Projecting Economic Benefits:

Expansion Pathways

for

The University of Connecticut Health Center

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Prepared by:

Prof. Fred V. Carstensen, Director

Peter Gunther, Senior Research Fellow

Connecticut Center for Economic Analysis
341 Mansfield Road
University of Connecticut
Storrs, CT

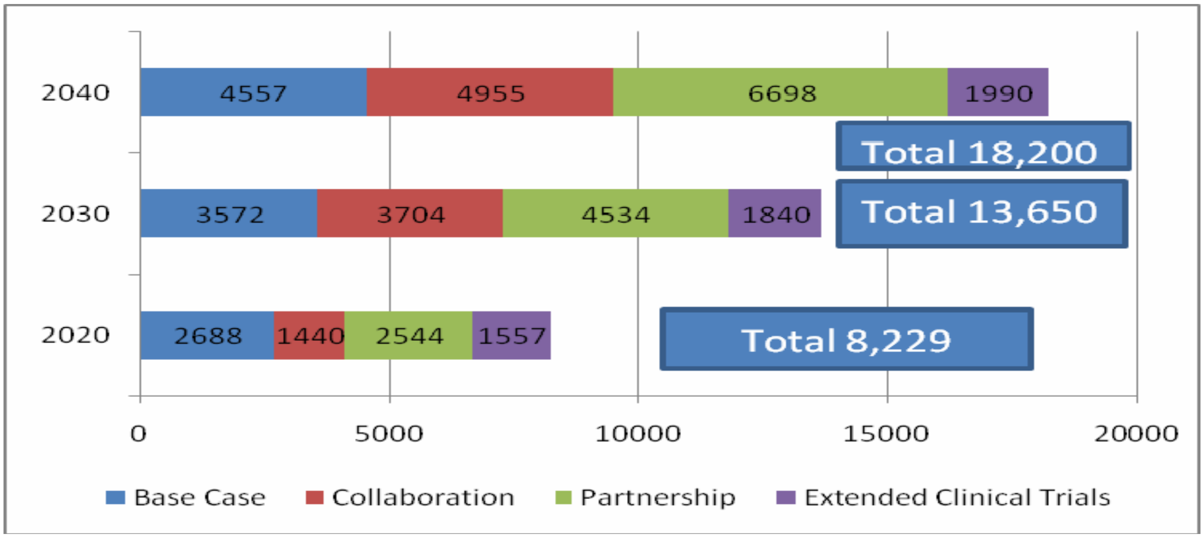
Executive Summary

The Connecticut Center for Economic Analysis of the University of Connecticut has prepared an analysis of the economic benefits that would flow from the expansion of the Schools of Medicine and Dentistry and construction of a new John Dempsey Hospital. The study considers four expansion pathways: 1) a baseline case with just the expanded Schools and new hospital; 2) development of the Connecticut Health Collaborative; 3) completion of the University Hospital Partnership with Hartford Hospital; 4) becoming a super site for clinical trials. Each successive pathway builds off the previous one; their economic benefits are thus additive. The charts below thus show the contribution of each pathway to job creation, income growth, and enhanced tax revenue.

The analysis relies on the dynamic REMI model of the Connecticut economy to project economic benefits; REMI, built from the U.S. Department of Commerce national input-output matrix, is nationally recognized for projecting economic impacts and is the basis on which the Connecticut Department of Economic and Community Development evaluates projects. This study looks at the growth in jobs and income out to 2040, and new tax revenue flowing to the state out to 2035, when capital bonds would be retired. The last two pathways—which achieve the fullest development of life sciences and generate the largest economic benefits—deliver the most impressive payoffs to Connecticut's citizens in new jobs and increased income and to state government in terms of tax revenue. Evaluated as investments, they deliver strikingly attractive returns.

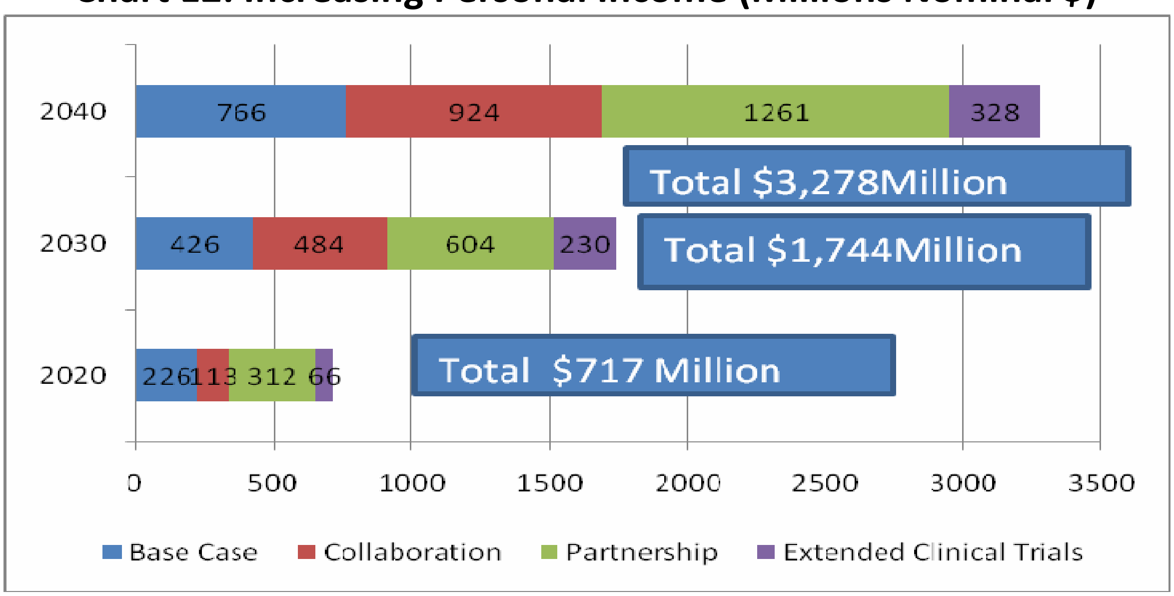
JOBS: Development of University Hospital joined with the Connecticut Health Collaborative quickly generates 8,229 new jobs by 2020; they then grow to 18,200 by 2040.

Chart E1: Creating New Jobs



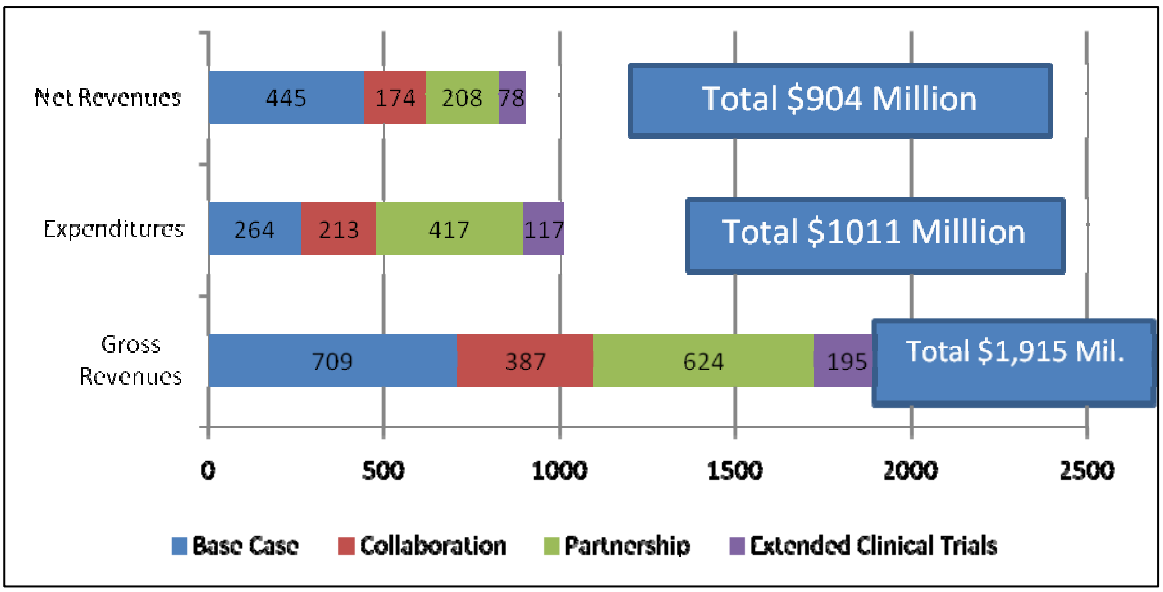
INCOME: Full development of the potential of the University Hospital with the Connecticut Health Collaborative generates $717 million in new personal income by 2020, nearly *$3.3 billion annually* by 2040 (nominal dollars, including inflation).

Chart E2: Increasing Personal Income (Millions Nominal $)



FISCAL BENEFITS: Development of University Hospital with the Connecticut Health Collaborative by 2035 (the assumed end-date for capital bonds) generates aggregate new tax revenue (discounted to present value) for the state approaching *$2 billion*; net of expenses for expanded government services, revenues exceed *$900 million*—a hefty return on an investment of $475 million.

Chart E3: Revenue Generation (Present value in Millions $)



Expansion of the University of Connecticut Schools of Medicine and Dentistry, the construction of a new John Dempsey Hospital, development of a broad clinical collaboration among area hospitals, and the partnership with Hartford Hospital offer a unique opportunity to move the UCHC into the top ranks of academic medical research centers, delivering state-of-the-art medical services to state residents, enhancing quality of life and longevity. Equally important, this initiative creates a major economic driver for Connecticut, generating thousands to new jobs, increased income, expanded state output, and significant net new tax revenues. This is the moment when Connecticut can redefine its future path, creating a more prosperous, healthy future.

The University of Connecticut Health Center: Economic Benefits of Alternative Expansion Pathways

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University of Connecticut Health Center:

Assessing the Economic Benefits

of Potential Expansion Pathways

Introduction

The decision to expand the University of Connecticut's Schools of Medicine and School of Dental Medicine follows from a critical issue. Connecticut must confront the challenge of replacing large numbers of practitioners who are reaching retirement, along with the rest of the baby-boom generation. Simultaneously, the surge in the elderly population will increase the demands on the medical system.[1] A complicating factor in replacing current practitioners by junior medical staff is legal: the rules no longer permit interns and residents to work Draconian shifts of up to 32 hours; they may legally work only up to 16 hours per day. In addition, younger doctors, particularly women who now constitute nearly half the medical graduates, are less willing to work the long hours put in by the previous generation. These factors shrink the supply of doctors available in any given hour of the day, increasing the need to expand the pipeline training new doctors and other medical professionals.

Nationally, the American Medical Association (AMA) reports that the United States is falling short of the AMA's target of expanding medical school enrollments by 30% by 2015.[2] The planned expansion of the University's Medical and Dental Schools responds to this critical need. Moreover, the Schools play a central role in life-long learning of current practitioners through placement of interns, on-going educational opportunities, and community interactions.

The motivation for considering alternative expansion pathways for the University Health Center is to facilitate evaluation of the comparative potential outcomes and consider which builds the strongest foundation for attracting leading medical and dental researchers to the faculty, together

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[1] Julie Robinson, Cynthia Gruman, Leslie Curry et al, **Connecticut Long-Term Care Need Assessment Part II: Rebalancing Long-Term Care Systems in Connecticut**, UCHC, June 2007. The only in-migrant category currently is women over 85; the current population projections anticipate the 65 and over population to grow by more than 60% by 2030. See http://ctsdc.uconn.edu/Projections.html

[2] AMA, **An Environmental Analysis Report Trends 200**8, p. 25

"The 2007 entering class to U.S. medical schools was the largest in the nation's history.3 In June 2008, the number of first-year enrollees totaled almost 17,800 students, a 2.3 percent increase over 2006.

• An annual survey on medical school expansion, released in 2007 by the Association of American Medical Colleges (AAMC), indicated that first-year enrollment in U.S. medical schools is estimated to grow 21 percent (3,400 students per year) by the year 2012 to 19,900 students.

• The total planned first-year enrollment for the 2012–2013 academic year is 19,909 at both existing and new medical schools. This is an increase of 3,421 (20.8 percent) in first-year enrollment compared with the total baseline first-year enrollment for the 2002–2003 academic year. The targeted 30 percent growth in first-year enrollment will be reached by 2017 but will be two years short of the AAMC's goal."

with outstanding students, thus up-grading medical and dental training—by implication the entire Connecticut medical system—and for significantly expanding research activities, including advanced clinical trials. This study evaluates the economic benefits to Connecticut that would flow from four alternative expansion scenarios; the first three build on conservative assumptions about both costs and benefits:

1) In conjunction with expanded enrollment in both the School of Medicine and the School of Dentistry, replacement of John Dempsey Hospital (JDH);

2) Expanded collaboration among central Connecticut hospitals to quality the "Collaboration" –inclusive of UCHC—for a Clinical and Transitions Services Award to provide more leadership in carrying out Phase 2 and Phase 3 drug trials;

3) A "Partnership" between the UCHC and Harford Hospital which leverages an additional $300 million dollar investment by the Hartford and the development of shared and advanced information systems, in addition to the new JDH;

4) All of the above, together with NIH accelerated clinical trial accreditation, and research awards that would bring UCHC into the top twenty (20) university medical research centers.

Each scenario generates specific expanded medical services that enhance the quality of life and longevity of Connecticut citizens. The analysis below lays out each alternative as currently configured, including likely synergies, benefits, and costs; the analysis then projects the economic benefits out to 2040 and fiscal benefits to 2035.

Methodology

To estimate the economic and fiscal impact of the planned expansion of UCHC and each of the scenarios, CCEA uses the REMI model, a dynamic input-output model of Connecticut's economy that permits projecting the consequences of projects out over a thirty-year time horizon. To project the economic value to Connecticut's economy of the four scenarios for expansion, the analysis evaluates the impacts of construction, operations, and improved health outcomes; the study reports the results in terms of increases in gross state output, personal income, job creation, population growth, and fiscal impacts. See Appendix II for a full description of the REMI model.

Scenario I: Replacement and Expansion of John Dempsey Hospital and the Schools of Medicine and Dentistry

The CASE Tripp Umbrack Report makes clear that the John Dempsey Hospital (JDH) is too small to support the requirements for the Medical School, provides poor privacy for surgical and emergency patients, is excessively noisy in-patient levels, has sub-standard operating rooms, lacks the building envelop required to store and to care for equipment properly, and has electrical and mechanical systems that are working at their maximum capacity and often already beyond their life expectancy. In particular, JDH cannot expand its heating, ventilation, and air conditioning (HVAC) systems and currently must use them inappropriately, resulting in excessive energy consumption.[3] In short, JDH provides a poor environment for delivering health services, discourages rather than attracts quality faculty, and is costly to operate.

The proposed replacement hospital would be built adjacent to the current building; it would expand licensed and staffed beds from 224 to 250, afford patient privacy, offer modern operating theatres, and rely on rational HVAC systems. Conversion of the existing building to offices and research facilities for faculty and students, and to house equipment needed to support on-line information technology, is central to recruiting and retaining new high-caliber faculty necessary for expansion of the entering Medical School classes from 80[4] to 100 annually and the entering School of Dentistry classes from 40 to 60. Commensurate with this expansion of enrollment, the analysis includes the associated expansion of nursing and complementary medical professionals. Because both the medical and dental programs run for four years, once all classes have ramped up to capacity, aggregate enrollment at the Medical and Dentistry schools will each have grown by 80 students.

To develop the analysis of the economic impacts of these developments, this study considers three distinction elements:

- Construction;
- Operational services and related activities;
- Resulting health benefits.

The impacts depend on the timing of construction, ramping up to full operation, and the health benefits that flow from those operations. For the purposes of this analysis, the study assumes that planning for construction begins in July, 2009, with completion of the new hospital by December, 2015. The hospital then becomes fully operational. The expansion of the Schools of Medicine and Dentistry begins in 2016 and finishes in 2019.

Construction the new JDH

"Construction" includes design through start-up of operations. The study assumes that detailed planning for construction of the $475 million JDH replacement begins in July 2009, with completion by December 2015. Table 1 lays out the annual expenditures as currently projected. The analysis allocates equipment costs to the last two years of construction, including retrofitting the existing hospital building. The projected equipment costs are conservative, based on the recent upgrade of a single cardiac operating room at St Paul's Hospital in Vancouver BC for a cost of $3.8 million.[5]

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[3] The Connecticut Academy of Science and Engineering, A Needs-Based Analysis of the University of Connecticut Health Center Facilities Plan, March 2008. p. xii.

[4] This year 85, as opposed to the historical 80, students were accepted into first year.

[5]Surgeons and cardiologists at the Providence Heart + Lung Institute at St. Paul's Hospital have a new $3.8-million state-of-the-art cardiac operating room to accommodate the growing number of breakthrough heart

Table 1: Construction Expenditures (1000s 2008$)

	2010	2011	2012	2013	2014	2015	Total
JDH Replacement Hospital							
Authorization to Proceed							
CON Documents & Submission							
Architect Selection and Contract							
CON Documents/Schematic Design	3,220.000	780.000					4,000
CON Submission & Approval							
Design Completion							
Design Development		2,100.000	6,900.000				9,000
Construction Documents			6,709.091	5,290.909			12,000
Procurement & Construction							
Finalize GMP Contract with Const. Manager							
Construction (including IT costs. Contingency, etc.)				106,227.273	225,409.091	48,363.636	380,000
Construction Administration/Misc Costs				6,988.636	14,829.546	3,181.818	25,000
Equipment Procurement					7,250.000	2,750.000	10,000
Construction Closeout/ Equipment Installation						35,000.000	35,000
Total	3,220.000	2,880.000	13,609.091	118,506.818	247,488.637	89,295.454	475,000

Operations: the School of Medicine and John Dempsey Hospital

This study assumes that full operations at the new hospital begin January 2016, with new teaching faculty coming on board in-line with growth in enrollments of the Medical School. The aggregate benefits come from the expanded faculty, staff, and students, and from improved health outcomes.

