Joseph George Caldwell
Curriculum Vitae (EU format)

1. Family name: Caldwell
2. First names: Joseph George
3. Date of birth: 23 March 1942
4. Nationality: United States of America and Canada
5. Residence: 1432 N. Camino Mateo, Tucson, Arizona 85745-3311 USA
6. Education:

Institution / Dates	Degree(s) or Diploma(s) obtained:
Spartanburg High School, Spartanburg, South Carolina USA 1958	Academic Diploma
Carnegie-Mellon University, Pittsburgh, Pennsylvania USA 1962	BS, Mathematics
University of North Carolina at Chapel Hill, Chapel Hill, North Carolina USA 1966	PhD, Statistics

7. Language skills: Indicate competence on a scale of 1 to 5 (1 - excellent; 5 - basic)

Language	Reading	Speaking	Writing
English	1	1	1
Spanish	3	3	3
French	4	4	4
German	5	5	5

8. Membership of professional bodies: American Statistical Association, Institute of Mathematical Statistics, Institute for Operations Research and Management Science
9. Key qualifications

Organizational, contract and project management. Management approach: Standards-based quality management. Management Experience: Management positions include: Manager of contract research firm (seven years); successful bidder on numerous technical contracts, including four Small Business Innovation Research (SBIR) contracts; Director of more than twenty technical projects; Adjunct Professor of Statistics at the University of Arizona, Tucson, Arizona; Director of Management Systems (chief information officer) with the Bank of Botswana (Botswana's central bank); Manager of Research and Development and Principal Scientist of US Army Electronic Proving Ground Electromagnetic Environmental Test Facility.

Technical qualifications and skills: PhD in Statistics. Management Consultant / Consulting Statistician / Research Director / System Developer. Consultant in statistics (experimental design; sample survey design and analysis; descriptive and analytical survey design; time series analysis); optimization (constrained optimization; Lagrangian optimization; game theory); operations research; information technology (systems and software engineering; system development; management information systems (MIS); database design; geographic information systems (GIS); information technology (IT) management); demography (population projections, synthetic estimation); economics (tax policy analysis; cost-benefit analysis; econometrics); program planning, monitoring and evaluation; policy analysis; strategic planning and analysis. Consultant to US government agencies, state governments, corporations and foreign governments. Experience in many application areas, including economics, banking, health, education, social services, industrial operations research and military systems. Director / supervisor of projects in the areas of:

- monitoring and evaluation (M&E); program impact evaluation; planning and policy analysis of government programs in health, education, human services, urban problems, rural development, agriculture and environment; economics (public finance, tax policy analysis, cost-benefit analysis, econometrics); institutional development
- information technology: systems and software engineering; developer of computer models and software packages; management information systems / geographic information systems design and implementation; personnel management information system (PMIS); education management information system (EMIS); database system design and development; data modeling; experienced in use of software development standards.

Teaching and Technical Training. Adjunct Professor of Statistics at University of Arizona; developer and presenter of technical seminars in *Statistical Methods for Monitoring and Evaluation: A*

Comprehensive Survey Course. Training of information-technology professionals (institutional development) in Malawi, Zambia and Botswana (management information systems in Malawi and Zambia, and banking applications in Botswana). Training of professors in impact evaluation in the Philippines.

10. Other skills: Statistical program packages (Stata, SAS, SPSS); programming languages (Fortran, C, Visual Basic); database development systems (dBASE, Microsoft Access, SQL, some Oracle, Informix); ESRI ArcView geographic information system (GIS). Much experience with Microsoft Integrated Development Environment (Visual Studio / .NET Framework, Visual Fortran, Visual C, Visual Basic, Visual FoxPro, Front Page). Some experience with Unix-based systems.

11. Present position: Consultant in Statistics

12. Years in this position: 40

13. Experience in various countries:

Country	Date
USA	1974-present. Statistical Consultant, Software Engineer, Contract Research Manager, Project Director, Professor of Statistics, all time except for periods indicated below.
Bahamas	2014, 3 weeks, Statistical Consultant (presentation of course on small-area estimation)
Jamaica	2011, 1 week, Statistical Consultant (impact evaluation design, sample survey design)
Burkina Faso	2010, 2 weeks, Statistical Consultant (impact evaluation design, sample survey design)
Namibia	2010, 2 weeks, Statistical Consultant (sample survey design)
Germany	2009, 1 week, Statistical Consultant (impact evaluation design, sample survey design)
Ghana	2009, 2 weeks, Statistical Consultant (impact evaluation design, sample survey design); 1996, 2 3-week trips, Statistical Consultant (sample survey design and analysis)
Honduras	2007-2010, 4 1-week trips, Statistical Consultant (impact evaluation design, sample survey design)
Liberia	2007-08, 2 weeks, Communication / Computer Systems Integrator (system specification)
Guinea	2007, 2 weeks, Statistical Consultant, Computer Systems Consultant).
Portugal	2006, 1 week, Source Selector for National Personnel Management Information System
Timor-Leste	2006, 2 months, Source Selector for National Personnel Management Information System
Zambia	2002-2005, 3 years, Software Engineer, developed Education Management Information System
Botswana	1999-2001, 2 years, Director of Management Systems, Bank of Botswana
Bangladesh	1998, 1 month, Software Engineer, requirements specification for national Education Management Information System
Canada	1997-98, 6 months, Consultant in Statistics, Optimization and Software Engineering (variable rate loan pricing model), Canada Trust
Malawi	1993-94, 18 months, Software Engineer, developed national Personnel Management Information System; 1995, 6 weeks, Statistical Consultant (sample survey design for annual school enrolment survey);.
Egypt	1991-92, 18 months, Statistical Consultant (Manager of Evaluation)
Philippines	1979-82, 6 1-month trips, Consultant in Impact Evaluation, Chief of Party, Project Director
Haiti	1975-76, 4 1-month trips, supervised USAID Agricultural Tax Policy Studies

14. Professional experience (positions / activities of at least 18 months duration – individual projects and activities of shorter duration are described in Annex).

Date from – Date to	Location	Company / Donor/ Contracting Company	Position	Responsibilities
1974-present	Various	Various	Consultant in Statistics	Consultant in statistics, specializing in the design of analytical surveys for impact evaluation of programs and projects in the US and foreign countries. Design techniques combine the methodologies of experimental design and sample survey design. Applications include experimental designs (randomized assignment of treatment), quasi-experimental designs (structure similar to experimental designs, but lacking randomised assignment of treatment) and observational data. Analytical survey designs use marginal stratification (implemented using variable probabilities of selection) to achieve adequate variation (balance, spread, orthogonality) in explanatory variables, and multidimensional matching to reduce bias and increase precision. Use statistical power analysis to determine sample size. National-level monitoring systems and impact evaluations implemented in the US and a number of developing countries (listed above). Sample survey designs include design-based approach (for descriptive surveys, used in program monitoring) and model-based approaches (for analytical surveys, used in program evaluation). Analysis is based on causal modeling using the Neyman-Rubin conceptual framework (counterfactuals model, potential outcomes model). Many applications involve pretest-posttest-comparison-group designs using the double-difference estimator of program impact. Analysis involves the use of complex estimators, such as a two-step estimator based on a first-step selection model and a second-step outcome model (e.g., a propensity score based estimator). Analysis involves heavy use of econometric modeling, as described in *Econometric Analysis* 7th ed. By William H. Greene (Prentice-Hall, 2012) and *Econometric Analysis of Cross Section and Panel Data* 2nd ed. by Jeffrey M. Wooldridge (MIT Press, 2010, 2002). Numerical calculations are done using the Stata statistical programming package. Dr. Caldwell has been active in the design of analytical surveys since the mid-1970s. In the 1970s he designed a number of national-level analytical survey designs in the United States and directed the *Economic and Social Impact Analysis / Women in Development* project in the Philippines (providing training in impact evaluation of development projects). His approach to analytical survey design combines aspects of experimental design and sample survey design. For quasi-experimental designs involving matching of sample units of treatment and control samples, his approach overcomes the intrinsic shortcoming of the popular propensity-score-matching (PSM) procedure, that sample units may match well on the propensity score but not match well on variables (“covariates”) that have an important effect on outcomes of interest, resulting in low precision for impact estimates (the so-called “balancing” problem). His methodology for designing analytical surveys is presented in the article, *Sample Survey Design for Evaluation (The Design of Analytical Surveys)*, posted at Internet web site http://www.foundationwebsite.org/SampleSurveyDesignForEvaluation.pdf.

				As part of his statistical consulting practice he has presented seminars on sample survey design and analysis, and he posts articles and software on statistics and related topics on his website, http://www.foundationwebsite.org (such as a program to estimate sample sizes for analytical surveys – see below for links to these, in Section 15, Other Relevant Information).
2002-2005	Lusaka, Zambia	Academy for Educational Development	Software Engineer	Development of Education Management Information System. Technical advisor (management information system developer) to a project funded by the US Agency for International Development, to develop an Educational Management Information System (EMIS) for the Zambia Ministry of Education. The purpose of the EMIS is to collect, store, and retrieve data (produce reports) from the Annual School Census, in support of program planning and analysis by the Ministry and donor agencies. Applications were developed using the Microsoft Access database development system, the Academy for Educational Development's EdAssist system, and the ArcView geographic information system (GIS). The system made effective use of optimizing techniques (indexing, execution of SELECTs and AGGREGATEs prior to table JOINs), to produce very fast running queries. The project included training of host-country counterpart staff in Microsoft Access database development, maintenance and use.
1999-2001	Gaborone, Botswana	Bank of Botswana	Director of Management Systems	Director of Management Systems. Responsible for management of all information technology operations for the Bank of Botswana, Botswana's central (reserve) bank (IT vision, strategy, policy, procedures, operations, acquisition, training, staff development). The Bank's computer system was comprised of over 300 networked microcomputers running under Windows NT/95/98/2000, Novell 4.1 and UNIX operating systems. Managed a group of 16 information technology specialists to operate and support the Bank's computer hardware and software applications (network management; Microsoft Office Suite; Internet/intranet; banking operations; accounting; investment portfolio / foreign reserve management; financial data services; economic analysis; human-resources management; and asset management. Introduced modern management and software engineering practices based on standards-based quality management (ISO 9000 Quality Management standard, ISO 12207 Information Technology standard, Carnegie Mellon University Software Engineering Institute Capability Maturity Model (CMM), DOD-STD-498 Software Development and Documentation). Responsible for system development (design, implementation), procurement, training, operations and maintenance (annual budget approximately USD3 million, exclusive of staff salaries, training, and noncomputer facilities and equipment). Responsible for setting Bank's IT vision, strategy, policy, procedures, security. Supervised approximately 30 IT projects. Directed the Bank's Year-2000 date-change ("Y2K") program, in accordance with international standards (Bank for International Settlements and US government) (no date-change problems encountered after the century date change). Directed preparation of the Bank's first disaster-recovery plan. Supervised the development of the Bank's first web page, and acquisition of the country's first "code-line clearing" system (for magnetic-ink character recognition (MICR) of bank checks). Participated in all meetings of the Bank's Executive Committee and Board of Directors; reported to the Governor and Deputy Governor.
1993-	Lilongwe,	Academy for	Software	Civil Service Personnel Management Information System Development Project. For the Malawi Department of Human Resources Management and Development, Dr. Caldwell designed and implemented the Malawi

1994	Malawi	Educational Development	Engineer	Civil Service Personnel Management Information System (PMIS). The system was developed using the dBASE database management information system, for use on microcomputers (standalone or networked) using the MS-DOS operating system. The system includes a variety of demographic and employment-related data for Malawian civil servants, and offers the users (personnel officers) a wide range of easy-to-use data entry and query/report capabilities. Experienced database users may generate queries and reports using SQL (Structured Query Language) commands or any of dBASE's automated query and report-generation features, but the system is designed with a powerful graphical user interface (GUI) so that a nontechnical user may generate all standard queries and reports without the need for any programming or entering of complicated commands, simply by making selections from a suite of menus. Data entry is facilitated by a series of easy-to-use data entry screens, with ample on-line help and validation of all entered data. Employee records may be displayed on the screen or printed. The system development effort was conducted in full compliance with the DOD-STD-2167A software development standard (predecessor of today's ISO 12207 Information Technology Standard), and included the production of almost 1,000 pages of detailed system documentation, including a *System Design Document, Software Requirements Specification, Software Design Document, Software Programmer's Manual, Software Product Specification,* and *Software User's Manual*. The project included on-the-job training of members of the Department's Management Information Systems Unit (systems analysts, programmers) in systems engineering (requirements analysis, technology assessment, synthesis of alternatives, specification of evaluation criteria, selection of a preferred alternative, top-level design, detailed design (optimization), implementation, and test), the modern software engineering discipline (structured, top-down design), management information system design, dBASE, software development project management, and basic microcomputer upgrading and repair; and classroom instruction for system users (personnel officers) in use of the system for data entry and retrieval (queries and report generation). In a follow-up check ten years after completion of the system, it was still in operation.
1991-1992	Cairo, Egypt	Chemonics	Manager of Evaluation	Served as manager of Monitoring and Evaluation for the USAID-funded Local Development II - Provincial (LDII-P) project, which provided technical assistance in the development and maintenance of USAID-funded infrastructure projects in Egypt (potable water, waste water, roads, buildings, rolling stock, environment, and information systems). The LDII-P project was the largest USAID local development project in the world, having funded the development of over 16,000 local-level projects. On this project, Dr. Caldwell made heavy use of automated management information system tools (dBASE, SPSS) to store, process, and retrieve data on project status and needs assessment (including continuous monitoring of project status indicators), and applied the techniques of sample survey (questionnaire development, stratified random sampling) and rapid appraisal techniques (focus group interviews) to assist end-of-project evaluation, as well as continuous monitoring of indicators. Dr. Caldwell lectured on the use of geographic information systems (GISs) in development planning, and supervised training of development planners in use of the PC-ARC/INFO GIS.
1988-	Tucson,	Vista	President	Founded and operated contract research firm specializing in strategic and tactical analysis, simulation and modeling, program monitoring and evaluation, artificial intelligence applications, and software systems

1991	Arizona USA	Research Corporation		development. Winner of four Small Business Innovation Research (SBIR) contracts. Projects included the following: • Research in Artificial Intelligence for Noncommunications Electronic Warfare Systems • Tactical Theater Air Warfare Methodologies • Fast Algorithms for Real-Time Estimation, Prediction and Control
1982-1988	Tucson and Sierra Vista, Arizona USA	Bell Technical Operations, Combustion Engineering	Principal Scientist, Manager of Research and Development	Manager of Research and Development and Principal Scientist of United States Army Electronic Proving Ground (EPG) Electromagnetic Environmental Test Facility (EMETF). The EMETF conducts operational test of military communication-electronics systems (such as the Global Positioning System) prior to deployment. Responsible for design and analysis of operational test and evaluation of military electronic equipment. Managed staff of about 16 (mostly PhDs in engineering, science and mathematics). Supervised the design and analysis of development tests of defense communications electronics (C-E) systems. Directed the following projects: • Dynamic Electromagnetic Systems Combat Effectiveness Model. • Simulation of Realistic Electromagnetic Environment for Stress Load Testing. • Simulation Model Architecture / Intelligence Electronic Warfare (IEW) Model Extension. • Statistical Analysis of Voice Scoring Data. • Requirements Specification for Computer-Graphics Deployment Analysis System.
1982-1986	Tucson, Arizona USA	University of Arizona	Adjunct Professor of Statistics	Taught the graduate course, Sampling Theory and Methods, and the required basic undergraduate statistics course for all students of business, public administration and management information systems. This class was very large, with about 500 students per semester. Presented lectures to two classes of 250 and supervised five graduate teaching assistants, who conducted homework-review and test-review sessions in small classes (of about 30 students each).
1977-1981	Alexandria, Virginia and Tucson, Arizona USA	Vista Research Corporation	President	President and manager of contract research firm. Contracts included the following. • Microsimulation Forecasting Model for Human Development Services Programs • