until 2014. We also analyze the long run impact of CIRM's grants on the strengthening of two fast growing biopharmaceutical clusters in California.

We prepared this report at the request of CIRM, and were compensated for doing so. We were given complete control of the report's contents. The views expressed in the report are the product of independent and objective analysis, and do not necessarily reflect the views of either **BRG** or CIRM.

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[3] ECONOMIC IMPACT OF RESEARCH FUNDED BY THE CALIFORNIA INSTITUTE FOR REGENERATIVE MEDICINE: POLYCYTHEMIA VERA/PRIMARY MYELOFIBROSIS by Henry Miller.

III. One time impacts.

III.1 Direct, Indirect and Induced effects

The appropriate way to measure the one-time economic impacts of CIRM's grants is to recognize that their contributions go beyond direct disbursements. For example, the expenditure in a laboratory entails the acquisition of specialized equipment which in turn might require purchasing steel, which would necessitate its own inputs, and so on. Only the goods and services manufactured or sold in California should be included in this estimation because those acquired in another country, or another state create jobs in those locations but not in California, thus not constituting a benefit to California's economy.[4]

Regional Input Output models quantify inter industry linkages in a way that allow the ripple effects of the initial expenditure on the (regional) economy to be determined. Those effects (on employment, output, tax revenues or income) are classified as "direct," "indirect," or "induced".

- **Direct impacts** are directly generated by the initial expenditure.
- **Indirect effects** result from the expansion of supplier industries whose products are used by the industries producing the goods and services directly acquired (e.g., equipment, computers and electronic equipment or the buildings needed to house the new laboratories).
- **Induced effects** reflect the expansion of overall economic activity that results from the increased purchases of consumer goods and services by the workers considered in the previous paragraphs.[5]

The **IMPLAN** model and data base is such a modeling system. It combines industry surveys, data collected periodically by the U.S. Bureau of Economic

[4] Proposition 71 recognized this problem. One of its goals was that more than 50% of the goods and services used in CIRM-supported research would be purchased from California suppliers. CIRM grantees have been requested to make good faith efforts to obtain 50% or more of their goods and services from California suppliers. http://www.cirm.ca.gov/Grants_Management#California_supplier

[5] See the Appendix for further description of the model used.

Analysis and Input-Output benchmarks with other data to produce a balanced account format.[6] In this context, “balanced” accounts incorporate all goods and services transactions[7] as well as all income flows, tax revenues, subsidies and expenditures by all economic agents (consumers, investors and the government). In a broad sense, it is an all-encompassing snapshot of the economy. This model and data base has been used by over 1,500 public and private institutions and was customized by BRG to produce this report.[8]

CIRM’s grants during the period 2006-2014 (projected) can be classified into four broad categories:

- **Training:** Funds supporting skilled individuals who provide human capital to stem-cell research projects;
- **Research:** Funds contributing to supplies and other services necessary to conduct research;
- **Construction:** Funds for new construction or rehabilitation of facilities; and
- **Equipment:** Funds for the purchase of equipment to sustain research.

Apportionment to those four categories is shown in Table 1.[9] Close to 70% of CIRM’s grants have been for research and training, and the rest for facilities and equipment. Recipients of Major Facilities Grants, which amounted to $271.0 million, have obtained $561.8 million of matching funds for construction and an additional $322.5 million for faculty recruitment and other capital expenses.[10]

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[6] The guidelines for the construction of such a model can be found in **HANDBOOK OF INPUT-OUTPUT TABLE; COMPILATION AND ANALYSIS**. United Nations, New York, 1999.

[7] Including imports into the state and exports out of the state.

[8] Two other models are RIMS II (https://www.bea.gov/) and REMI (http://www.remi.com).

[9] CIRM staff assisted in identifying each grant’s appropriate category.

[10] CIRM requires that applicants pledge, at a minimum, 20 percent in matching funds. For our purposes, only funds from institutions outside of California or from foundations without a geographic bias should be considered, because resources reassigned to complement CIRM’s grants would have had an impact in their alternative use. We assume that the $561.8 million and $322.5 would not have otherwise been spent in California, so there is no off-set to consider.

Table 1
Classification of CIRM's Grants

Year	Training	Research	Construction	Equipment	Total
2006	$ 12.1	$ -	$ -	$ -	$ 12.1
2007	$ 9.2	$ 30.5	$ 1.0	$ -	$ 40.7
2008	$ 7.7	$ 35.8	$ 189.6	$ 21.9	$ 255.0
2009	$ 10.7	$ 69.7	$ 23.3	$ 33.1	$ 136.8
2010	$ 27.6	$ 172.7	$ 3.5	$ 2.1	$ 205.9
2011	$ 22.8	$ 147.7	$ 12.9	$ 2.6	$ 186.0
2012	$ 12.8	$ 118.0	$ 10.5	$ 1.6	$ 142.9
2013	$ 2.2	$ 57.5	$ -	$ -	$ 59.7
2014	$ -	$ 11.5	$ -	$ -	$ 11.5
Total	$ 105.2	$ 643.2	$ 240.8	$ 61.3	$ 1,050.6

Funds committed as of July 2010. All numbers in millions of dollars.

In keeping with the latest statistical information, our model assumes that most of the economic spillover from CIRM's funding stays in California because 98% of the intermediate inputs are produced in California in the case of the Training and Construction grants while in the case of Research the amount is 80%.[11] 62% of acquired Equipment comes from out of state, but that spending represents only 5.8% of the total.

III.2 Economic Impacts: Employment

The economic impacts of CIRM's grants on job creation for the period 2006-2014 are shown in Table 2. The disbursement of $1.9 billion[12] implies the creation of 24,654 Full-time Equivalents (FTE)[13] over the period 2006-2014: of those 10,730 are direct; 5,297 are indirect and the rest 8,627 are induced. The implicit

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[11] IMPLAN.

[12] $1.05 billion for grants plus matching funds of $561.8 million for construction and $322.5 million for recruitment.

[13] Full-time equivalent (FTE) is a way to measure a worker's involvement in a project. An FTE of 1.0 is equivalent to a worker being fully employed for a year. If the work year is defined as 2,080 hours, one worker occupying a paid full time job all year would consume one FTE. Two employees working for 1,040 hours each would consume one FTE between the two of them.

employment multiplier -2.3-[14] is within the range of expected values: the Washington Research Council estimated it to be 3.9 in the case of life sciences[15] and the Selig Center for Economic Growth to be 3.5 in Georgia. In the later case, the report attributed such a high number to the "above-average salaries in many life sciences occupations as well as relatively high degree of interaction between the life sciences and the state's overall economy."[16] As both of these studies measured the impact of the life sciences industry at large, they are not strictly comparable to the case of CIRM's specific grants.[17]

Table 2

Employment Impact of CIRM's Grants & Projected Grants

	GRANTS		MATCHING FUNDS		TOTALS	
Year	**Amount**	**Employment**	**Amount**	**Employment**	**Amount**	**Employment**
2006	$ 12.1	262	-	-	$ 12.1	262
2007	$ 40.7	529	$ 2.2	29	$ 42.9	558
2008	$ 255.0	2,950	$434.3	5,119	$689.3	8,069
2009	$ 136.8	1,639	$54.5	653	$191.3	2,292
2010	$ 205.9	2,777	$112.2	1,515	$318.1	4,292
2011	$ 186.0	2,655	$162.3	2,121	$348.3	4,776
2012	$ 142.9	1,790	$75.0	1,026	$217.9	2,816
2013	$ 59.7	825	$36.5	504	$ 96.2	1,329
2014	$ 11.5	159	$7.3	101	$ 18.8	260
Total	$ 1,050.6	13,586	$884.3	11,068	$1,935.1	24,654

Funds committed as of July 2010. FTEs. Dollar amounts are in millions

Indirect employment multipliers measure the number of jobs that result from the expansion of suppliers when direct jobs are created and they vary for different types of investments, as shown in table 3. For every job created directly by investments in Training, Research, Facilities or Equipment, 0.19, 0.50, 0.50 and 1.63 jobs are created indirectly, respectively. Indirect employment multipliers

[14] 24,654/10,730 = 2.3.
[15] Washington Research Council, "Washington Life Sciences Impact Study". November 2009.
[16] Kochut, B, Humphreys, J. "Shaping Infinity." 2009.
[17] It is possible that the average salary of a recipient of a CIRM grant is significantly higher than average because of their extraordinary level of specialization.

differ by type of grant because inter-industrial linkages are not the same: spending in Equipment has a multiplier almost 9 times larger than spending in Training.

Induced employment multipliers measure the number of jobs that result from the expansion of overall economic activity that results from increased purchases of consumer goods and services by both direct and indirect jobs. Induced employment multipliers also differ by type of investment reflecting variations in the income of the participants and thus their consumption patterns.

Table 3
Disaggregated Employment Multipliers

	TRAINING	RESEARCH	FACILITIES	EQUIPMENT	AVERAGE
Indirect Effect	0.19	0.50	0.50	1.63	0.49
Induced Effect	0.30	0.62	0.46	0.65	0.52
Total Effect	1.55	2.44	2.19	4.34	2.28

The "total effect" is NOT the sum of the "indirect and induced effects" because indirect jobs are measured as a proportion of direct jobs while induced jobs are a proportion of the sum of direct and indirect jobs.

III.3 Economic Impacts: Tax Revenues

The growth in economic activity brings about an increase in State and Local tax revenues. As can be seen in Table 4, $201.6 million dollars of tax revenues would accrue to California's governments: $157.2 million to the State and $44.4 to local governments.[18]

[18] Local government's main sources of revenue are the proceeds from the property tax and a share – estimated to be 9.5%- of the sales tax.

Table 4
Estimated Increase in State and Local Tax Revenues

	Sales	Property	Personal Income	Corporate Income	Other	Total
2006	$ 127,284	$ 101,404	$ 120,092	$ 21,078	$ 131,556	$ 501,414
2007	$ 1,069,418	$ 851,977	$ 1,284,754	$ 130,306	$ 1,100,819	$ 4,437,274
2008	$ 16,513,935	$13,156,223	$16,940,775	$2,688,248	$17,143,571	$ 66,442,752
2009	$ 4,812,522	$ 3,834,013	$ 5,233,614	$ 684,534	$ 4,937,575	$ 19,502,258
2010	$ 8,435,326	$ 6,720,204	$10,455,945	$ 962,757	$ 8,667,589	$ 35,241,821
2011	$ 9,452,710	$ 7,530,729	$11,219,817	$1,196,140	$ 9,742,890	$ 39,142,286
2012	$ 5,531,620	$ 4,406,899	$ 6,926,744	$ 619,939	$ 5,685,503	$ 23,170,705
2013	$ 2,628,204	$ 2,093,822	$ 3,311,376	$ 291,024	$ 2,700,940	$ 11,025,366
2014	$ 516,280	$ 411,307	$ 652,827	$ 56,762	$ 530,524	$ 2,167,700
Total	$ 49,087,299	$39,106,578	$56,145,944	$6,650,788	$50,640,967	$201,631,576

"Other state and local taxes" include: fines, fees, motor vehicle tax, and state employment taxes (payroll). Homeowners and businesses pay property taxes. Most organizations that receive CIRM funds directly are universities or non-profit research institutes that are exempt from paying property taxes.

IV. On-going Impacts

IV.1 Direct On-going Impacts

In contradistinction to one time impacts, on-going impacts result from economic structural changes that take place either directly when CIRM sponsored research results in therapies that lengthen the life expectancy of patients and allow them to rejoin the labor force or, indirectly, when CIRM's grants promote economic clusters. Each and every discovery of a successful therapy has an enormous impact on the life of afflicted individuals. In contrast, its economic impact is a function of the prevalence of the disease, the cost of conventional treatment, decreases in morbidity and mortality and the effect of the disease on patient productivitiy. In the case of cures for orphan diseases,[19] the overall economic impact is limited precisely because the number of beneficiaries is limited.

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[19] By orphan disease we mean one that, according to US criteria, affects fewer than 200,000 persons.

Calculations of these benefits are outside of the scope of this report but are considered in the accompanying one.[20]

The economic impact of successful therapies for widespread diseases can entail structural adjustments in labor force participation and consumption patterns with macroeconomic impacts. A recent article estimates that "a permanent 1 percent reduction in mortality from cancer" - one of CIRM's targets - has a present value of "nearly $500 billion, whereas a cure (if one is feasible) would be worth about $50 trillion".[21] Those benefits come from extending life, raising its quality and from the increased income derived from returning to work. It should be further noted that the distribution of such benefits is likely to differ by gender and age group.

IV.2 Indirect On-going Impacts

Indirect on-going economic impacts stem from the fact that CIRM grants are putting California in a position of leadership in stem cell research leading to the recruitment of world-class scientists and the establishment of a biological science and biotechnology infrastructure that is likely to further attract venture capital investment in research and start-up firms. These benefits would result from three phenomena:

1. Additional grants and donations that would fund research;
2. Venture capital that would invest in biotechnology start-ups;
3. New treatment facilities that would serve patients travelling to California as research leads to successful therapies.

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[20] ECONOMIC IMPACT OF RESEARCH FUNDED BY THE CALIFORNIA INSTITUTE FOR REGENERATIVE MEDICINE: POLYCYTHEMIA VERA/PRIMARY MYELOFIBROSIS by Henry Miller.

[21] Kevin M. Murphy and Robert H. Topel, *The Value of Health and Longevity*, Journal of Political Economy, 2006, vol. 114, no. 5.

The importance of agglomeration economies has been recognized since the late XIXth century by one of the founders of economics, Alfred Marshall, and have become preeminent through the work of Paul Krugman[22] and Michael Porter who popularized the notion of clusters as geographic concentrations of interconnected companies in a particular industrial sector. Michael Porter has shown that firms located in regions with strong clusters foster new business formation and start-up employment. Strong clusters also influence location decisions of multi-establishment firms as they will want to locate new plants close to those clusters to take advantage of the positive externalities they create. Finally, strong clusters contribute to the survival of start-up firms.[23] In subsequent work, he showed that industries participating in a strong cluster those with a large presence of related industries register higher employment growth, as well as higher growth of wages, number of establishments, and patenting. The beneficial effects of clusters extend to other related clusters in the same region and in adjacent regions in addition to other industries, including new ones. Importantly, there is evidence that new industries emerge where there is a strong cluster environment.[24]

The Cluster Mapping Project at Harvard[25] has identified two fast growing Biopharmaceutical traded-clusters in the San Jose-San Francisco-Oakland and San Diego-Carlsbad-San Marcos areas which created jobs 33 and 17 times faster than expected during the period 1998-2007. As seen in the following map, CIRM grants have been given to institutions that concentrate in these areas along with another concentration in the Los Angeles area.

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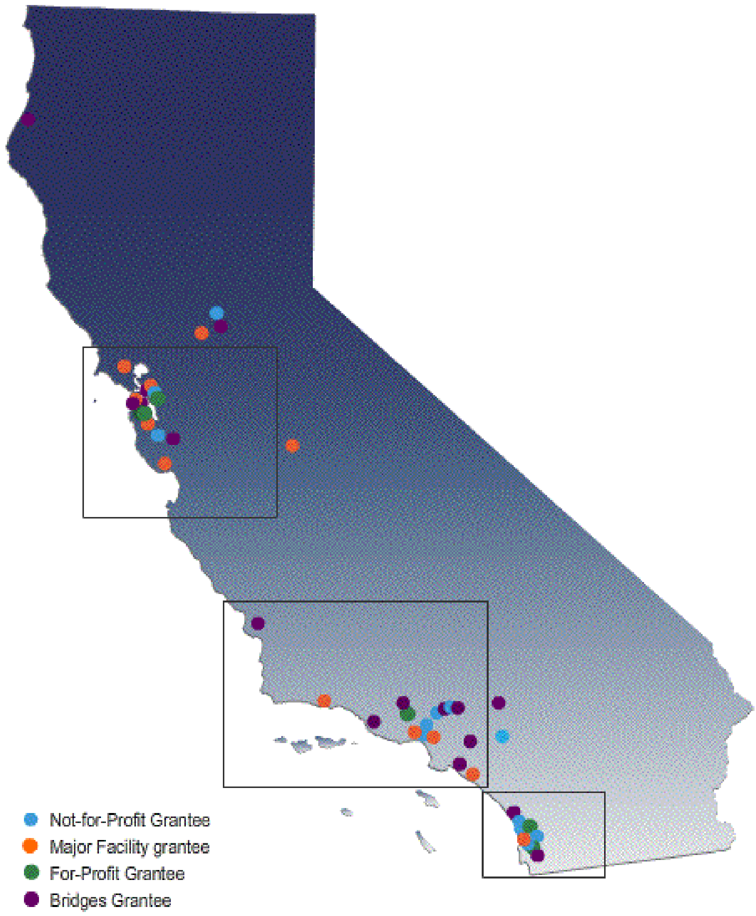
[22] Nobel Prize in Economics, 2008.

[23] Mercedes Delgado, Michael E. Porter, Scott Stern, *Clusters and Entrepeneurship* Journal of Economic Geography, May 2010.

[24] Mercedes Delgado, Michael E. Porter, Scott Stern *Clusters, Convergence, and Economic Performance*, August 2010.

[25] Traded industries sell products and services across economic areas. They pay higher wages, have far higher rates of innovation and influence local wages. http://data.isc.hbs.edu/isc/

Map of CIRM-Funded Institutions



http://www.cirm.ca.gov/CaliforniaGranteeMap

The recipients of Major Facilities Grants have obtained $3.26 of matching funds for every dollar received from CIRM. Of that $3.25, $2.07 is being used to construct world-class facilities able to accommodate 2,000 scientists. The remaining $1.19 is being used primarily to recruit new researchers to these facilities. The magnitude and location of these facilities suggest that the existing clusters will be strengthened and that a third may appear in the L.A. area. The indirect, ongoing impacts of CIRM's grants are too recent to be measurable but, as time goes on, virtuous cycles are likely to develop with measureable impacts in employment, wages, number of establishments and patents granted. The extent and health of the clusters will be measurable by using County Business Pattern data by Standard Industrial Classification (SIC) Code by County[26].

Inasmuch as the research financed by CIRM leads to new therapies, it is likely that patients will travel to California to be treated. New treatment facilities are thus likely to be established as they were in Rochester Minnesota (the Mayo clinic employs 32,000 [27]) and in Houston (according to the BLS it has more than more than 178,000 life science and health care professionals). Recent evidence indicates that, over the last decade, Minnesota and Texas have been losing ground to Florida and California in these sectors, further suggesting that the biopharmaceutical sector could become a fast growing source for well paying jobs.[28]

V. Conclusion

CIRM grants, including their matching funds, have both **one-time economic impacts** -benefits that last while the grants are being disbursed- and **on-going impacts** that persist and result from induced structural changes. Building facilities and acquiring equipment have construction impacts while the projects are being built and end when the projects are completed. On-going impacts accrue directly to patients that have entered remission because of the increases in life expectancy and personal income for the patients and indirectly because of the emergence of clusters.

We find that the $1.1 billion in CIRM grants along with $884.3 million in matching funds will have the following effects during the period 2006-2014:

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[26] The recent purchase of TargeGen, a developer of kinase inhibitors in the San Diego area, by Sanofi-Aventis for up to $560 million is due in part to research supported by CIRM.

[27] http://www.raedi.org/economic_overview.html#economy

[28] Bewteen 1998 and 2007, job creation in this sector in California has been growing ten times faster than expected while it was negative in Minnesota and Texas. http://data.isc.hbs.edu/isc/

- The creation of 24,654 FTEs, many of which are well paying;
- Payment of $157.2 million dollars in tax revenues to the State of California and $44.4 million to local governments.

CIRM research grants and new facilities will increase the number of stem cell scientisits in California and are likely to foster the growth of two biopharmaceutical traded-clusters that have been identified in the San Jose-San Francisco-Oakland and San Diego-Carlsbad-San Marcos areas. They also may spwan another trade cluster in the Los Angeles area

APPENDIX 1: STUDY METHODOLOGY

1. OVERVIEW

We prepared this Appendix to describe the method used to measure the economic impact of CIRM's grants. When CIRM funds research to develop a treatment for a specific disease, those funds pay salaries and buy goods and services which create a flow of funds through both California's and the national economy. Traditional economic impact measurement calculates the value of these funds. CIRM expenditures, however, have an additional impact: they may cure the condition and/or substantially affect health care costs. Changes in treatment and incidence affect the pattern of expenditures that are currently made by patients and their health care providers. Remission modifies the labor force participation of the patient. A comprehensive measure of economic impact must include this change in health care expenditures and the increase in income that results from a higher labor force participation as well as the broader economic impact of adding funds to the economy.

2. PRIOR RESEARCH

The economic benefits of stem cell research have been studied to guide policy decisions. One of the studies, conducted by The Analysis Group, addressed the economic impact of CIRM's activities, although on a less specific basis than the current report.

2.1 California - Prior Studies of the Economic Impact of Stem Cell Research

Before CIRM's creation, two studies regarding its potential economic benefit were published. The first, "Analysis of the Financial Impact on the California State Budget of the Proposed California Institute of Regenerative Medicine" - published in late 2003 - focused on the potential economic impact of the issuance of bonds if Proposition 71 was approved as proposed. The second report, "Economic Impact Analysis: Proposition 71 California Stem Cell Research and Cures Initiative," took a broader approach to estimating economic impact by providing estimates through 2039. While neither report incorporates specific healthcare savings, the second indicated that California could save somewhere between $3.4 and 6.9 billion annually in State funding and its citizens could save $9.2 to 18.4 billion annually from reduced healthcare costs related to six major conditions.

Analysis Group, in collaboration with Dr. Laurence Baker, conducted an economic impact analysis for CIRM shortly after grant making began in 2008 to provide an initial "assess[ment of] the economic implications of this funding for California".[29] The conclusions show that CIRM's grant making significantly impacts California in ways that include:

- Creating a need for researchers who will assist senior researchers that are recruited to the state as a result of CIRM's grants,
- Stimulating matching funds from both institutional and private donors,
- Motivating stem-cell related companies to increase operations, and
- Creating international collaborations.

This study's methodology was limited by the scarcity of data because it was carried out shortly after the first grants were allocated. In light of the limited data, the study discusses economic benefit as a return on investment (ROI) and indicates that there is considerable potential for economic benefits of stem cell research, but that the "largest benefit to the State from CIRM funding is clearly a potential for future healthcare savings." Methods to measure savings were not undertaken.

[29] Baker L, Deal B. "CIRM – Interim Economic Impact Review." September 10, 2008.

These studies are similar to studies conducted in other states but none of them include a clear description of methods used or develop measures of health care cost savings using a methodology similar to that described in this report.

2.2 Michigan Stem Cell Economics Study

Goodman and Berger identified both "humanitarian and economic costs" as a result of a prohibitive law against stem cell research.[30] They concluded that more than 770,000 Michigan residents are diagnosed with one of seven illnesses that could benefit from stem cell therapies:

- Type 1 Diabetes and Latent Autoimmune Diabetes in Adults,
- Parkinson's Disease,
- Spinal Cord Injury,
- Acute Myocardial Infarction,
- Stroke,
- Alzheimer's Disease, and
- Amyotrophic Lateral Sclerosis (ALS).

Treatment costs for these diseases in Michigan are almost $8 billion annually. Although they did not measure potential savings specifically, the researchers concluded that as little as a one percent savings would generate overall annual health care cost savings of $80 million. In addition, the study also indicated that Michigan's biotech industry has approximately 50,000 workers. The researchers concluded that each one percent additional investment in stem cell research would create 443 new jobs.[31]

Although the Michigan study was intended to be comprehensive, little information was offered on methods used other than reference to the use of "economic evaluation" and cost-benefit analysis.

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[30] Goodman AC, Berger S. "Michigan Stem Cell Economics Study." Sept 2008.
[31] Ibid.

2.3 Missouri State Auditor's Office

The Missouri State Auditor's Office compiled comments regarding a proposed stem cell initiative in 2009.[32] These comments included the following measures of economic impact:

- The Department of Economic Development notes that restricting stem cell research "could have a significant negative impact on technology and research-related business growth."[33]
- The City of St. Louis indicates that restricting stem cell research could reduce their revenues by approximately $14.3 million. The City ranks twelfth in terms of NIH funding, which could be jeopardized as biotech firms find states with fewer research restrictions.
- Both biotech and venture capital firms agreed that any restriction on stem cell research would reduce their ability to do research, expand their business and support new initiatives.

In addition, a report filed with the Federal Reserve Bank of St. Louis indicated considerable benefits to the State from stem cell research.[34] The report's author identified 286,000 Missouri residents living with one of five diseases that may benefit from stem cell research. The treatment costs for these five diseases were $2.7 billion in 2004. State government was responsible for $299 million of these costs. As a result, it was estimated that a potential treatment for one of the diseases could save $150 million annually and $7.3 billion over 25 years.[35] As in the case of the Michigan study, there is little information on methods used to arrive at conclusions presented in the Missouri studies.

2.4 New Jersey Economic Impact of Stem Cell Research

When New Jersey established a stem cell research initiative, the Governor required completion of an economic benefit analysis of the program, which included $270 million in capital expenditures and $450 million in grant funding.

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[32] Missouri State Auditor's Office. "Fiscal Note 09-38." July 2009.
[33] Ibid.
[34] Schmidt J. "Economic Benefits of Missouri Stem Cell Research." *Federal Reserve Bank of St. Louis.* 2009
[35] Ibid.

Economic benefits were identified in a report prepared by Seneca and Irving dated October 2007.[36] They identify the following economic benefits of proposed capital expenditures:

- 7,766 direct and in-direct job-years,
- $19.7 million additional state tax revenues annually, and
- $21.8 million additional local tax revenues annually.

Economic benefits arising from the research funding proposed in the initiative included:

- 22,062 direct and in-direct job-years,
- $56.5 million additional state tax revenues annually, and
- $62.3 million additional local tax revenues annually.

In addition to the benefits listed, Seneca and Irving concluded that New Jersey could potentially benefit from annual healthcare savings of $11.3 billion, $813 million arising from lost work days annually and $60.7 billion in annual savings generated by preventing premature death.[37] These numbers are larger than those in the present study on a prorated basis. However, as in the case of the Michigan and Missouri studies, there is little information about the methods and assumptions used to arrive at conclusions presented in the New Jersey study.

2.5 Texas Study of the Economic Potential of Stem Cell Research

Weinstein and Clower concluded that Texas supports a proportionally smaller amount of the national biotech industry than expected based on the State's population and share of national GDP. This study models two scenarios illustrating potential benefits over a period of seven years if the biotech industry grew with specific emphasis on stem cell research.

[36] Seneca JJ, Irving W. "Updated Economic Benefits of the New Jersey Stem Cell Capital Projects and Research Bond Acts." October 2007.
[37] Ibidem.

- Scenario 1 assumes Texas continues to retain its current share of the national biotech industry. Doing so will contribute $42.5 billion to the state economic activity, including 112,000 jobs.
- Scenario 2 assumes Texas' share of the national biotech industry doubles. If this were the case, the industry would contribute $87.4 billion to the state economic activity and 230,000 jobs.[38]

As in the case of studies completed in other states, the methodology used to measure economic impact did not include measurement of health care cost savings.

2.6 Estimating the Economic Benefits from Medical Research in the UK.[39]

The Academy of Medical Sciences, the Medical Research Council and the Wellcome Trust commissioned a one-year study to compare the economic benefits accruing to the UK of medical research with its cost. The report estimates that "the total health … gains to public/charitable CVD research in the UK 1975–1992 give an Internal Rate of Return[40] of around 9%". In the case of mental health research the equivalent metric is 7% for the same period. According to the authors, such estimates "need to be treated with extreme caution" because of the "considerable uncertainties" in both methods and data. Since "the estimated rates of return are very sensitive to the assumed lag between the years when the research expenditure occurs and the years when the ultimate health benefit arises, and to the proportion of the benefit attributable to UK research as opposed to world research as a whole …all quantitative results are no more than rough approximations".

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[38] Weinstein BL, Clower TL. "The Economic Development Potential of Stem Cell Research in Texas." March 2007.

[39] http://www.wellcome.ac.uk/stellent/groups/corporatesite/@sitestudioobjects/documents/web_document/wtx052110.pdf

[40] The internal rate of return (IRR) is a rate of return used in capital budgeting which measures the profitability of investments.

3. METHOD TO MEASURE ECONOMIC IMPACT.

Current methods to measure economic impacts trace their ancestry to Francois Quesnay's[41] *Tableau Économique* a descriptive framework that starts from the fact that every sale is a purchase and thus economic activity can be thought of as a circular flow among different economic agents. Wassily Leontief[42] published the first US Input-Output tables in 1936 and Richard Stone generalized the method to include national income accounts through the social accounting matrix.[43]

3.1 A simple Input-Output Model

The beginning point is to consider an economy as constituted by households and producers. The former make two types of decisions so as to maximize their utility: they choose the amounts of goods and services they buy and they decide how much labor and capital services to sell to finance such purchases. Like the firms, they take the prices of the goods that they buy and the wage they receive when they work as fixed. Producers choose the amounts of goods and services they buy (including hiring workers and using capital) to maximize their profits.

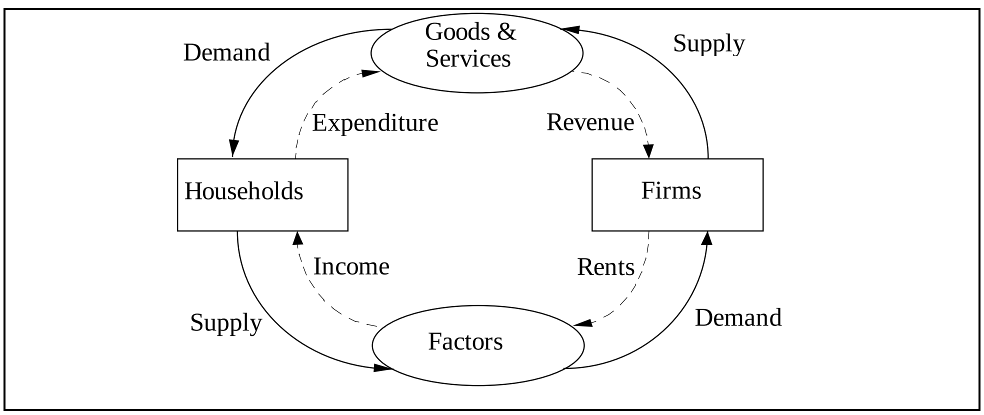
Thus, firms and households relate to each other through two markets: factor markets and goods-and-services markets. Firms sell goods and services to households on the goods-and-services markets. Households sell labor and capital services to firms on the factor markets. There is a price in each of these markets. There is a price for labor, called the "wage," and a price for capital services, called the "rental rate." Equilibrium in a market means that the quantity supplied (which is a function of price) is equal to the quantity demanded (which is also a function of price) in that market.

[41] French economist of the Physiocratic School (1694–1774).
[42] For his work in this field, he won the Noble Prize in 1973.
[43] He too won a Nobel Prize but in 1984.

These relationships are shown in Figure 3-1, sometimes called a “circular-flow diagram.” The outer sets of flows, shown as solid lines, are the flows of “real” items, goods, services, labor, and capital. The inner sets of flows, shown as broken lines, are the monetary flows. Firms supply goods and services to the goods-and-services market in return for revenues that they receive from the goods-and-services markets. Firms demand capital and labor from the factor markets and in return pay wages and rents to the factor markets.

Households buy goods and services from the goods-and-services markets and give up their expenditure as compensation. They sell capital and labor services on the factor markets and receive income in exchange.

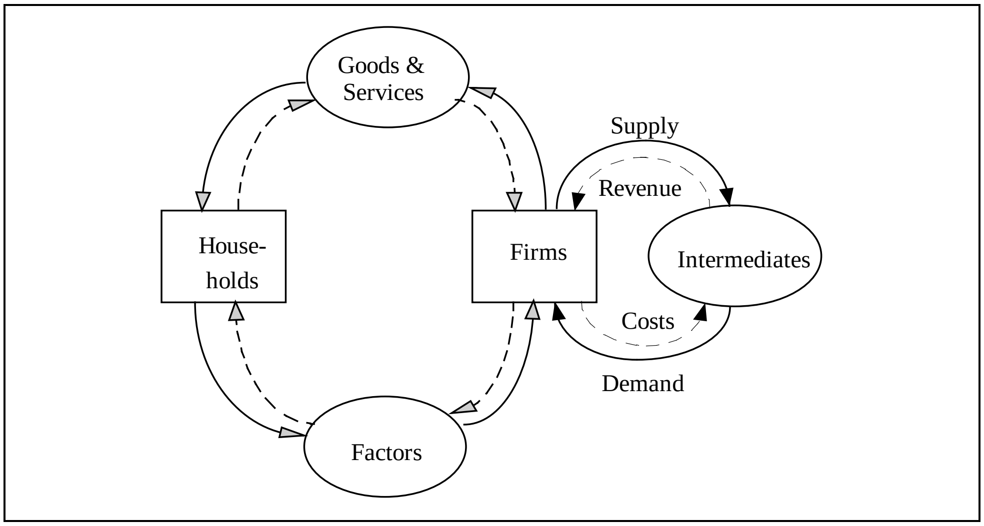
Figure 3-1.The Basic Circular-Flow Diagram



3.2 Intermediate Goods

The economy is far more complex than the basic circular flow shown in the figure above. There are not only final goods-and-services markets but also intermediate goods markets in which firms sell to firms. A typical example of this would be chemicals sold to pharmaceutical firms. The final output of the chemical industry is said to be an intermediate good in the pharmaceutical industry. This type of market is demonstrated in Figure 3-2. Here, part of the supply of a firm (chemical industry in the example) is not sold to households but rather to another firm in exchange for revenue. From the other firm's point of view, it buys an input to production from a firm rather than from a household. The expense of buying the input is a cost of production.

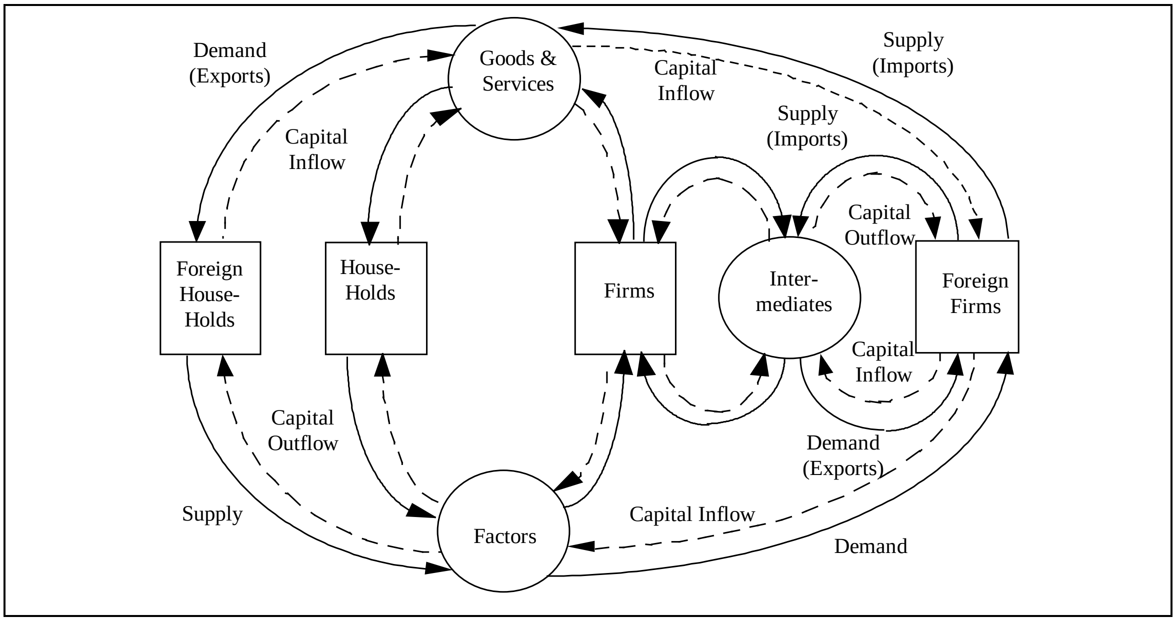
Figure 3-2. The Circular-Flow Diagram with Intermediate Goods



3.3 Rest of the World.

Economies are open, which means that goods, services, labor, and capital in one state are readily traded with neighboring states and countries. In our model, all producers and households outside California are modeled in one group called "Rest of World". No distinction is made between the rest of the US and foreign countries. California interacts with "foreign" consumers and "foreign" producers. Taking the producers first, Figure 3-3 shows that the producers sell goods on the (final) goods-and-services markets and on the intermediate markets, i.e., they sell goods to both households and firms. The model takes these goods as being imperfect substitutes for the goods made in California.

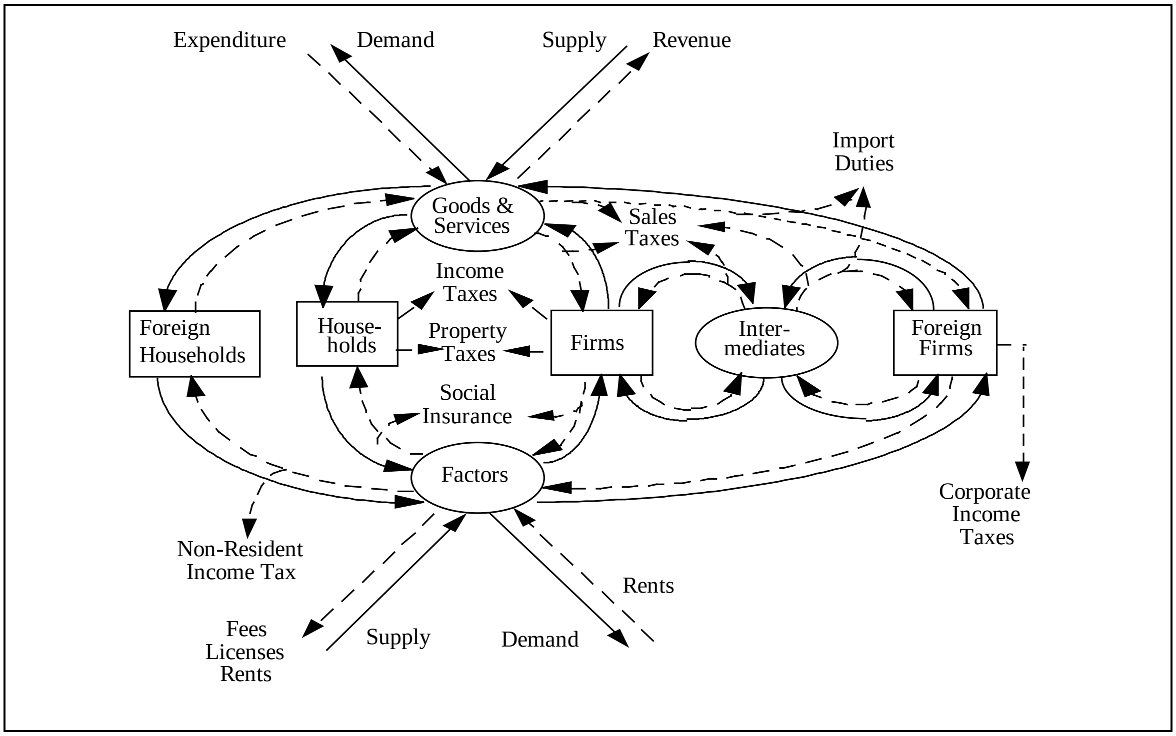
Figure 3-3. The Circular-Flow Diagram with Intermediate Goods and Trade



3.4 Government.

Finally, we consider government. Combining the taxing and spending effects of the three levels of government (federal, state, and local) gives the additional flows in Figure 3-4. Beginning at the top, the figure shows that government buys goods and services and gives up expenditures. It supplies goods and services for which it may or may not receive revenue. Government also supplies factors of production, such as roads and education (bottom). The middle section of the diagram shows the myriad of ways in which government raises revenue through taxation.

Figure 3-4. The Complete Circular-Flow Diagram



3.5 The Model.

The Model used was developed by IMPLAN.[44] It considers 440 industrial sectors; 9 types of households (differentiated by income levels); 4 types of government spending (Federal: Defense& Non-Defense; State & Local Government: Education & Non-Education); 22 types of taxes and transfers (15 at the State and Local level including sales and property; 7 at the Federal level including personal income tax, corporate income tax and social security contributions); and 4 types of investment flows (Capital Formation; Inventory Additions; and 2 types of Government investment). It combines classical input-output analysis, region specific Social Accounting Matrices and Multiplier model.

The data are from 2008 and combine many sources. Among the most important ones: Bureau of Economic Analysis (BEA); Covered Employment and Wages

[44] http://implan.com/V3/Index.php

(CEW); BEA REIS Data; BEA Output Data; National Income & Product Accounts; and Consumer Expenditure Survey.

Data on CIRM expenditures for specific research projects were combined with this model to yield the measure of overall economic impact.