Because the specific areas of specialization are still in process of being developed, this analysis extrapolates expansion in staffing on the basis of current averages of hospitals belonging to the Connecticut Hospital Association (CHA). While the 29 member Association membership includes all the main teaching hospitals, [6] it also encompasses other hospitals, so CHA averages likely understate direct employment impacts. Actual employment and related cost projections will depend on the specifics of the choices made in expanded services. [7] This analysis relies on a recent CCEA study[8] for wages, salaries, and security costs at JDH, adjusted from 2006 to 2008 at rates commensurate with those of Connecticut hospitals.

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procedures being pioneered at the facility. See http://www.providencehealthcare.org/NewCardiacOperatingRoom.htm

[6] http://www.cthosp.org/

[7] "… there are some standards in the industry around the differences between critical care, intermediate care, med-surgical, and then specialty areas, like OR, ED, psych, etc. Typically you will see 1:2 (RN: patient) ratios in critical care areas; 1:3-4 in intermediate care areas; 1:5-7 or so in general medical-surgical units for budget planning purposes; again, a lot has to do with the type of unit that you are dealing with, (e.g., we have a Level III NICU with a transport service; we admit babies are very young gestational ages; this may not "compare" with other Level III NICU's; we have a "mixed" ICU, which means that the skill set of the staff needs to be a lot broader in order to care for these patients, and the acuity can be very high).

[8] Stan McMillen and Philip Shaw, "The FY 2006 Economic Impact of Continuing Operations of the University of Connecticut Health Center (Fourth Report)."

Hospital care is labor intensive. CHA statistics show that in 2007 hospitals had 6.667 employees per staffed bed. Maintaining this level of staffing in the new JDH requires adding 173.3 staff, assuming current national vacancy rates. If JDH filled all positions, the increased staffing would be 186.5, including 52 physician and surgeons. Maintaining current faculty/student ratios,[9] the expansion of Medical School enrollment implies adding 20.4 physicians and surgeons to the faculty as well as support staff. Using national averages, combining the modest expansion of JDH beds and the Medical School translates into a total increase of 248.5 FTEs.

The analysis relies on the estimates of wages and salaries for new staff data in the CCEA study for 2006 adjusted to 2008 dollars. This is a conservative approach because the objective in the combination of the new hospital and expanded Medical School is to upgrade faculty and staff. Table 2 summarizes the increases in wages and salaries as well as security costs, in 2008 dollars, for this base case.

Finally, state health outcomes will improve from the greater presence of higher quality students working in Connecticut hospitals, students who transfer knowledge to current practitioners as well as learning from them and enhanced on-going training seminars for current practitioners. The last of these components will have special support through the use of electronic simulators in new JDH laboratories, simulators on which both students and practitioners will update their skills. Because newly attracted researchers will conduct many of these seminars, the quality of care Connecticut's citizens receive will improve. Upgrading faculty, staff, students, and hospital accommodations to single rooms will both retain local patients and attract external medical tourists. A section below projects this particular value.

Table 2: JDH and School of Medicine Annual Employment and Associates Costs 2016-2019

Operations JDH and the Medical School	**2016**	**2017**	**2018**	**2019**
Incremental Direct Employment	62.12	124.23	186.35	248.47
Incremental Direct Wages and Salaries (Million 2008 $)	4.93	9.86	14.80	19.73
Direct Security Costs	1.19	2.39	3.58	4.77
Annual Incremental Day-to-Day Capital and Non-Capital Operating Expenditures (Millions $)	27.54	55.08	82.62	110.16

[9] For the fall of 2005 at the Health Center, OIR statistics indicate for full-time faculty: 163 tenured full-time, 44 untenured on tenure-track, and 291 non-tenure track. http://www.neasc.uconn.edu/std5.htm.

The day-to-day capital and non-capital operating expenditures include maintenance and repair. Given that the new hospital will be larger but designed to operate substantially more efficiently and that renovations to the current JDH space will include significant efficiency upgrades, the analysis projects the increase in operating costs at 50% above current costs. Table 2 shows the increasing economic impacts only to 2019, when the School of Medical will be fully staffed up and admissions reach 100 annually; the economic stimulus in each subsequent year remains identical to that in 2019.

The analysis includes seven additional elements to capture the full array of impacts; these are expansion of the School of Dental Medicine, the value of additional medical graduates, including additional residents, increases in Federal transfers, student expenditures, related expected additional research, retention of physicians and surgeons in Connecticut, and anticipated improved health outcomes.

School of Dental Medicine

The expansion of the School of Dental Medicine by 20 students per class is a 50% increase. Over four years, this implies the additional of 20.4 faculty, who in turn require support staff. At full operation, direct employment generation will thus reach 62 positions. Table 3 summarizes the resulting annual direct stimuli for employment, wages and salaries, security, and additional operating expenditures. The incremental operating expenditures relate to the expansion of the School of Dental Medicine and dentists offices on a per employee basis. Because the School is not acquiring a new facility, these costs are lower than for the JDH and the School of Medicine expansion.

Table 3: School of Dentistry Annual Employment and Associated Costs 2016-2020

Source of Stimulus	2016	2017	2018	2019
Incremental Direct Employment	15.50	31.00	46.50	62.00
Incremental Direct Wages and Salaries (Million 2008 $)	1.15	2.30	3.45	4.60
Direct Security Costs	0.28	0.56	0.83	1.11
Incremental Day-to-Day Capital and Non-Capital Expenditures (Millions $)	0.75	1.51	2.26	3.01

Interns and Residents

From 2020 onward, additional medical graduates will swell the ranks of interns and residents, thereby generating further employment and earnings. The current average length of internships and residency, including post-doctoral studies, is 2.9 years. Using average wages and salaries for interns and residents for 2006 extrapolated to 2008 and extending that average into the future results in additional stimuli to the Connecticut economy, shown in Table 4. Again incremental operating expenditures are developed per employee, with no additional capital facilities.

The federal government supports medical services with payments to the State per medical resident. Because these funds per resident exceed what the State spends, there is an incremental transfer above the expenses noted above. This transfer will add $3.9 million to the state impact in 2020, rising year over-year to $15.4 and then $32.4 million in 2023, at which value it remains.

Table 4: Interns and residents Annual Employment and Associated Costs 2020-2023

	2020	2021	2022	2023
Incremental Direct Employment	20.00	40.00	58.00	58.00
Incremental Direct Wages and Salaries (Million 2008 $)	0.95	1.89	2.74	2.74
Direct Security Costs (Million 2008 $)	0.23	0.46	0.66	0.66
Incremental Day-to-Day Capital and Non-Capital Expenditures (Millions 2008 $)	1.03	2.06	2.99	2.99

Student Expenditures

Part of the economic impact expansion of the UCHC generates comes from student expenditures. The earlier CCEA UCHC study documented these expenditures for 2006; this study extends them to 2008 using the CPI to account for inflation. The analysis includes these expenditures for all those requiring training, inclusive of physicians and surgeons, dentists, and support staff. Current vacancy rates in the 6.6% to 10.7% range within these professions make it clear that there are no surpluses of these skilled workers, requiring training rather than simply hiring all trained staff. This process essentially assumes that support staff on average will require four years of training. While some need less training, others such as nurse practitioners and other RNs with extended licenses require more training. These expenditures grow by $3.44 million per year starting in 2016 until 2019 when they reach $13.77. The analysis distributes these expenditures among economic sectors based of a survey of student expenditures.

Research

The core objective of the expansion is the attraction of higher quality faculty; thus the study conservatively assumes that new faculty will be as research-oriented as current faculty, attracting on average the same level of research funds per capita. Under this conservative assumption, the additional faculty will attract funding of $2.8 million per year two years after their hiring in 2018, rising to $10.4 in 2021, when new staffing ends. In the time between their appointment and the start-up of grant funding they will be offered relocation incentives averaging $400,000 over two years in order to establish their laboratories and to qualify for R&D grants.

Graduates

Current experience shows that with the expansion fifty-two percent of graduates from intern and residence programs can reasonably be expected to remain in Connecticut, with minor annual attrition of 1.5% annually. Thus the increase of 20 new dentists coming from the first graduating class in 2020 results in 7.57 FTEs by 2040. The rest are working part-time, have died, changed professions, or left Connecticut. On average, dentists, physicians, and surgeons generate demand for additional support staff of 2.04 persons. The study assumes that these practitioners are distributed among Connecticut counties in proportion to personal income in 2008, resulting in direct economic stimulus throughout the state. The analysis projects the impact arising from those graduates, interns, and residents remaining in Connecticut in each subsequent year.

Considering the dental graduates plus the physicians and surgeons entering the Connecticut labor force 2020-2023 generates, by 2040, direct employment impacts of 2,322 FTEs, including complementary medical personnel.

Total Operations Stimuli

Table 5 aggregates these components for the entire state. These data exclude improvements in amenity value of improved health, which this study addresses separately below. The annual stimulus continues to increase until 2023, at which point the number graduating dentists and medical students completing residencies stabilizes so that only the retention of practitioners perpetuates slow growth. Initial employment impact is 217 FTEs in 2016, rising to 734 FTEs by 2025. Annual total expenditures for additional personnel, day-today operations, student expenditures, and transfers of grants are worth $42.1 million in 2016, rising to $164.6 million in 2019, then gradually thereafter to $218.2 million in 2023. Thereafter the economic impact remains constant..

Table 5: Total Incremental Operating Stimuli: 2016-2023

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Incremental Direct Employment (1000s)	0.217	0.248	0.279	0.310	0.360	0.410	0.461	0.524	0.616	0.734	0.850
Incremental Direct Wages and Salaries (Million 2000 $)	14.351	16.338	18.325	20.313	23.088	25.866	28.738	32.885	38.988	46.817	54.528
Direct Security Expenditures (Millions 2000 $)	3.471	3.951	4.432	4.912	5.584	6.256	6.950	7.953	9.429	11.322	13.187
Incremental Operating Expenditures and Student Expenditures and Research Grants (Millions 2000 $)	82.002	92.578	102.877	121.301	129.937	138.574	139.284	142.373	146.919	152.749	158.492
Induced Additional Federal Transfers to CT (Millions 2000$)	0.00	0.00	0.00	0.00	3.59	14.35	30.17	30.17	30.17	30.17	30.17
Total Direct Impacts (Millions 2000 $)	99.823	112.868	125.634	146.526	158.609	170.696	174.972	183.211	195.336	210.888	226.208

Table 5 cont'd: Total Incremental Operating Stimulus: Hartford County 2024-2037

	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Incremental Direct Employment (1000s)	0.965	1.077	1.189	1.298	1.406	1.512	1.617	1.720	1.821	1.921	2.020
Incremental Direct Wages and Salaries (Million 2000 $)	62.124	69.606	76.975	84.234	91.384	98.427	105.364	112.197	118.928	125.557	132.087
Direct Security Expenditures (Millions 2000 $)	15.024	16.833	18.616	20.371	22.100	23.804	25.481	27.134	28.761	30.365	31.944
Incremental Operating Expenditures and Student Expenditures and Research Grants (Millions 2000 $)	164.149	169.721	175.210	180.616	185.941	191.187	196.353	201.442	206.455	211.393	216.256
Induced Additional Federal Transfers to CT (Millions 2000$)	30.17	30.17	30.17	30.17	30.17	30.17	30.17	30.17	30.17	30.17	30.17
Direct Impacts (Millions 2000 $)	241.297	256.160	270.801	285.221	299.426	313.417	327.198	340.773	354.144	367.315	380.287

Several factors may increase economic impacts; among them are:

- Further extending care to the underserved;
- Expansions of Medicare;
- More concentration in specialties that require more qualified and higher-paid staff;

- More specialized medical teams;
- Participation in Phase II and Phase III clinical trials, and,
- Enhanced reputation of the School of Medicine and JDH, improving retention of Connecticut patients and attraction of medical tourists.

Later scenarios capture some of these potential additional economic benefits.

Amenity Benefits

Amenity benefits arise from improved operations, repetition of surgical procedures by teams accustomed to working together that minimize AMEs, improvements in the blood supply and blood products, and upgraded information systems that minimize the likelihood of adverse drug interactions, the use of improved equipment and sufficient warnings from epidemiologists to avoid, or at least to minimize, the spread of contagious diseases. This analysis follows the procedure that William Nordhaus of Yale developed; it values the Value of Statistical Life Year (VOSLY) from the VOSL (Value of Statistical Life) assessed over 25 years. Using $5.3 million as the benchmark on VOSL, the VOSLY is about $360,000. This analysis does ***not*** capture these benefits, which come in the non-pecuniary form of improved quality of live and longevity, but they total millions of dollars on the basis of this valuation. (See Appendix I for a full discussion of valuing medical amenities.)

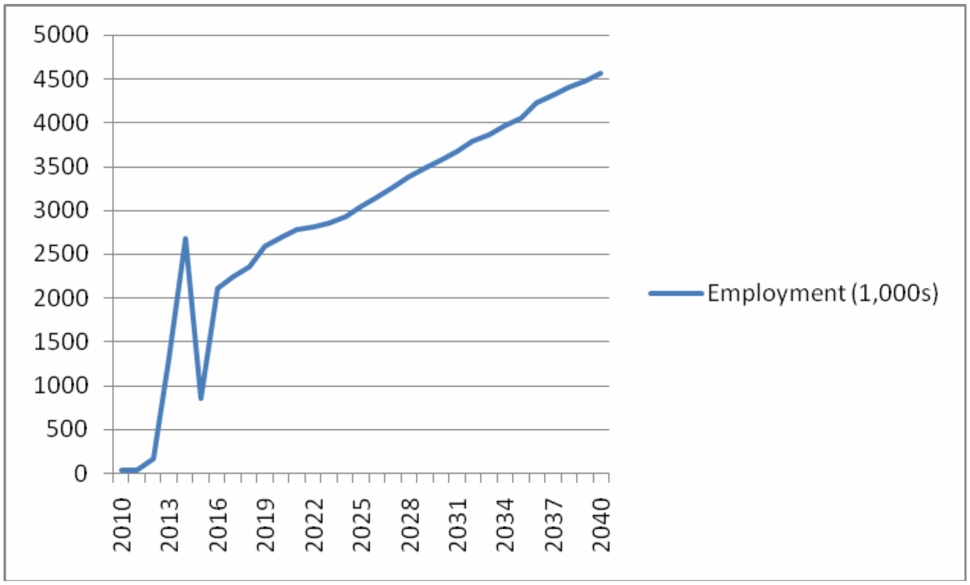
Projecting Dynamic Economic Benefits

The study presents the dynamic economic outcomes from each of the scenarios, using the REMI model of Connecticut's economy. This section presents the total dynamic impacts on employment, CRGDP, personal incomes, population, labor force and the State for both the construction and operation of the new JDH in conjunction with the expanded medical and dentistry programs.

Employment

The construction phase generates over 2,500 jobs at its peak in 2014; employment then drops temporarily as completion nears and the emphasis shifts to purchase and installation of equipment. Faculty expansion occurs over the first four years of operations in line with increased student enrolment. The analysis assumes that each faculty member requires a little over two support staff, so that the post-construction slump in total labor force impacts is brief. In addition, once graduates begin to practice, additional employment not only dwarfs the construction impacts but is also more widely distributed through the state. By 2040, additional employment reaches 4,557.

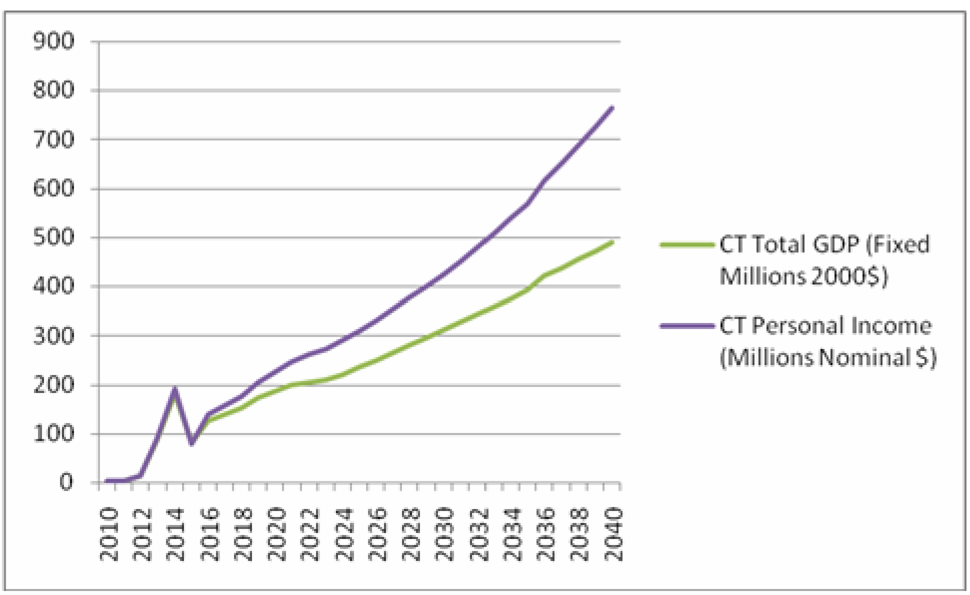
Chart 1: Job Creation - Base Case



Incomes

Consistent with increased employment at well-paying professional jobs in Connecticut, personal income expands significantly, following similar patterns to those for employment shown in Chart 2. The two income measures differ significantly because personal income is in nominal dollars and includes inflationary forces that are likely to be in play with or without the project. The fixed measures are against constant valued dollars in 2000.

Chart 2: Increases in Income - Base Case

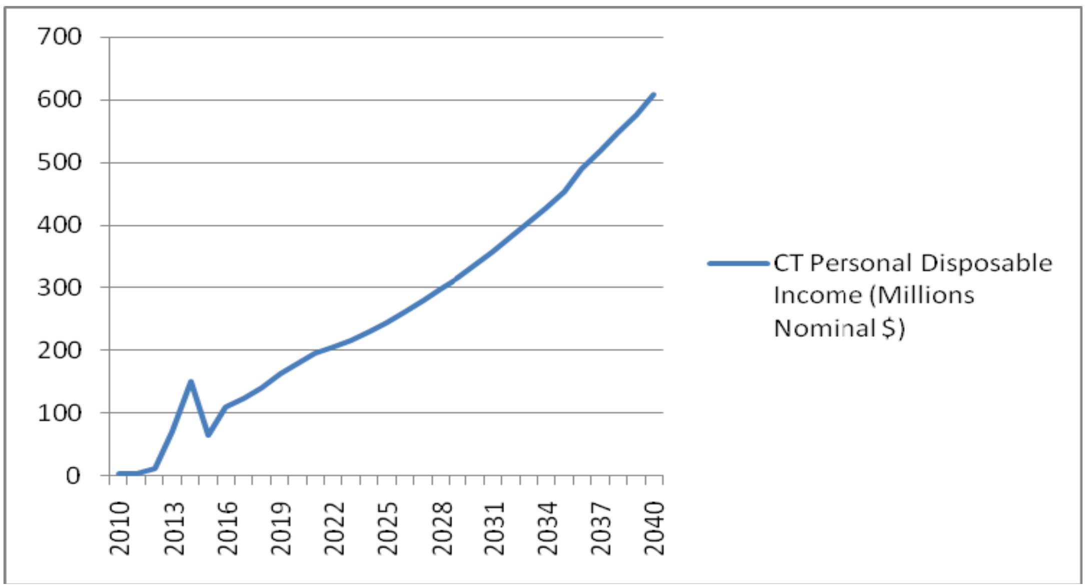


Notably, annual income impacts by 2024 are sufficient to cover half the construction costs of the project. Similarly, Connecticut real gross domestic product (CRGDP) reaches the same level in 2029.

Disposable Income

With greater prosperity, personal disposable income rises. While all the series rise during construction, the important sustained gains come during the operating phase.

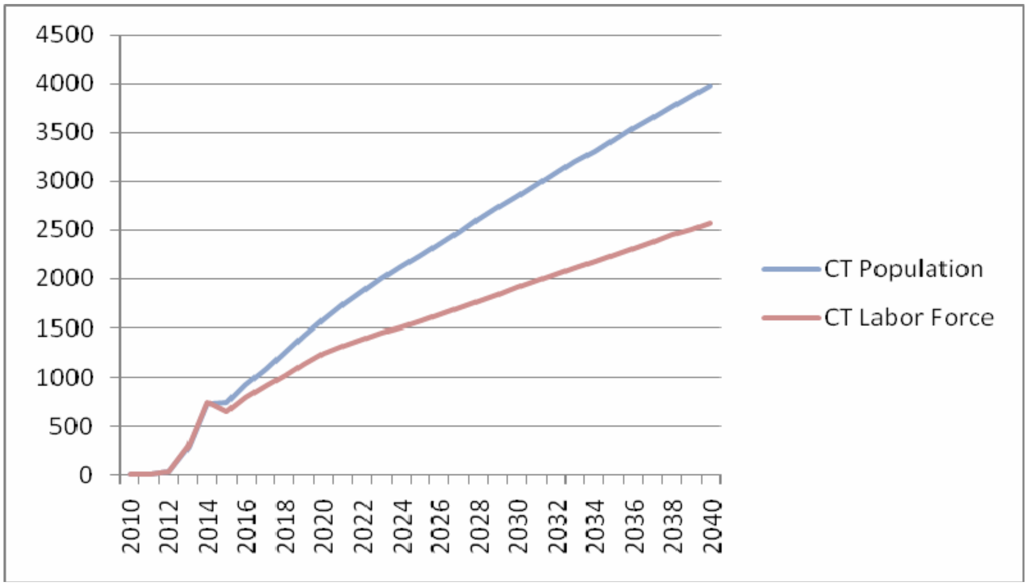
Chart 3: Increase in Personal Disposable Income – Base Case (Millions Nominal $)



Demographic and Labor Impacts

Higher incomes, with more and better employment opportunities, encourage Connecticut citizens to find employment in the State and attract migrants. Chart 4 illustrates these impacts. The additional jobs attract 2,576 workers to the State along with their families, so population increases by 3,978 in 2040 beyond current population growth. The growth of jobs at a rate faster than in-migration of new workers results in a falling rate of unemployment in the region and the state.

Chart 4: Demographic and Labor Impacts - Base Case



Fiscal Impacts

With both the facility coming on line and the expanded population and subsequent need for services, the fiscal impacts on the State and the County are significant. Table 7 summarizes state fiscal impacts.. The Connecticut revenue numbers include the normal tax revenues, supplemented by the windfall from that portion of the Federal Transfers that support interns and residences. In addition, state PILOT for hospitals is typically 25% of local property taxes; the projection of expenditures includes those transfers. Finally, expenditures also include interests on the initial bonding of $475; the result is that in the base case under conservative assumptions [10]the state does not fully recoup the initial capital commitment.

Table 7: Net Present Value of Fiscal Impacts Discounted at 5% Base Case 2016-2035 Millions 2000 $

	Revenues	Expenditures	Net
Connecticut	708.8	264.2	444.6

[10] The analysis both minimizes the likely benefits and maximizes government costs, which are calculated on a per capita basis and driven, in aggregate, by the growth in population. This assumes that there are no scale effectives in provision of government services nor any future reductions in those expenditures on a per capita basis.

Conclusions

This base line project clearly contributes to the health of Connecticut's economy and, importantly, to the welfare of patients. But it fails to create a framework in which JDH and area hospitals can capture a larger share of research funding or to take leadership in the important phase 2 and phase 3 drug trials. It also thus runs the risk of being less attractive for high-value medical researchers in the near term and less able to retain those who do join the faculty in the long run. There is no account taken of the amenity benefits which will arise from improved infrastructure, better information systems, improved operating rooms, and the attraction of highly qualified surgeons and physicians. Simply extending the lives of 100 patients by only one year would yield sufficient benefits on top of the fiscal impact to justify the investment. Alternatively, saving six lives in the neonatal unit, permitting them to lead normal lives thereafter, would generate benefits that close the fiscal shortfall.

Scenario 2: The Connecticut Health Collaborative

The recently formed Connecticut Health Collaborative includes UCHC, Harford Healthcare Corporation, St Francis Hospital and Medical Center, The Hospital of Central Connecticut, and Connecticut Children's Medical Center. The Collaboration "will seek to support the educational and research missions of all affiliates by expanding their interaction with medical student, interns and residents and enhancing their access to emerging science through the systematic transfer of state-of-the-art knowledge to each hospital's workforce."[11] The Collaboration will also support the UConn School of Medicine in its effort to secure a Clinical and Translational Science Award. Such an award would help to fund a new Connecticut Institute of Clinical and Transitional Science. In addition, the Collaborative will explore cooperative initiatives in allied health education and will undertake new efforts to enhance the health status of Connecticut citizens by using research to develop and disseminate new and successful models of care particularly for underserved populations.[12]

The Collaborative targets in principal the following:

- Attaining the licensed for Phase 2 and Phase 3 trials;
- Enhancing research;
- Cooperation in allied health education; and,
- Developing and utilizing new models of care particularly for underserved populations.

Clinical and Translational Science Award

The collaborators have vested interests in supporting the UConn School of Medicine in its effort to secure a Clinical and Translational Science Award. Such an award facilitates undertaking medical trials that would fund a new Connecticut Institute of Clinical and Transitional Science, a facility

[11] Transforming Health Education, Research and Clinical Care in the Greater Hartford Regions: A Conceptual Framework. p. 1.
[12] ibid

central to a shared commitment among members to organize, expand, and deepen biomedical research in the region.[13] Spurred by the mapping of the human genome, pharmaceutical research has become increasingly bio-based. Complex Phase 2 and Phase 3 trials may go beyond the traditional purviews of medicine to require genomic profiling in the selection of candidates for the trial.[14] Because the sample populations in trials need to be representative of likely patients, the racial and linguistic mix of the populations served by the Collaborative enhances the likelihood of qualifying for and wining contracts. Qualifying for such trials creates an important potential source of additional revenues from a growing base[15] for all members of the Collaborative. Expenditures for a Phase 3 drug trial can range from $85[16] to $400[17] million for a new pharmaceutical. Drugs already approved for one or more specific uses may also be tested for additional indicators in trials which may be somewhat less costly.

In addition to these incremental revenues from the Collaborative, where beds need to be utilized to support trials, members benefit from accelerating their closure of the gap between staffed and licensed beds. Currently there are 9,162 licensed beds in Connecticut but only 7,225 are currently staffed. The CASE Tripp Umback report forecast only slow closure of this gap – out to 2030 in some cases[18]—so that alternative uses of the space are likely to have occurred. Thus, absent the Collaborative would probably raise the cost of closure, requiring relocation of support activities and perhaps additional capital costs to create space for the licensed beds

The expansion to undertake Phase 2 and 3 trials will involve attracting the qualified staff to build teams of researchers. This study projects adding 82 physicians and doctors, over and above those included in the Base Case, to the staff of the UCHC or up to 850 affiliated clinicians undertaking private practice 40-60 percent of the time. Once accredited, these operations are expected to come-up to speed quickly and be fully operative in the second year.

Given the normal level of complementary staffing, adding physicians and surgeon would involve a total staff of 250 FTEs earning $20.7 million and security benefits of $5.0 million (2008$). Total annual operating costs are expected to reach $55 million. Attracting these individuals and ramping up the activity occurs over a ten year period in order to assemble the best possible staff.

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[13] Ibid

[14] Vincenzo Pagliarulo*, Ram H. Datar, Richard J. Cote, *The Role of Genetic and Expression Profiling in Pharmacogenomics: The Changing Face of Patient Management*, **Molecular Biology** (2002) pp. 101-105.

[15] Op Cit. AMA p. 91 reports "According to the PhRMA, the pharmaceutical industry spent a total of $59.8 billion on R&D in 2007—an increase from $47.6 billion in 2004. The industry group reported 23 drugs approved in 2007. There were 2,700 compounds in development in 2008, up from 2,000 compounds in 2003." (Originally reported in **Pharmaceutical Research and Manufacturers of America**. *Pharmaceutical Industry Profile 2008*. Washington, DC: PhRMA; March 2008.)

[16] http://www.aapspharmaceutica.com/publications/newsmagazine/2004/feb04/21.pdf (AAPS Magazine Feb. 2004, p.21)

[17] http://www.aapspharmaceutica.com/meetings/files/125/wed/302/0900/vick.pdf

[18] Op cit. The Connecticut Academy of Science and Engineering p. 49.

Both the personnel group and the expenditures may be larger, depending on the specific trials being undertaken. Trials for “tailored” drugs, designed for persons with specific genomic markers, would also utilize the highly complementary skills in genetic biology in screening patient-participants in the trials. In addition, in order to sustain participation some trials remunerate participants, thereby creating a group of part-time employed. For these reasons, the study targets the expected income from trials to reach $125 million when the division is fully operative. This level of staffing and effort would bring the average R&D funding at the UCHC up to the levels of the University of Virginia, about the middle of the medical schools ranked 20-40 in the nations[19]. Revenues exceed operating costs in order to generate funds for the Collaborative and to defray the capital costs of converting licensed space not currently deployed for staffed beds back into those uses.

There are also net amenity values to carrying out trials in Connecticut that accrue to its citizens because they have early access to improved drugs and medical technologies. Table 8 classifies outcomes of Phase 3 trials, ranging from those that are approved by the FDA to those that are cancelled in mid stream because they are doing patients harm. CCEA anticipates working with the FDA in assessing the average percentages falling into each group as part of establishing the amenity value to Connecticut citizens of having initial access to drugs in Phase 2 and 3 trials. Clearly trials that fall into the first classifications generate benefits. Health impacts for those in the third group are neutral and those in the last one can harm patients and need to be subtracted from benefits. Even within unsuccessful trails the percentage benefiting may exceed those placed in harm’s way. To the FDA’s and the pharmaceutical companies’ credit, trials that appear to be remotely dangerous are typically cancelled early in the process. These benefits will be in the form of reduced pain and suffering and extend longevity.

Table 8: Phase 3 Trial Possible Outcomes

Possible FDA Indicator Outcomes	**Sample % with Significantly Improved Outcomes**	**Sample % with Improved but not Significant**	**Sample % with No Difference in Outcomes**	**Sample % Worse Off**	**Size of Sample**	**Length of Trial (Months)**
Licensed	60	24	15.999	.001	3,000	24
Not Licensed	60	24	15	1	3,000	24

Expected values from the improved outcomes (amenity value) can be calculated from trial results. Consider a trial of 3000 persons, half of whom receive the drug and half who are administered a placebo. “Significant improvement” is defined as extending the recipient’s life expectancy by two or more years[20]. Those classified as “Improved but not significantly” nevertheless add a year to their expected lives. Expected lifespan of those showing “No statistical significance difference” is neither

[19] Clinicaltrials.org.

[20] Even thought benefits may extend longer than the two years, for those drugs that are approved after the length of the trial two years this is the maximum length of time over which it is legitimate to claim benefits, because the drug would be available on the market after the two years.

extended nor contracted. Those worse-off die five years earlier than expected. Under these conditions and a VOSLY of $360,000, the amenity value accruing to Connecticut citizens is then $777.5 million from the first trial above and $642.6 million from the second, in excess of the trial's cost. These estimates are conservative because they do not adjust for the likelihood that several participants would have died before the successful drug was marketed and average personal incomes are well above national averages. In addition, where trials are highly successful, the placebo group may be administered the experimental drug thereby boosting the number of beneficiaries.

Enhancing Research

There is synergy between access to a larger number of beds and the attraction of high qualified personnel to the UConn School of Medicine because specialists need access to a large number of beds in order to serve a sufficient number of patients to sustain their specialized interests and to enhance research opportunities. Similarly, patients should fare better with additional expertise being at hand and in the ongoing training of local practitioners. Thus this initiative is designed to extend and enhance the School of Medicine's already strong ties into communities throughout Connecticut by attracting additional specialized researchers and clinicians while improving the quality of medicine delivered and, ultimately, patient care.

Cooperation in Allied Health Education

As noted above modern medicine requires expertise well beyond the realm of doctors to include scientists and allied medical personnel. The University of Connecticut's School of Nursing collaborates with multiple hospitals. Any expansion of the medical system, even for the trials, will require additional allied personnel with special training in the research involving Phase 2 and 3 trials. Cooperation in training these personnel is also central to development of new and successful models of care, particularly for underserved populations and utilization of understaffed beds.

New Models of Patient Care

New models of patient care range across a multitude of initiatives, including, but not restricted to:

- Formation of specialized teams to make greater use of each team member's expertise to lower costs by utilizing fully the skills of registered nurses and postgraduate nurses where the latter are licensed to carryout diagnostics, set the simpler orthopedics, and prescribe pharmaceuticals aside from narcotics. These accredited specialists free doctors to concentrate on more complex cases;
- Improved integration of emergency workers into hospital patient care settings;
- Improved information systems designed to facilitate short-term patient transfers among hospitals with specialized equipment, avoiding the expense of redundancy or underutilization;
- Integrated information systems among pharmacies and emergency wards to alert medical personnel to avoid drug conflicts in comatose or incoherent patients and foreshorten time needed to take medical histories;

- Expanding the University of Connecticut Medical School's expert ties with clinicians in the field who face regionally specific maladies, including those that may be genetically based;
- Enhance software to forewarn clinicians of possible adverse drug interactions and safer alternatives when prescribing pharmaceuticals;
- Installing easy-to-use remote sensing devices in patients' homes so that they can be diagnosed remotely, thereby allowing patient to take more responsibility for their own care and home nursing personnel to undertake larger case loads; and,
- Extensions of the precedents set in the University Connecticut Medical School's successful neonatal care to other applications.

In each of the above cases there are both expenditures and positive patient care outcomes. Generally the more specialized a medical team, the better its performance in terms of accelerated patient recovery and fewer AMEs. Because none of the above specific new models of patient care have been explicitly designated for adoption, Table 9 illustrates case studies of outcomes where some of the above have been adopted, indicating the Collaborative's opportunity to generate benefits.

Table 9: Selected Case Studies in Collaboration – Sketch and Benefits

Type of Collaboration	**Benefits**
The Alberta Hip and Knee Replacement Pilot has assembled a highly specialized group of health care workers in diagnostics, patient advisory systems, specialized surgical procedures, and aftercare. Assessments are made by the case manager – nurse – the case doctor, and physiotherapist, followed up with patient education prior to the procedure, and monitored subsequently usually by the same personnel.	Slashed waiting times from 47 weeks to 4.8 weeks by handling a third more patients than experienced in more general practice operating theatres. Limit the time in which patients are in chronic pain through a central assessment clinic, streamlined referrals, specialized and experienced teams with fewer complications, and integrated patient care. Hospital time has been reduced from 6.4 to 4.3 days. With earlier access, there has been less damage prior to surgery so that patient recuperation times are faster[21]
British Columbia has established Critical Care	Makes fuller use of scarce health workers.

[21] http://www.healthcouncilcanada.ca/en/index.php?option=com_content&task=view&id=11&Itemid=12 (Alberta Hip and Knee Replacement)

Teamwork in Rural BC[22] in its Kootenay Region to improve paramedic services by pairing them with nurses and more fully utilizing paramedics by expanding their scope of practice to allow them to work with nurses in enhanced critical care and to assist in hospital care. (This initiative has many parallels with JDH's mobile neonatal care units.)	Features radio contact to better treat critical patients and accelerate access to air ambulances, thereby freeing up ambulance time.
Increased access by hemophiliacs to specialists from Gander, Newfoundland and Labrador and to professors at Memorial University's Medical School in St. John's. (Twillingate has among the highest rates of hemophilia in the world.)	Professors reassess patients in Twillingate over the summer with ongoing contact with family physicians through telemedicine and electronic files when complications arise and complex diagnoses are required. Gives specialists not only an intimate understanding of each complex case but also implicitly provides additional ongoing training to family practitioners through case discussions. Closes the chasm between locales with high incidences of an ailment where it can be difficult to entice experts to reside and the medical regions where expertise is housed[23]. Increases patient loadings for professors in their areas of research.
E-Prescribing project for Patient Safety at Toronto's Baycrest long-term care facility links doctors, nurses and pharmacists into a computerized expert prescribing system tailored to the health needs of seniors. The expert systems normally deployed to identify adverse drug interactions were enhanced to take account of the special problems of seniors many of whom were on 20	Physicians involved have found five times more errors in prescribing drugs than they were aware of prior to the development of the system. Improvements occurred from avoiding misinterpretations of hand-written instructions, greater awareness of what other drugs had been prescribed by other physicians and NPs, information on alternative pharmaceuticals, and better and more-up-to-date information on

[22] http://www.healthcouncilcanada.ca/en/index.php?option=com_content&task=view&id=11&Itemid=12 (Critical Care Teamwork in Rural BC)
[23] http://www.healthcouncilcanada.ca/en/index.php?option=com_content&task=view&id=11&Itemid=12 (Twillingate Newfoundland and Labrador)
[24] Health Council of Canada, **Annual Report to Canadians 2005**, p. 15.

prescriptions. On a need-to-know basis, the system is accessible both on site and externally by doctors in their homes, aimed at increasing patient safety[24].	patients and potential for adverse drug interactions[25].
PharmaNet is a British Columbia chain-wide electronic database containing the records of all prescriptions in a central database. Each prescription is checked for potential adverse drug interactions. Unlike other jurisdictions where pharmacists can only check against their own store's records, this system checks against prescriptions housed at all members of a chain within drug stores and at terminals in hospitals among all prescriptions at all pharmacies.	If a patient frequents more than one pharmacy in a chain, the BC system identifies all potential adverse drug interactions and any double dipping. Convenient access to pharmacies for mobile patients encourages them to stay on their regimes. The database houses accurate medical histories of the drug regimen of each patient so that emergency personnel can update patient medical histories quickly by starting with the knowledge based in the pharmaceutical records. Whether the patient is conscious or not, initiating treatment based on these records is better than treatment with only very basic information, such as blood type[26].
The Electronic Patient Record at the University of Toronto and three of its teaching hospitals represents a broader virtual application with many similar but more comprehensive outcomes. The Electronic Patient Records pilot has assembled records on over one million patients under the University of Toronto Health Network with the Toronto General, Princess Margaret and Toronto Western hospitals. Previously records were stored in 40,000 sq ft of	The system has stopped over-ordering of some surgical tests. Allows information to follow patients via data collected at any of the sites, particularly useful when closely adjacent hospitals specialize in specific procedures[27].

[25] http://www.healthcouncilcanada.ca/en/index.php?option=com_content&task=view&id=11&Itemid=12 (E-Prescribing for Patient Safety)
[26] http://www.healthcouncilcanada.ca/en/index.php?option=com_content&task=view&id=11&Itemid=12 (PharmaNet)
[27] http://www.healthcouncilcanada.ca/en/index.php?option=com_content&task=view&id=11&Itemid=12 (Electronic Patient Records)

chart storage often not well organized and inefficient to find information. Now all records, even doctors' notes, are recorded and stored electronically and are available instantaneously.	
The Clinical Research Networks facet of NIH's Re-engineering the Clinical Research Enterprise Roadmap was designed to promote and expand clinical research networks that can rapidly conduct high-quality clinical studies that address multiple research questions. [28]	An inventory of existing clinical research networks (IECRN or Networks for Clinical Research) explored existing informatics and training infrastructures in order to identify characteristics that promoted or inhibited successful network interactivity, productivity and expansion. "Best practices" have been identified which can be disseminated to further enhance the efficiency of clinical research networks and by extension those operating on multiple campuses.
The Clinical Research Networks facet of the Re-engineering the Clinical Research Enterprise Roadmap supported **feasibility studies, selected through a Broad Agency Announcement**, aimed at enhancing the clinical research infrastructure through increasing the scope of research activities, increasing participation, and facilitating communication and cooperation among networks.[29]	The results of the inventory and the feasibility studies which was designed to assist in the development of a National Electronics Clinical Trials and Research (NECTAR) network. NECTAR was thought to provide the informatics infrastructure to serve as the backbone for interconnected and inter-operable research networks needed to conduct large trails across diverse cultures and genetic backgrounds.

The advantages of accelerating patient recovery accrue to:

- Patient in terms of quality of life – less chronic pain waiting for care, less time in chronic pain post surgery, and a more rapid return to their jobs and incomes;

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[28] NIH, Clinical Researh Networks and NECTOR - Overview , http://nihroadmap.nih.gov/clinicalresearch/overview-networks.asp.
[29] Ibid.

- Patients' families from reduction in caregiver responsibilities and costs;
- Reduced demand on medical social workers involved with homecare;
- Insurance savings; and,
- Medicare and Medicaid.

REMI Modeling with Trials

This section adds to the base case described above the benefits that flow from establishing the space and adding the human resources to undertake Phase 2 and Phase 3 clinical trials. This adds $100 million (2008 $) to the capital costs and adds 82 physicians and surgeons to the faculty, more than doubling what it would be if the present student/faculty ratio were maintained after the expansion of JDH and the Schools in the base case scenario above. Given the current levels of complementary staff in the State, the study anticipates a total of 250 additional direct jobs creation relative to the previous scenario.

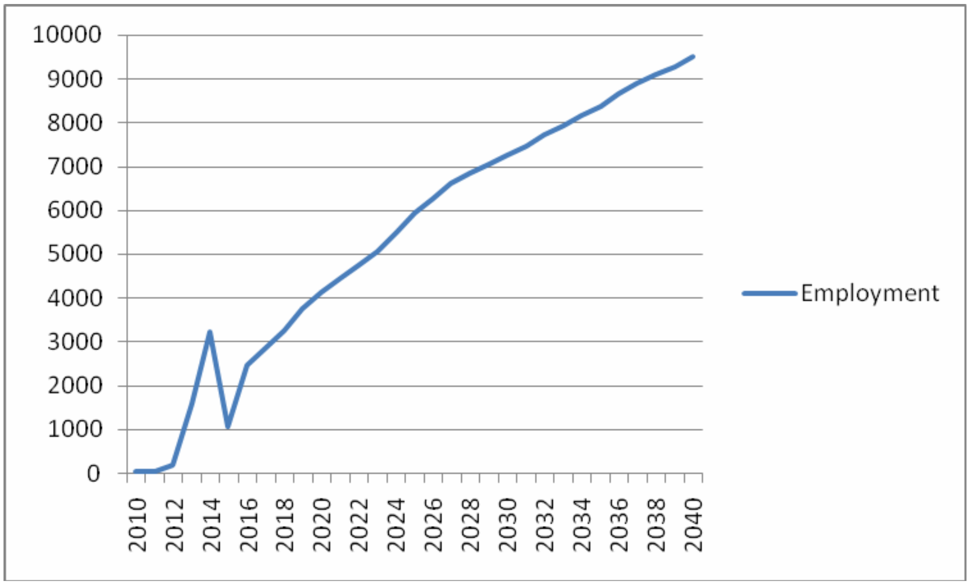
To fill positions quickly, the analysis includes a 20% signing bonus, generating an expected annual payroll of $20.7 million with a further $5.0 million in security costs. The current faculty generates average grants of $140 thousand. This expansion would bring the average per faculty up to $185 thousand.

Employment

This scenario generates significantly larger economic benefits. By 2040, Connecticut employment gains are 9,512 compared to 4,557 in the base case; see Chart 5 below.

The dynamics between the base case and this one are also different. Due to only gradually reaching full capacity for clinical trials, employment impacts in the collaborative scenario are extended out into the mid 2020's when retained graduates perpetuate the drive for growth. The bump in 2036 occurs when the debt is paid out and the State is presumed to spend those annual funds.

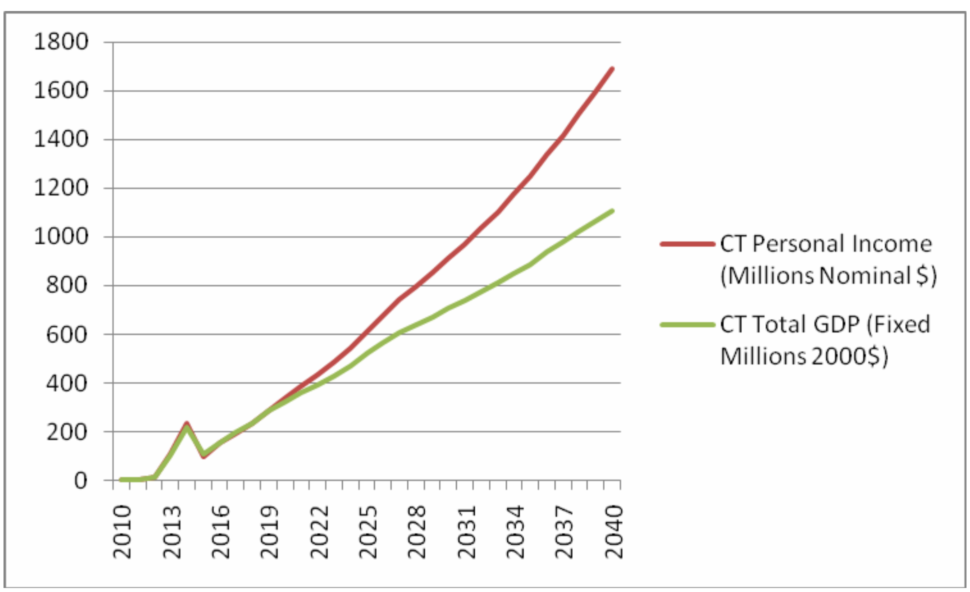
Chart 5: Job Creation – Connecticut Health Collaborative



Income

The Collaborative contains two income stimuli not explicitly in the base case -profits and signing bonuses designed to accelerate the start-up of clinical trials. Both impact REMI's assessment of incomes. Each enters directly into value-added and therefore GDP. The clinical trials team is intended to constitute a profit center, capable of contributing to the rest of the new Medical School.

Chart 6: Income Impacts – Collaborative



By 2025, Connecticut annual personal income impacts in nominal dollars exceed project construction costs. In 2040, increments to personal income reach $1,689 million, well above the $766 million of the base case. CRGDP rises to $1,109 million, more than double the $489.7 million in the base case.

Increasing Disposable Income

Connecticut's incremental disposable income, the after-tax funds consumers have left to spend or save, grows massively, from $608 million to $1,340 million illustrated in Chart 7. This increase in income makes a significant contribution to discretionary expenditures

Demographic and Labor Impacts

The Collaborative generates higher incomes and more and better employment opportunities than in the Base Case, encourage Connecticut citizens to find employment near home and attract migrants. Chart 8 shows these benefits over time. By 2040, the Collaborative expands the Connecticut labor force by 5,576 additional participants compared to 2,576 in the Base Case. Population increases by 8,576 compared to 3,978 in the Base Case. Employment growth outpaces that of the population and the labor force, suggesting lower unemployment.

Chart 7: Personal Disposable Income Impacts - Collaborative (Millions Nominal $)

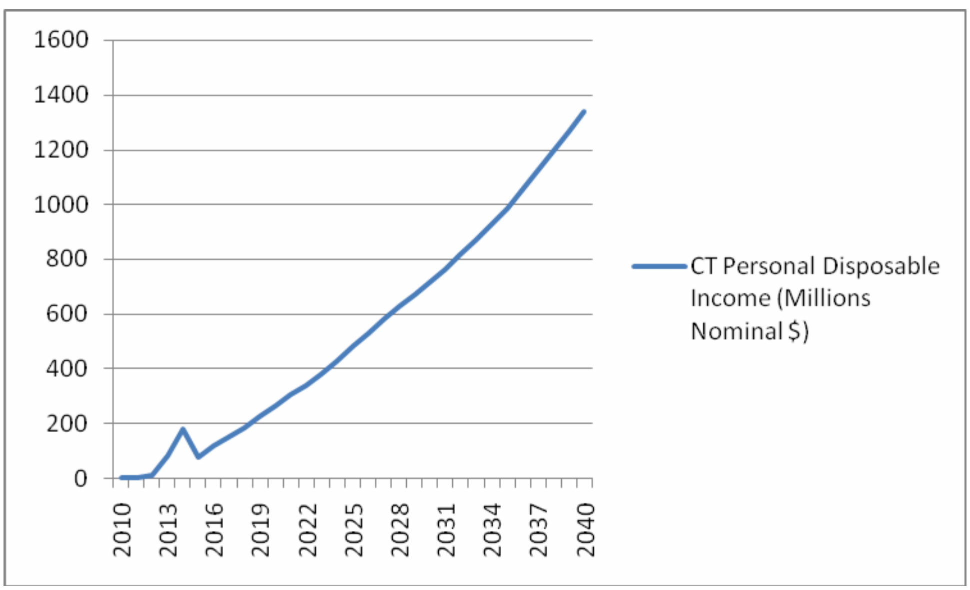
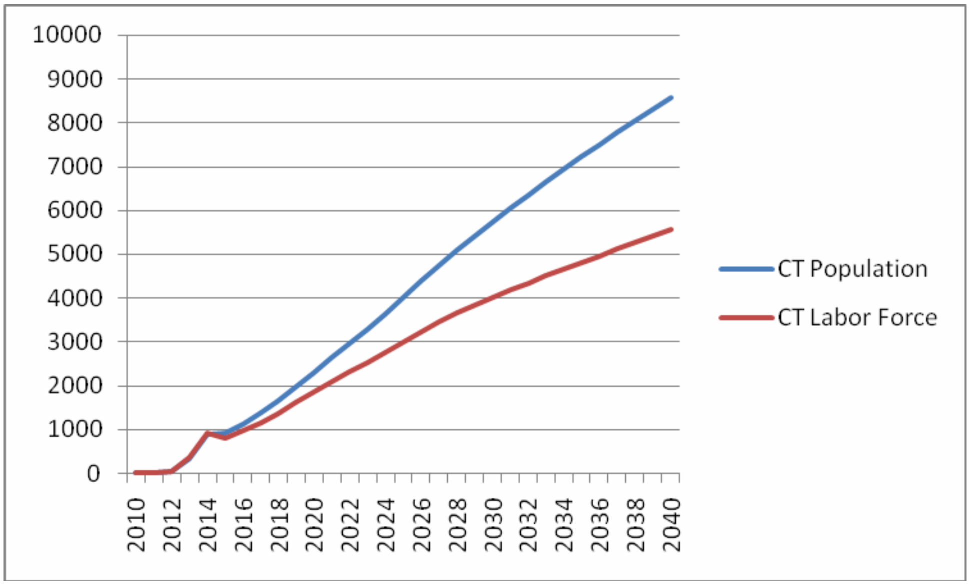


Chart 8: Demographic and Labor Impacts - Collaborative



Fiscal Impacts

State fiscal impacts are considerably stronger, as Table 20 shows. State fiscal impacts more than cover all capital costs. The Connecticut revenue numbers include the normal tax revenues supplemented by the windfall from that portion of the Federal Transfers to support interns and residences with a net present value of $236.4 million that the State retains. Other significant State revenues include personal income taxes with an NPV of $197.3 million and Sales tax NPV at $230.7 million. The State's key incremental expenditures are on Medicaid with a NPV of$83.1 million, public schools $56.3 million, and higher education $52.0 million.

Table 10: Net Present Value (NPV) of Fiscal Impacts Discounted at 5% Collaboration 2016-2035 (Millions 2000 $)

Jurisdiction	Revenues	Expenditures	Net
Connecticut	1,095.8	477,4	618.4

Conclusion

The robust REMI results for the Collaborative reveal that:

- The Collaborative will generate more than 11,400 net new permanent jobs;
- The project will generate State net revenues at present value of $618 million, clearly well beyond the initial bonding cost of $475 million.
- The project will create quality employment opportunities, facilitating retention of Connecticut citizens;

- Significantly increase household incomes in Connecticut;

- The Collaboration outperforms the base case by an order of magnitude higher than the relative additional investment.

In addition, the Collaborative presents opportunities to enhance medical care including the avoidance of adverse drug interactions and other AMEs. In short, as the costs and benefits of adopting these practices becomes clearer, collaboration is likely to produce amenity results that extend well beyond the findings this analysis presents. It also enhances opportunities for Connecticut patients to more readily access new drugs prior to their market availability in order to extend and enhance life.

Scenario 3: Principal Partnership

The Partnership creates a nucleus of a restructured UCHC clinical enterprise with development of a University Hospital with two campuses: Hartford and Farmington. The University will own the Farmington facility; Hartford Healthcare will be responsible for the operation of the hospital and continue to own and operate the Hartford Hospital. The explicit goal of the University Hospital is to evolve into one of the nation's premier academic medical centers. As the state's academic hospital and the core of Hartford Healthcare, the University Hospital will:

- Attract world class physicians, dentists, and other healthcare professionals;
- Serve as the flagship teaching hospital for the Schools of Medicine and Dental Medicine and the primary site for clinical research activities of the School of Medicine;
- Become a medical tourism destination for patients seeking state-of-the-art health care;
- Advance the School of Medicine's educational ranking, sponsored research, and clinical reputation;
- Advance the reputation and regional presence of Hartford Healthcare; and,
- Strengthen the entire Connecticut Health Collaborative and its member hospitals.

The University Hospital will have single medical staff with the development of model for a combined faculty with a common practice plan (n.b., employees of the Farmington facility will remain state employees and maintain right under their collective bargaining agreements). Including the clinical trials included with the analysis of the benefits of the Collaborative laid out above, to reach the status of a top 20-40 public medical school, the School of Medicine expand its research and clinical capacities.

This growth will be realized through:

- replacement and expansion of JDH;

- A leveraged $300 million new tower at the Hartford campus , built along similar expenditure patterns as the new JDH with a one year lead;[30]
- In addition about $30 million will be invested hardware, software and training to make the health and administrative information systems seamlessly compatible on both campuses. This transition is essential for the new University Hospital to 0perate as one medical facility, with patients and information moving between sites as needed,
- Overtime, starting in 2009, there will be an expansion of both parking and services at the Hartford Hospital including the addition of 80 beds and several Intensive Care Units (ICUs) by 2016 and 1100 parking places as well as major repairs on the existing garages to make them more user-friendly. The funds to be invested in the conversion of the IT systems and parking are over and above the $300 million.
- The hiring of new 411 clinical personnel including 160 doctors has been timed to coincide with the expansion of beds. In addition the Hartford is committed to expanding research staff 2016-2025. The objective is to attract first rate individuals to the School of Medicine. The 16 are expected to receive the same relocation package as those at JDH and to perform at least as well in attracting research grants.

In the short-term, Hartford Healthcare will provide financial resources essential to the transformation of the academic programs in the Schools of Medicine and Dental Medicine; in the long-term, the partners will negotiate the annual academic financial support Hartford Healthcare will provide. The analysis assumes State of Connecticut is expected to finance replacement of JDH and to provide operating support for academic research as well as certain state-related expenses of JDH.

Addressing Complex Medical Issues

The expansion of the Hartford Hospital provides the laboratories necessary to position that hospitals' staff to attract research funds as newly established members of the University community. It will also require an expansion of research staff. The combined efforts are intended to attract research faculty. To take advantage of this improved expertise and reputation, Connecticut patients with complex medical problems will remain in the state and non-residents will be attracted; both contributing additional revenue to the complex.

Hospital IT systems require the full gamut of communications—audio for experts to communicate; video for teaching, security, and insurance concerns; computational capacity to keep accounts in good order and privacy assured; immense storage. The demands on such a system are daunting, as the following examples reveal. Experimental MRIs now require as much as 10 gigabytes per scan! Most information needs to be accessible over at least hardwired and hand-held systems. In addition, security systems designed to ensure privacy need to allow two-way access for some patients under homecare as well as medical professionals on a need to know basis from within the

[30]That timing would allow research laboratories at the new JDH to fill with the expansion of the professional programs prior to new capacity being available at the Hartford campus of the University Hospital.

hospitals, their external offices, their homes, and in emergency response vehicles. Medical images require high densities, thereby adding complexity to image compression for efficient storage. All licensed practitioners, with each person's licensed authority, require access to intelligent systems in order to identify potential adverse drug interactions prior to finalizing prescriptions. Ideally, these systems have the software designed to suggest alternatives.

Adjustment to information technologies (IT) is modeled with the Partnership because unified integrated systems at both hospitals is a prerequisite for medical staff on both campuses to function as "one medical staff" within the development of model for a combined faculty with a common practice plan.

Timing

To accomplish all the above requires detailed planning, training, and careful management. The timing and costing of the above activities herein is designed to accomplish the tasks efficiently, specifically:

- Hartford Hospital is expected to bring staffed beds on line in 2009 (12), 2010 (20), in the Tower in 2015 (24) and at a later date, presumed to be 2016 (22);
- Since there will be several ICUs, the usual assumptions used to estimate staff requirements are conservative.
- Hiring will include attracting additional research faculty in a consulting capacity in the design stages to assure appropriate facilities development and as faculty accompanied by additional R&D personnel during operations;
- The IT systems planning and transition starts immediately. As noted above, hospital information systems are complex and require massive amounts of storage capacity. Efficient and compatible systems within the University Hospital will require new hardware and software components.
- Medical Tourism starts with the opening of the new facilities and ramps up at 10 additional staffed beds per year.

These impacts are assessed in addition to foregoing scenarios. The total investment will be closer to $437 million, providing solid matching with the State.

Construction

To take advantage of the training of expertise needed to construct patient care and laboratory facilities at both campuses, construction at the Hartford campus is slated for completion a year earlier than the JDH. This more compressed design and construction schedule appears in Table 11. In order to establish interchangeable IT services and ensure efficient and clear specifications when ordering new equipment as part to the Partnership, the analysis adds $20 million annually in 2010-

2012. There is a possibility that such funding could fall within the Federal Stimulus package; the likelihood of receiving such funding will be enhanced by advancing the process.

Table 11: Construction Cash Flow Hartford Hospital (1,000s 2008$)

Hartford Hospital	2009	2010	2011	2012	2013	2014	2015
Construction	40.125	67.225	19.125	71.125	104.5	105.6625	
Compatible IT Systems	1.125	1.125	1.125	1.125	4.5	5.6625	15.3375
Total	1.125	1.125	1.125	1.125	4.5	5.6625	15.3375

Operational Impacts

This scenario attracts 16 additional highly qualified researchers 2016-2025. The analysis foresees new faculty members perform at a high level by attracting additional R&D funds at $250,000 each annually and to average of 2 research assistants each. This level of R&D is well above the present level of$140 thousand, but well below leading researchers dedicated to clinical trials.

As the reputation of the University Hospital and the Connecticut Health Collaboration builds, medical tourism grows at a rate that demands an additional 10 staffed beds a year from 2015 to 2040. From 2015 to 2019, the additional faculty members treat these incremental patients. Thereafter, hospitals hire staff at the present levels of care to assist in treating this growing population. Medical tourism stimulates the economy outside of the hospital due to family visits at the rate of .5 per patient day. Minimally, those visits will result in one night of accommodations at $100 and one day of meals at $60. The study assumes that the capital costs of reclaiming rooms and providing the additional equipment for staffed beds from other uses are $100,000 per bed. While medical tourism is attracted to specific caregivers, once the New University Hospital reaches capacity, there may be an opportunity to for others to relieve occupancy pressures by converting space so as to rooms with staffed beds.

As beds come online and additional senior staff recruited, the Hartford Campus increases staffing by 443 persons in 2025. Medical Tourism results in the hiring of 66.7 in 2025, growing to 1066.7 in 2040. ,

Economic Impacts

The impacts discussed below include all activities discussed thus far. As in the case of earlier discussions, the following sections cover employment, incomes, disposable incomes and income tax revenue, demographics and labor force projections, and aggregate state fiscal impacts

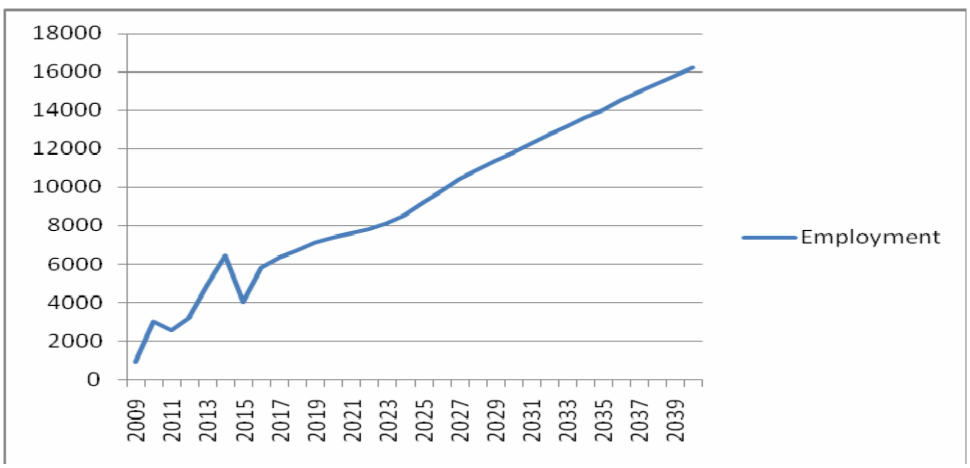
Employment

The employment impact relative to the present situation and previous scenarios are significantly larger than in the earlier scenarios, as Chart 9 shows. Because of larger construction impacts and year earlier hiring of initial researchers, and start-up of staffed beds at the Hartford Campus, employment impacts in 2017 already exceed the 2040 impacts of the first scenario. Driven by the additional hiring, employment expands to 7,120 in 2019 followed by modest continuing expansion to 16,210 in 2040.

Due to the pacing of construction, there is bit of a plateau in employment. Early hiring at the Hartford campus ameliorates some of the post-construction dip experienced in the previous two cases.

Chart 9: Employment Impacts – Partnership et al

(Employment Created)

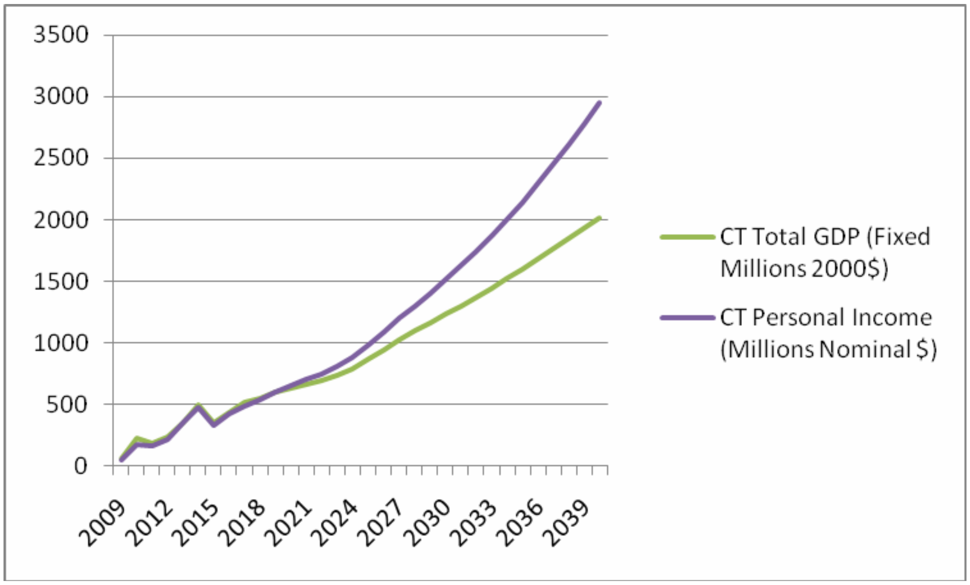


The more rapid growth in this scenario after the student body reaches its full complement results from medical tourism. Without it, the trajectory would be rising more modestly due to the establishment of practices in the State by undergraduate and post-doctoral graduates, noted in the Collaborative analysis.

Income

Illustrated in Chart 10, statewide personal income more than doubles that in the collaborative scenario. The patterns of income growth are roughly similar to those for employment, thought post-construction growth is more rapid due to the higher level of income earned in medical professions.

Chart 10: Increases in Income – Partnership at al



Personal Disposable Income

As illustrated in Chart 11, by 2040 Connecticut additional personal disposable income of $2.340 million is substantial. Should the Collaboration build as part of the cluster of excellence around the new University Hospital, these benefits could be still larger.

Participation by Hartford Healthcare, medical tourism assists in accelerated growth relative to the previous case and is joined by in the 2020s by the 52% of graduates and post-doctoral graduates who establish practices throughout the State.

Demographic and Labor Impacts

Even higher incomes and more and better employment opportunities and healthcare relative to the previous cases encourage Connecticut citizens to find employment near home and attract migrants. These increments are illustrated over time in Chart 12. By 2040, the Connecticut labor force will have expanded by 9,805 compared to 2,576 new participants in the Base Case, again implying a falling rate of unemployment. Population increases by 14,920 compared to 3,978 in the Base Case.

Chart 11: Personal Disposable Income Impacts – Partnership et al (Millions Nominal $)

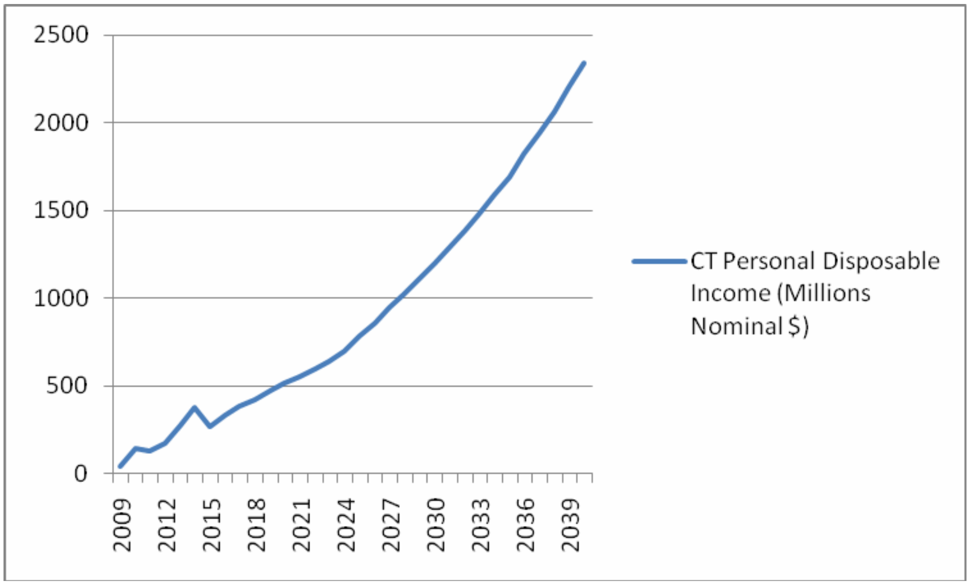
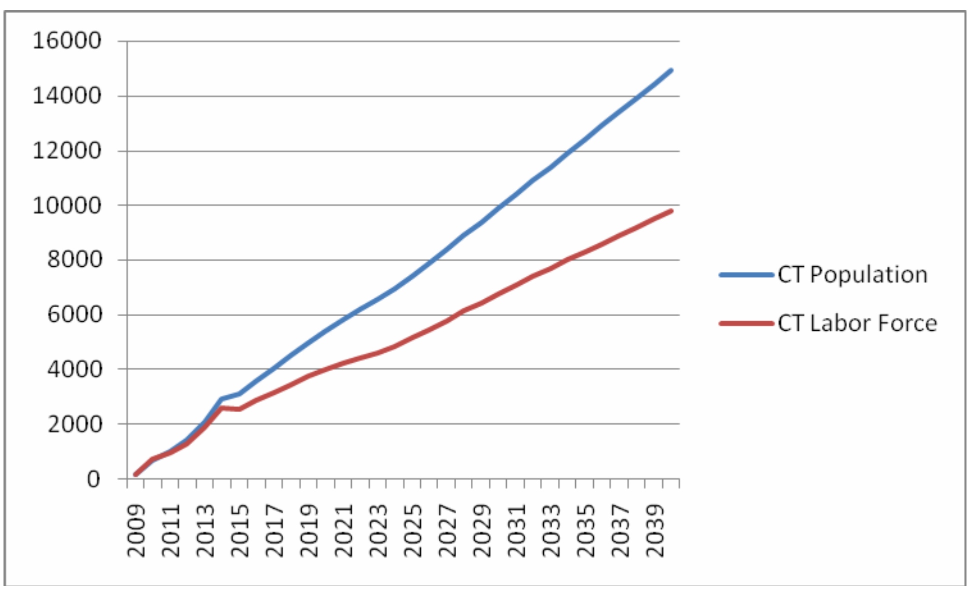


Chart 12: Demographic and Labor Impacts – Partnership et al



Fiscal Impacts

Consistent with the larger investment of $1012 million, State fiscal impacts are considerably stronger, as Table 10 shows. State fiscal impacts are sufficient to more than finance the entire capital costs. The Connecticut revenue numbers include the normal tax revenues supplemented by the windfall from that portion of the Federal Transfers to support interns and residences, with a net present value of $236.4 million, which the State does not now pass through. Other significant State revenues include personal income taxes with an NPV of $339.1 million and Sales tax NPV at $396.5 million. The State's key incremental expenditures are on Medicaid with a NPV of$155.5.0 million, public schools and higher education $202.9 million.

Table 12: Net Present Value (NPV) of Fiscal Impacts Discounted at 5% Partnership et al

2015-2035 (Millions 2000 $)

Jurisdiction	Revenues	Expenditures	Net
Connecticut	1,719.8	893.9	825.9

Conclusions

REMI results for the Partnership indicate that:

- That the project will generate net new State revenues to pay off bond financing;
- The project will generate significant new employment, facilitate Connecticut citizens remaining in the State to work;
- The project will generate significantly higher household incomes in Connecticut;
- The Partnership with synergistic ties to the Collaborative outperforms other alternatives by an order of magnitude larger than the relative additional investment; and,

In addition, the Partnership presents opportunities to enhance education and medical care, including avoidance of adverse drug interactions and other AMEs. It also generates a larger pool of expertise for staff to access via a fully interactive communications system, facilitating improved care. In short, as the costs and benefits of adopting these practices becomes clearer, the Partnership and Collaborative working together are likely to produce clinical results that extend well beyond what this analysis is able to capture.

Scenario 4: Expanded Trials and Partnership

There are clear opportunities to expand participation in clinical trials even beyond what has been envisaged thus far. At the level of research effort included above, clinical trials would bring the School of Medicine up to the level of activity per faculty of the University of Virginia which is the middle of the pack of the top 20-40 medical schools. Alternatively by increasing clinical trial revenues from $125 million to $170 million would bring the new university hospital in line with the University of Iowa, second among the top 20-40 in research dollars per faculty at $285,400[31]. Given that level of success, the second avenue for expansion is additional hiring. This scenario assumes

[31] Clinicaltrials.org and Gregg Hart data.

that additional hiring of 35 physicians and surgeons while maintaining R&D grants per faculty at the $285.4 thousand. In doing so it increases revenues from clinical R&D to $242.6 million from the initial $125 million.

There are other possible expansion paths – increased medical tourism, an increasing number of students, outreach, additional life-long learning and higher retention rates of graduates. The clinical trial alternative is but one example from a complex array. It also has the advantage of being clear and feasible, in that others have achieved these heights. It also complements other strengths at the University of Connecticut in biology and genetics, which are both increasingly critical to drug trials as expanding numbers of new drugs are biologically and genetically based.

Relative to the previous case, direct employment impacts only increases by 106.5 annually once the staff is at full complement over the ten year recruitment period. The largest additional impact occurs in R&D due to the rise in the average size of the grants and the incremental number of researchers. It is up $112.2 million. These funds leave room to hire additional personnel over and above those included directly with the corresponding greater indirect and induced impacts.

Employment

BY 2040, employment is 1,990 above that in the previous case. The large multiplier comes from the relatively high wages and salaries, the capacity to hire additional researchers. The major employment impacts are the sustained ones after all the facilities come online. The nearer-term impacts are substantial and again influence the dynamics, Construction at the Hartford Campus and the opening of new staffed beds early in this scenario assist in redressing current employment issues.

Chart 13 differs from its predecessors in that it shows the additional impact that is contributed by each scenario with the upper limit of each color representing the total of the combined impacts. The culmination of the four scenarios is an employment impact of 18,200

Labor Force

The expanded clinical trials call forth additional labor to serve the trials, their support industries and those who meet induced demands. The expansion adds as further 1,375 to the labor forces so that it reaches a total of 11,180. Chart 14 shows the incremental growth in labor force resulting from each scenario.

Chart 13: Employment Impacts – Expanded Clinical Trials and Partnership

(Employment Created)

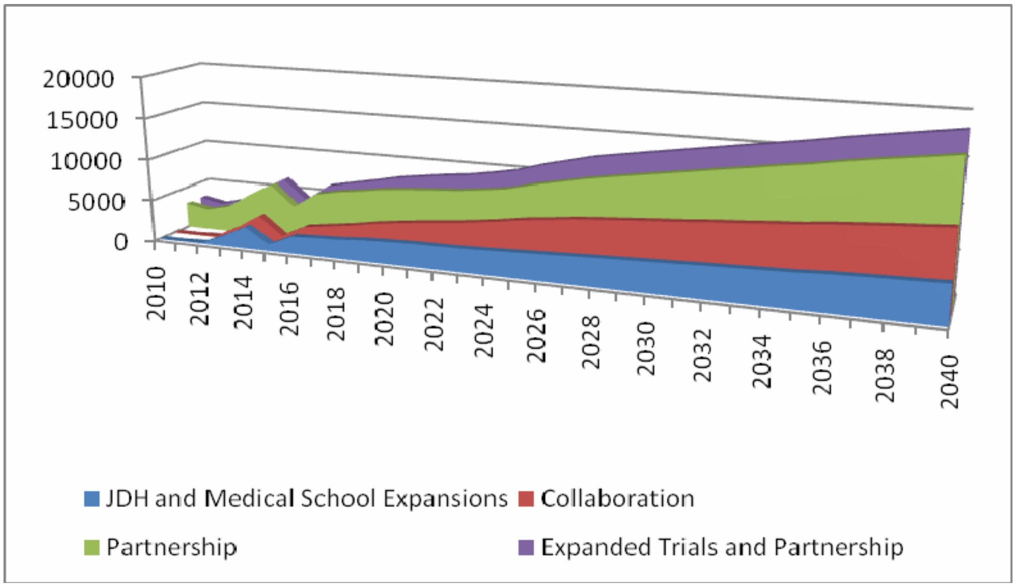
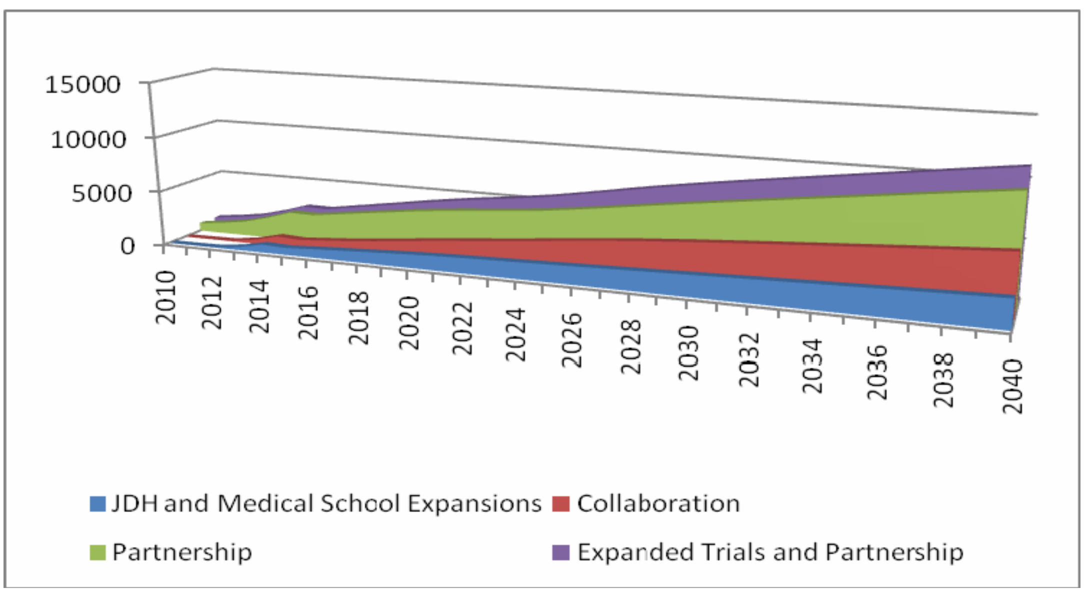


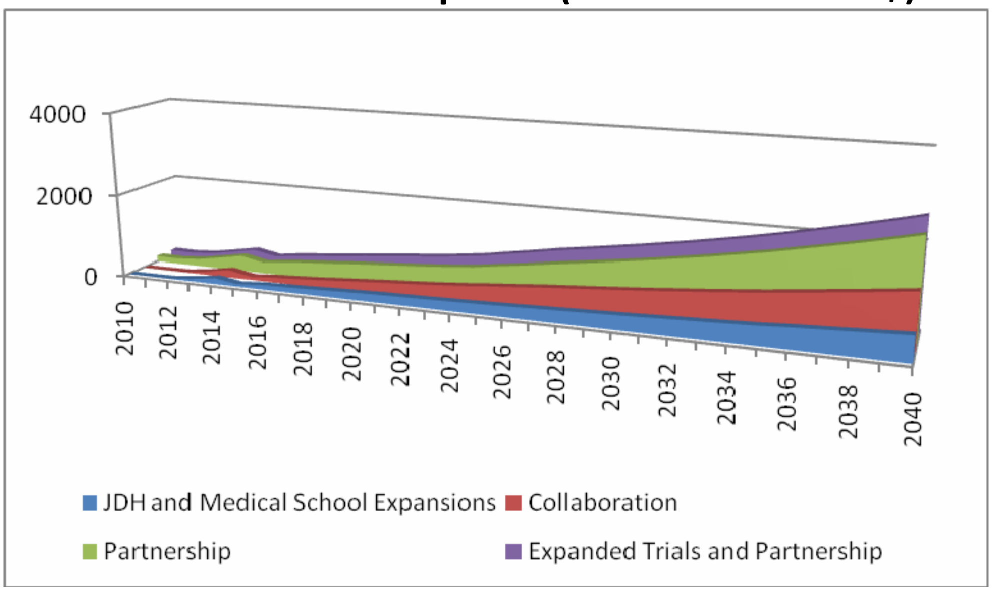
Chart 14: Labor Force Impacts – Expanded Clinical Trials and Partnership et al (Persons)



Personal Disposable Income

Personal Income rises by $328 million as a result of expanded trials over the previous case. In doing so it contributes $261 million to personal disposable income shown in Chart 15. All four scenarios increase Personal income by $3,278million in 2040 and personal disposable income by $2,601 million in nominal dollars.

Chart 15: Personal Disposable Income Impacts – Expanded Clinical Trials and Partnership et al (Millions Nominal $)



Output

Measured in constant 2000 dollars, Connecticut gross output increase sequentially in each scenario, as this study shows. By 2040, the extended clinical trials would add another $150 in annual output. Chart 16 shows the incremental growth that each scenario delivers.

Population

The expanded clinical trials also impact on population. Since employees and the increased labor force have families, population increases of 2,240 exceed those of labor. The total impact on population is to increase it by 17,160 as illustrated in Chart 17. The increase is slightly below that of the number employed, indicating that the unemployment rate is lowered as part of the impacts of this expansion.

Chart 16: CRGDP Impacts – Expanded Clinical Trials and Partnership et al (Millions Nominal $)

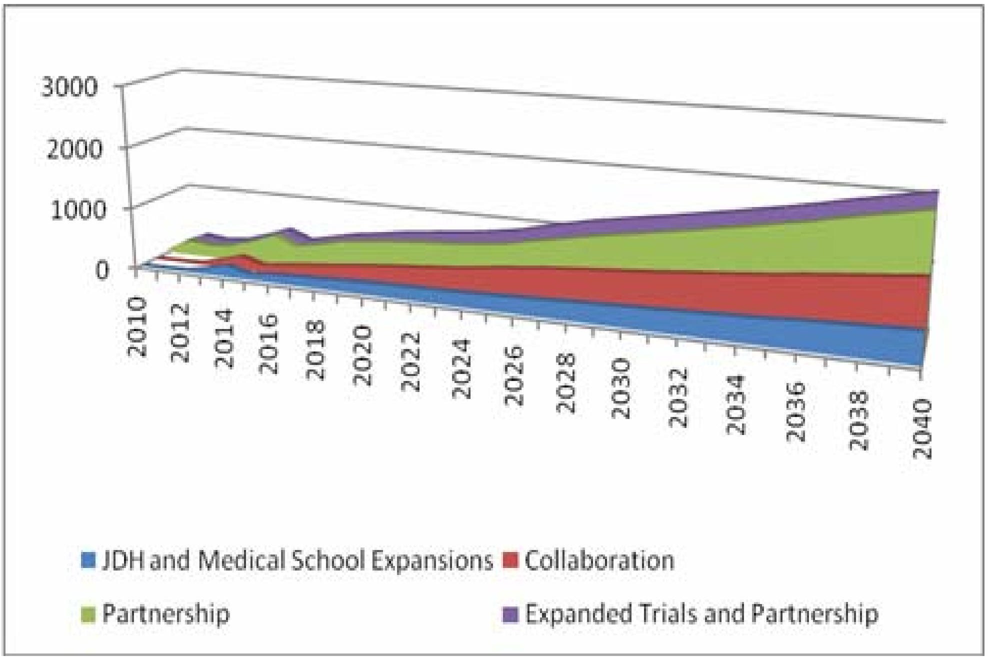
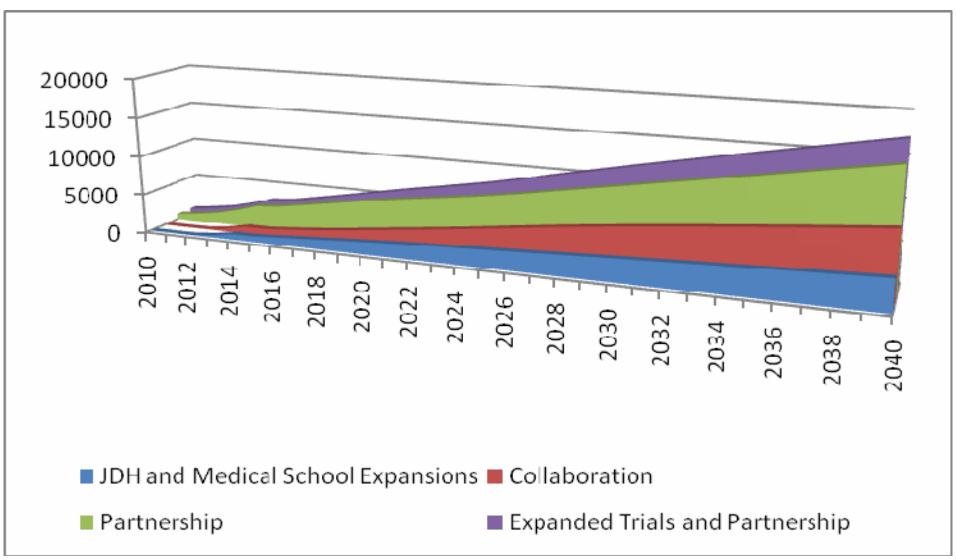


Chart 17: Population Impacts – Expanded Clinical Trials and Partnership et al (Persons)



Fiscal Impacts

The State budget is influenced by both increased earnings from high income jobs and by State expenditures related to the higher levels of population, including educational demands from those populations. The overall fiscal impact is strongly positive for each higher pathway; the present value (5% discount rate) of revenues less expenditures grows. Sales tax generates the most revenue, at $447.6 million, while the State income tax comes in at $382.8 million. The major increases in government expenditures—making the higher conservative assumption that cost go up at a constant per capita rate—will for education ($229.5 million) and Medicaid ($175.9 million)[32].

Table 13: Net Present Value (NPV) of Fiscal Impacts Discounted at 5% Expanded Clinical Trials and Partnership et al: 2015-2035 (Millions 2000 $)

Jurisdiction	Revenues	Expenditures	Net
Connecticut	1,914.8	1,011.0	903.8

The fiscal benefits far outweigh the initial capital commitment and deliver strong returns to the State on its investment.

Overview

None of the projections of economic benefits for these development scenarios includes the amenity benefits acknowledged above. Moreover, in every case the approach has been conservative, minimizing the potential gains and maximizing potential costs. Thus, except for the fourth pathway, which contemplates the benefits of the University of Connecticut moving into the top twenty academic medical research centers, the study understates the likely benefits. Only in that final pathway does the study look at the larger potential that is clearly achievable—and one that would still leave the Connecticut complex well behind leading other public university medical centers.

Clearly, expansion of the University of Connecticut Schools of Medicine and Dentistry, the construction of a new John Dempsey Hospital, development of a broad clinical collaboration among area hospitals, and the partnership with Hartford Hospital offer a unique opportunity to move the UCHC into the top ranks of academic medical research centers, delivering state-of-the-art medical services to state residents, enhancing quality of life and longevity. Equally important, this initiative creates a major economic driver for Connecticut, generating thousands to new jobs, increased income, expanded state output, and significant net new tax revenues. This is the moment when Connecticut can redefine its future path, creating a more prosperous, healthy future.

[32] One of the benefits of the enhanced medical services complex is precisely in reduced long-term medical costs, thus reducing future costs of Medicaid.

Summary Charts

Chart S1: Job Creation

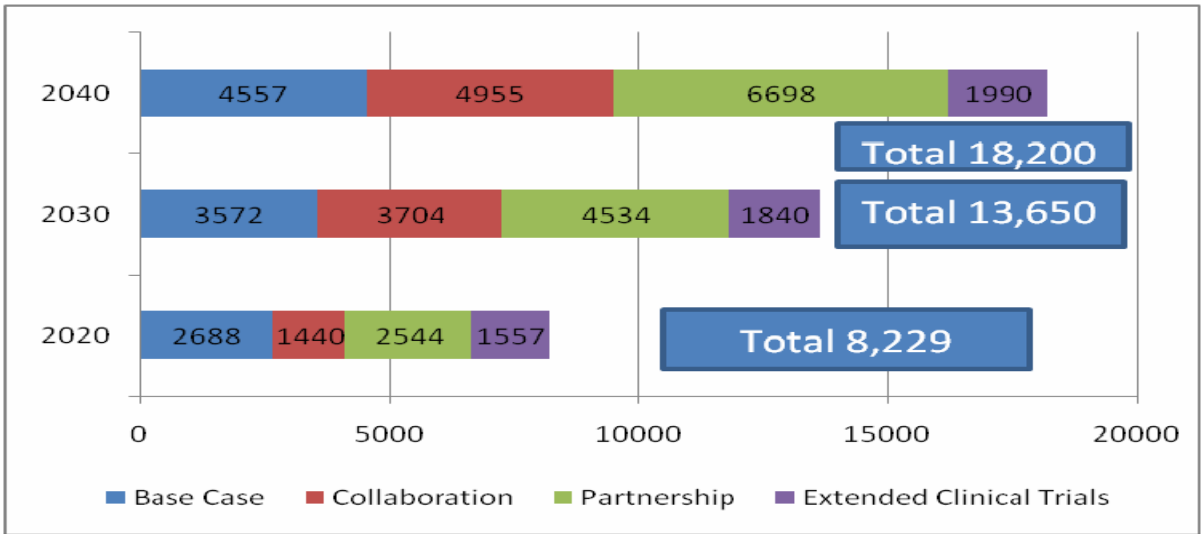


Chart S2: Increase in Personal Income (Nominal $)

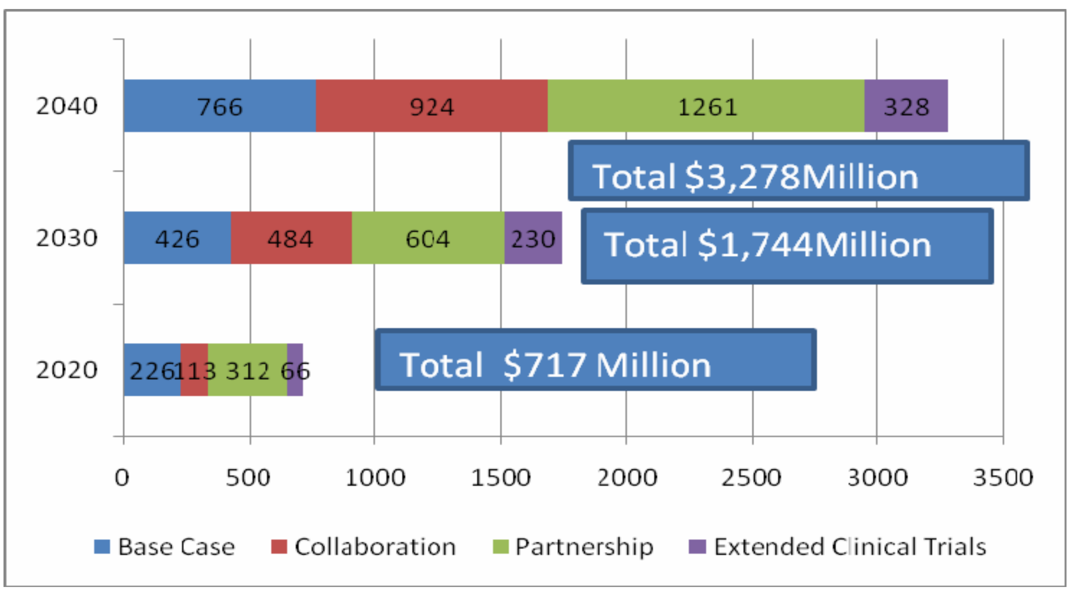


Chart S3: Growth in Total State Output

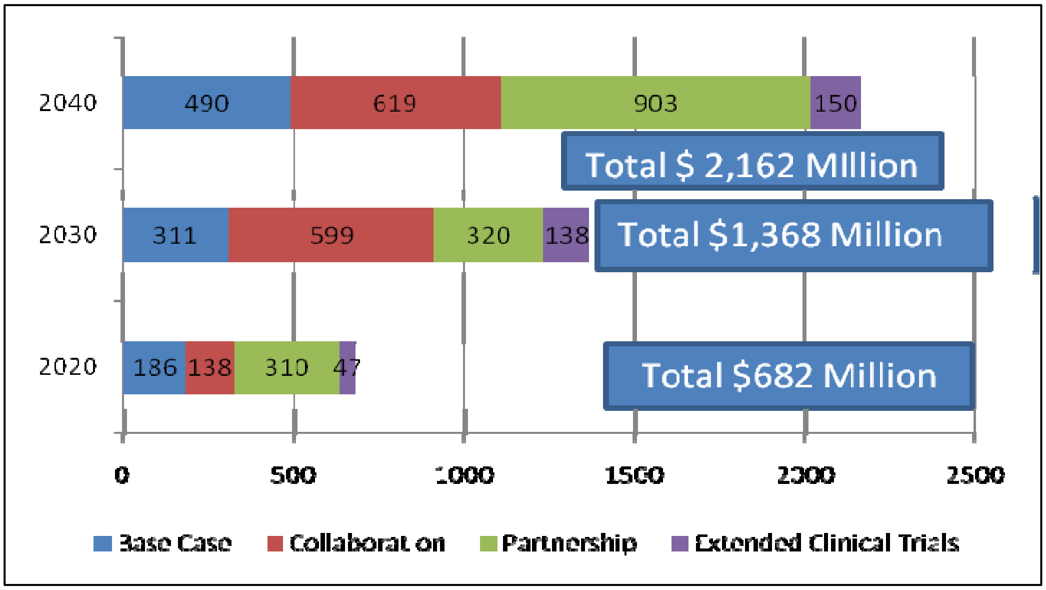
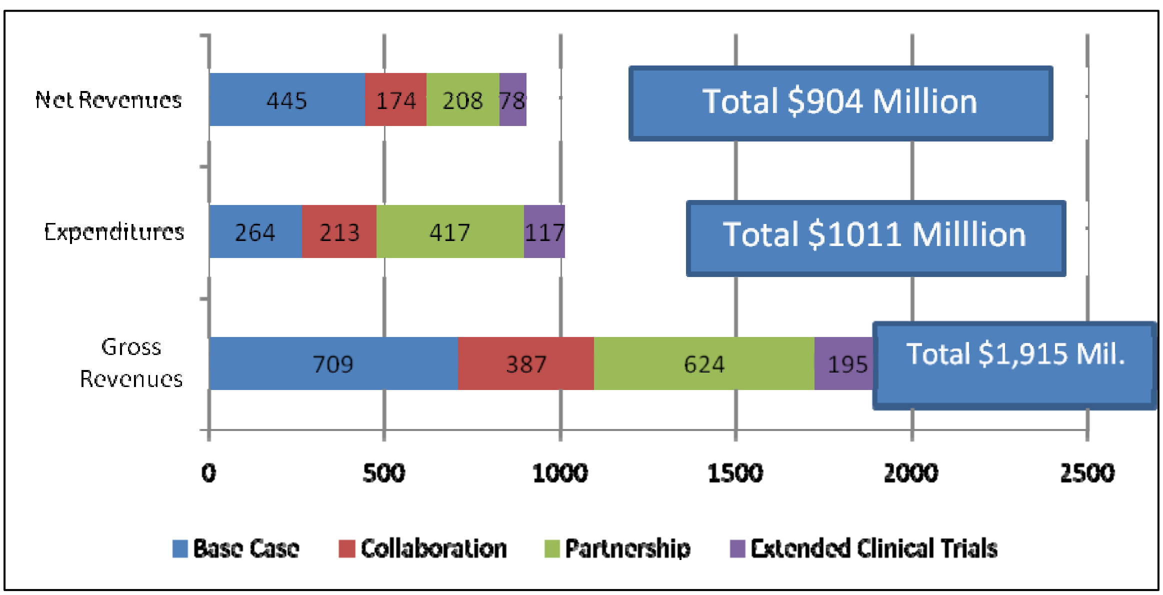


Chart S4: Fiscal Benefits



Appendix I: Amenity Value of Improved Health Outcomes

Estimating amenity benefits is difficult without delineating carefully root causes and likely effects on longevity and the quality of life. Amenity benefits can arise from improved operations, repetition of surgical procedures by teams accustomed to working together that minimize AMEs, improvements in the blood supply and blood products, and upgraded information systems that minimize the likelihood of adverse drug interactions, the use of improved equipment and sufficient warnings from epidemiologists to avoid, or at least to minimize, the spread of contagious diseases. Putting dollar values on these benefits remains controversial because it implies placing a value on human life and well-being. There are two emerging methodologies with which to establish the Value of Statistical Life (VOSL): hedonic and contingency values.

The hedonic approach yields estimates based on the additional pay demanded for acceptance of higher risk jobs where, ideally, all other job attributes are identical. Risks are estimated by looking at deaths per 10,000 employees and then comparing wages and bonuses in the high risk position relative to the less risky one. For example, where remuneration in $500 higher to cover an additional risk of death of 1/10,000, then the VOSL is given by the following equation,

1) VOSL= $5,000,000 = $500/(1/10,000)

Using regression analysis to estimate the difference in remuneration attributable to risks among narrowly defined occupations where relative death rates are known, researchers estimate VOSL. Brett Day surveyed 25 credible American, Canadian and UK studies using this method; these studies range in their estimates of VOSL from $2.65 million to $95.17 million (U.S. 1996).

In his study of hedonic based studies, Day finds that VOSL differs depending on:

- Income – the higher the income the greater is VOSL; and,
- Baseline risks – the higher the baseline risks the higher is VOSL, though at very low levels those differences may be imperceptible.[33]

After weighing individual early studies to give greater weights to those based on larger samples and usually having higher *t* scores and also adjusting for the above variables, Day estimated the VOSL at $5.16 million (U.S. 1996).

Two subsequent studies drawing on larger selections of meta-data produced considerably lower results. By excluding studies where the risk component was endogenous and including a broader range of other explanatory variables, Millar estimates VOSL at $4.0 million U.S. 1998.[34] With more comprehensive coverage of 200 estimates and expanding the number of explanatory variables, Taylor *et al* reach an estimate of $1.5 to $2.5 million using Bureau of Labor Statistics (BLS) data, but

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[33] Day, Brett A Meta-Analysis of Wage-Risk Estimates of the Value of Statistical Life. The n is included in the equation because in uncompetitive labor market the willingness to accept work may differ among individuals and therefore be the sum of each individual's determination of the compensation required, and therefore differ from the $500.. pp. 3-4.

[34] Miller T. *Variations between countries in the Values of statistical life,* **Journal of Transportation Economics and Policy** 2000 34(2), 169-88.

rising to the $2-$4 million)U.S. 1998) range with the higher rates in National Institute of Occupational Safety and Healthy (NIOSH) data.[35]

In a second *genre* of VOSL studies, researchers develop contingency values. Theoretically, this approach has advantages relative to the hedonic based studies because each respondent establishes his or her own risk premium through a questionnaire, thus identifying those who would be willing to act at less than the market premium. Conceptually, well defined CV questions can focus on fatalities or injuries and therefore differentiate clearly between the two risks. Because the risks of fatality and of disability are highly correlated, the willingness to accept (WTA) inherent in the hedonic use of labor force data is inherently upward biased.[36] A well defined CV approaches should avoid some of that upward bias inherent in the hedonic approach. Apropos to health related issues, CV methodology also facilitates data collection on areas where labor markets do not directly play a role and allows all interested parties to participate. The approach is however fraught with shortcomings in terms of the awareness of respondents concerning risks and in striking a balance between informing them in the process of the questionnaire while avoiding biasing their responses.[37]

In his assessment of 336 CV studies, Kenji Takeuchi finds that base risks and risk reductions lead to a willingness to pay (WTP) of $431 in the United States, measured in 1996 dollars, for reduced risks in transportation and that there is an additional bonus of $130, a 30.2 percent increase, to avoid health care risks. In his study, the average risk reduction was 91 per 100,000.[38] Even with the health bonus included, this WTP leads to VOSL estimate of $616,000, well below those obtained from labor market data.

Adjusting the above estimates of VOSL to 2008 $ by GDP Chained 2000 indexes yields a consistent base with the rest of this study. As Table 6reveals, the range of possible estimators remains large. Omitting the two extremes leaves a range consistent with Bureau of Labor's estimates of $2.6 to $5.3 million as the value that society places on life. Following Yale's William Nordhaus,[39] the Value of Statistical Life Year (VOSLY) was estimated from the VOSL assessed over 25 years. Using the $5.3 million benchmark on VOSL, the VOSLY is about $360,000.

These values facilitate assessing amenity benefit within dollar value ranges. As noted at the outset, without details on the new centers or the expansion of the existing ones with JDH and without knowing who will be attracted to the new facilities, it is complex to assess amenity benefits. Saving 8-16 lives attributable to the new center in its first year would have the equivalent impact of its operational stimulus, including the expansion of the School of Medicine.

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[35] Mrozek, Janusz R. and Laura O. Taylor, *What Determines the Value of Life? A Meta-Analysis,* Department of Economics, Andrew Young School of Policy Studies, Georgia State University, Aug 29, 2001, pp. 22-23.
[36] Pearce, David, *Valuing Risks to Life and Health: Towards Consistent Transfer Estimates in the European Union and Accession States*, EC Workshop on Valuing Mortality and Valuing Morbidity, Brussels 2000.
[37] Chapter 9, Questionnaire design: contingent valuation.
[38] Kenji A Meta-analysis of the Value of Statistical Life, Institute of Social Sciences Meiji University, p. 5.
[39] Nordhaus, William D. *The Health of nations: The Contribution of Improved Health to Living Standards*, Unpublished Yale University site.

Table 6: Estimators of the VOSL $2008

Author	Million $ in Year Noted	GDP Deflator Rate of Increase	Millions 2008 $
Day(1996)	5.16	1.37	7.07
Millar (1998)	4	1.32	5.29
Bureau of Labor Upper (1998)	4	1.32	5.29
Bureau of Labor Lower (1998)	2	1.32	2.64
Takeuchi (1998)	.616	1.32	0.81

Appendix II: The REMI Model

The Connecticut REMI model is a dynamic, multi-sector, regional model developed and maintained for the Connecticut Center for Economic Analysis by Regional Economic Models, Inc. of Amherst, Massachusetts. This model provides detail on all eight counties in the State of Connecticut and any combination of these counties. The REMI model includes all of the major inter-industry linkages among 466 private industries, aggregated into 67 major industrial sectors. With the addition of farming and three public sectors (state and local government, civilian federal government, and military), there are 70 sectors represented in the model for the eight counties.

The REMI model is based on a national *input-output* (I/O) model that the U.S. Department of Commerce (DoC) developed and continues to maintain. Modern input/output models are largely the result of groundbreaking research by Nobel laureate Wassily Leontief. Such models focus on the inter-relationships between industries and provide information about how changes in specific variables—whether economic variable such as employment or prices in a certain industry or other variables like population affect factor markets, intermediate goods production, and final goods production and consumption.

The REMI Connecticut model takes the U.S. I/O "table" results and scales them according to traditional regional relationships and current conditions, allowing the relationships to adapt at reasonable rates to changing conditions. Listed below are some salient structural characteristics of the REMI model:

- REMI determines consumption on an industry-by-industry basis, and models real disposable income in Keynesian fashion, that is, with prices fixed in the short run and GDP (Gross Domestic Product) determined solely by aggregate demand.
- The demand for labor, capital, fuel, and intermediate inputs per unit of output depends on relative prices of inputs. Changes in relative prices cause producers to substitute cheaper inputs for relatively more expensive inputs.
- Supply of and demand for labor in a sector determine the wage level, and these characteristics are factored by regional differences. The supply of labor depends on the size of the population and the size of the workforce.
- Migration—that affects population size—depends on real after-tax wages as well as employment opportunities and amenity value in a region relative to other areas.
- Wages and other measures of prices and productivity determine the cost of doing business. Changes in the cost of doing business will affect profits and/or prices in a given industry. When the change in the cost of doing business is specific to a region, the share of the local and U.S. market supplied by local firms is also affected. Market shares and demand determine local output.
- "Imports" and "exports between states are related to relative prices and relative production costs.
- Property income depends only on population and its distribution adjusted for traditional regional differences, *not* on market conditions or building rates relative to business activity.
- Estimates of transfer payments depend on unemployment details of the previous period, and total government expenditures are proportional to population size.
- Federal military and civilian employment is exogenous and maintained at a *fixed* share of the corresponding total U.S. values, unless specifically altered in the analysis.

Because the each variable in the REMI model is related, a change in one variable affects many others. For example, if wages in a certain sector rise, the relative prices of inputs change and may cause the producer to substitute capital for labor. This changes demand for inputs, which affects employment, wages, and other variables in those industries. Changes in employment and wages affect migration and the population level that in turn affect other employment variables. Such chain-reactions continue in time across all sectors in the model. Depending on the analysis performed, the nature of the chain of events cascading through the model economy can be as informative for the policymaker as the final aggregate results. Because REMI generates extensive sector detail, it is possible for experienced economists in this field to discern the dominant causal linkages involved in the results.

The REMI model is a structural model, meaning that it clearly includes cause-and-effect relationships. The model shares two key underlying assumptions with mainstream economic theory: *households maximize utility* and *producers maximize profits*. In the model, businesses produce goods to sell to other firms, consumers, investors, governments and purchasers outside the region. The output is produced using labor, capital, fuel and intermediate inputs. The demand for labor, capital and fuel per unit output depends on their relative costs, because an increase in the price of one of these inputs leads to substitution away from that input to other inputs. The supply of labor in the model depends on the number of people in the population and the proportion of those people who participate in the labor force. Economic migration affects population size and its growth rate. People move into an area if the real after-tax wage rates or the likelihood of being employed increases in a region.

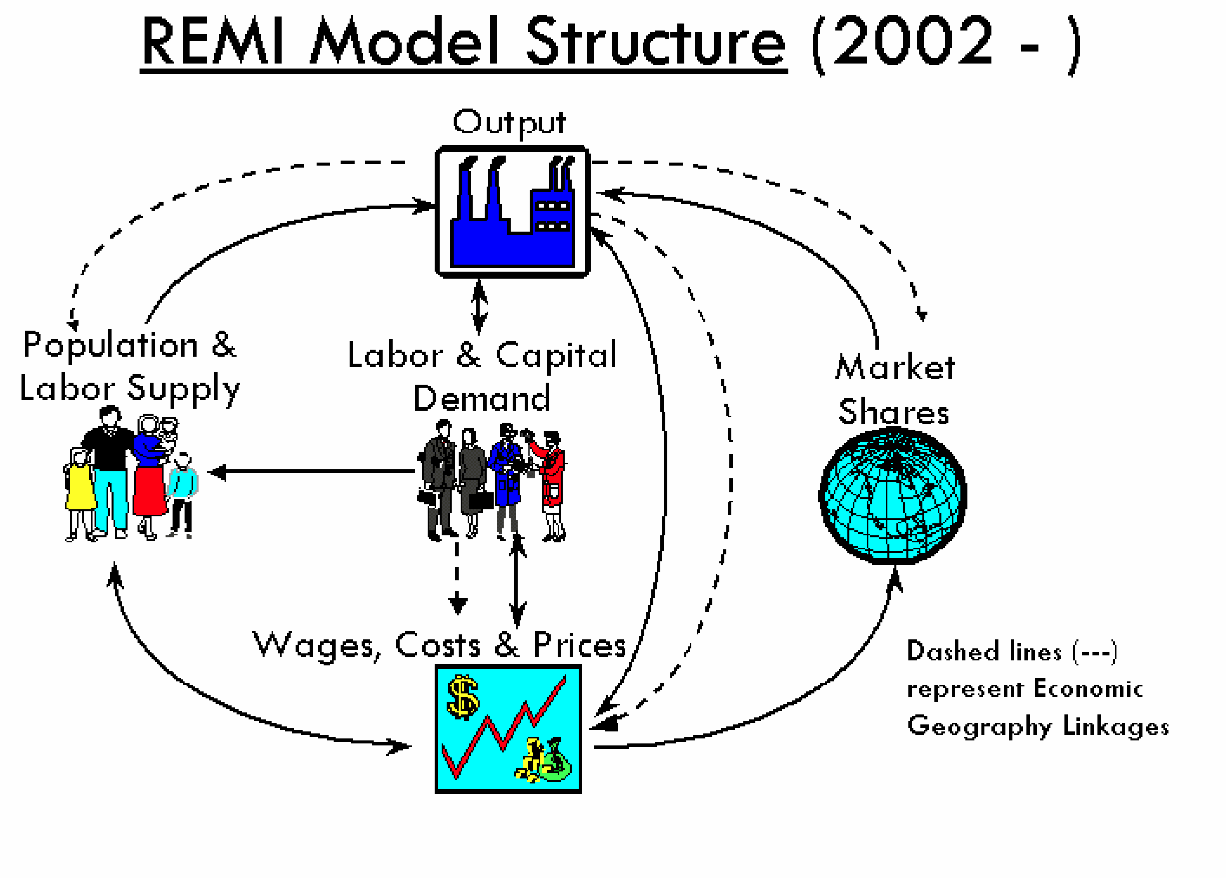
Real wage rates are determined by supply of and demand for labor. These wage rates, along with other prices and productivity, determine the cost of doing business for each industry in the model. An increase in the cost of doing business causes either an increase in price or a cut in profits, depending on the market supplied by local firms. This market share combined with the demand described above determines the amount of local output. The model has many other feedbacks. For example, changes in wages and employment impact income and consumption, while economic expansion changes investment and population growth impacts government spending.

Model Overview

Figure AV.1 is a pictorial representation of the model. The Output block shows a factory that sells to all the sectors of final demand as well as to other industries. The Labor and Capital Demand block shows how labor and capital requirements depend on both output and their relative costs. Population and Labor Supply are shown as contributing to demand and to wage determination in the product and labor market. The feedback from this market shows that economic migrants respond to labor market conditions. Demand and supply interact in the Wage, Price and Profit block. Once prices and profits are established, they determine market shares, which along with components of demand, determine output.

The REMI model brings together the above elements to determine the value of each of the variables in the model for each year in the baseline forecasts. The model includes each inter-industry relationship that is in an input/output model in the Output block, but goes well beyond the input/output model by including the relationships in all of the other blocks shown in Figure AIII.1. In order to broaden the model in this way, it is necessary to estimate key relationships econometrically.

Figure AII.1

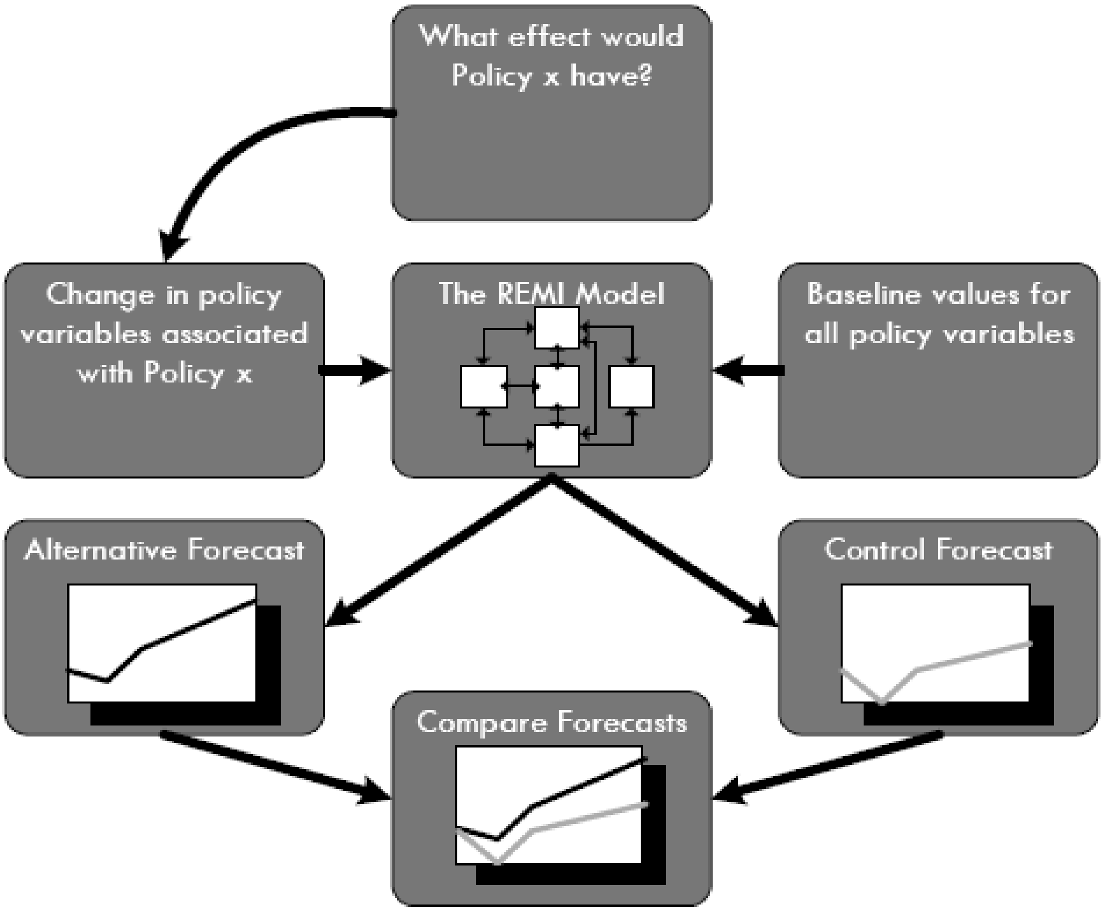


Estimation is accomplished by using extensive data sets covering all areas of the country. These large data sets and two decades of research effort have enabled REMI to simultaneously maintain a theoretically sound model structure and build a model based on all the relevant data available. The model has strong dynamic properties, which means that it forecasts not only what will happen, but also when it will happen. This results in long-term predictions that have general equilibrium properties. This means that the long-term properties of general equilibrium models are preserved without sacrificing the accuracy of event timing predictions and without simply taking elasticity estimates from secondary sources. Figure AIII.1

Understanding the Model

In order to understand how the model works, it is critical to know how the key variables in the model interact with one another and how policy changes are introduced into the model. To introduce a policy change, one begins by formulating a policy question. Next, select a baseline forecast that uses the baseline assumptions about the external policy variables and then generate an alternative forecast using an external variable set that includes changes in the external values, which are effected by the policy issue. Figure AIII.2 shows how this process would work for a policy change called Policy X. In order to understand the major elements in the model and their interactions, subsequent sections examine the various blocks and their important variable types, along with their relationships to each other and to other variables in the other blocks. The only variables discussed are those that interact with each other in the model.

Figure AII.2



Variables determined outside of the model include variables that:

- Determined in the U.S. and world economy (e.g., demand for computers);
- May change and affect the local area, but over which the local area has no control (e.g., an increase in international migration); and,
- Are under control of local policy (e.g., local tax rates).

For simplicity, the last two categories are called policy variables. Changes in these variables are automatically entered directly into the appropriate place in the model structure. Therefore, the diagram showing the model structure also serves as a guide to the organization of the policy variables (see Figure AIII.3).

Output Block

The Output Block variables are:

- State and Local Government Spending
- Investment
- Exports
- Consumption
- Real Disposable Income

These variables interact with each other to determine output and depend on variable values determined in other blocks as follows:

Additional Variables outside of the Output Block

Variables outside of the Output Block include its determinants:

- State and Local Government Spending Population
- Investment Optimal Capital Stock (also the actual capital stock)
- Output Share of Local Market (The proportion of local demand supplied locally, called the Regional Purchase Coefficient)
- Exports The Regional Share of Interregional
- and International Trade
- Real Disposable Income Employment, Wage Rates and the
- Consumer Expenditure Price Index

Labor and Capital Demand Block

The Labor and Capital Demand block has only three types of key variables:

- Employment - determined by the labor/output ratio and the output in each industry, determined in the Output block.
- Optimal Capital Stock - depends on relative labor, capital and fuel costs and the amount of employment.
- Labor/Output Ratio - depends on relative labor, capital and fuel costs.

Simply put, if the cost of labor increases relative to the cost of capital, the labor per unit of output falls and the capital per unit of labor increases.

Population and Labor Supply Block

The model predicts population for 600 cohorts segmented by age, ethnicity and gender. This block also calculates the demographic processes - births, deaths and aging. The models deal with different population sectors as follows:

- Retired Migrants are based on past patterns for each age cohort 65 and over.
- International migrants follow past regional distributions by country of origin.
- Military and college populations are treated as special populations that do not follow normal demographic processes.
- Economic migrants are those who are sensitive to changes in quality of life and relative economic conditions in the regional economies. The economic variables that change economic migration are employment opportunity and real after-tax wage rates.

This block allows the determination of the size of the labor force by predicting the labor force participation rates for age, ethnicity and gender cohorts, which are then applied to their respective cohorts and summed. The key variables that change participation rates within the model are the ratio of employment to the relevant population (labor market tightness) and the real after-tax wage rates.

Wage, Price and Profit Block

Variables contained within the Wage, Price and Profit block are:

- Employment Opportunity
- Wage Rate
- Production Costs
- Housing Price
- Consumer Price Deflator

- Real Wage Rate
- Industry Sales Price
- Profitability.

The wage rate is determined by employment opportunity and changes in employment demand by occupation for occupations that require lengthy training. The housing price increases when population density increases. The Consumer Expenditure Price Index is based on relative commodity prices, weighted by their share of U.S. nominal personal consumption expenditures.

The model uses the price index to calculate the real after-tax wage rate for potential migrants that includes housing price directly, while the price index used to deflate local income uses the local sales price of construction. Wage rates affect production costs, as well as other costs, and they in turn determine profitability or sales prices, depending on whether the type of industry involved serves mainly local or external markets. For example, a cost increase for all local grocery stores results in an increase in their prices, while an increase in costs for a motor vehicle factory reduces its profitability of production at that facility but may not increase their prices worldwide.

Market Shares Block

The Market Shares Block consists of:

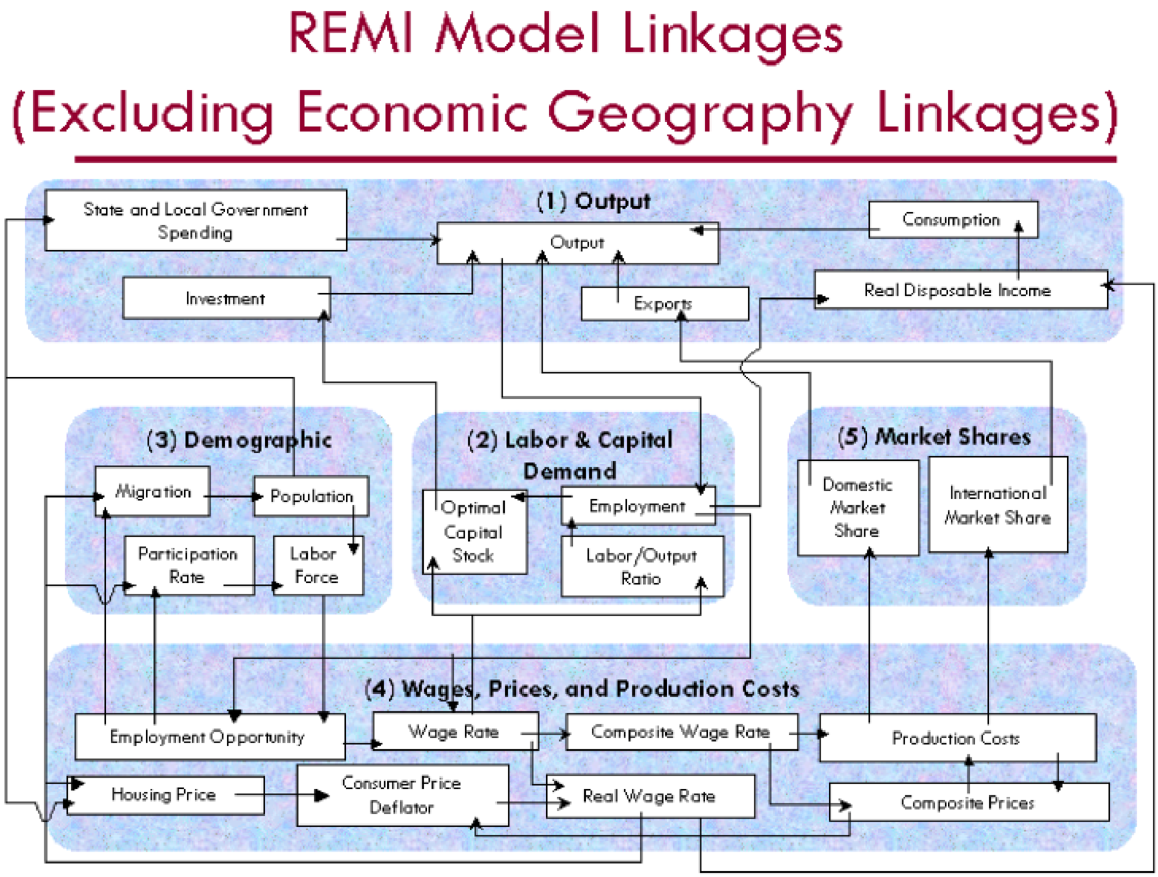
- Share of Local Market
- Share of External Market

An increase in prices leads to some substitution away from local suppliers toward external suppliers. In addition, a reduction in profitability for local factories leads to less expansion of these factories relative to those located in areas where profits have not decreased. These responses occur because the U.S. is a relatively open economy where firms can move to the area that is most advantageous for their business.

The Complete Model

Figure AII.3 illustrates the entire model and its components and linkages. This diagram is helpful in understanding the complex relationships shared by variables within the various blocks discussed above, as well as their relationships to variables in other blocks.

Figure AII.3


REMI Model Linkages
(Excluding Economic Geography Linkages)
(1) Output
State and Local Government Spending
Output
Consumption
Investment
Exports
Real Disposable Income
(3) Demographic
Migration
Population
Participation Rate
Labor Force
(2) Labor & Capital Demand
Optimal Capital Stock
Employment
Labor/Output Ratio
(5) Market Shares
Domestic Market Share
International Market Share
(4) Wages, Prices, and Production Costs
Employment Opportunity
Wage Rate
Composite Wage Rate
Production Costs
Housing Price
Consumer Price Deflator
Real Wage Rate
Composite Prices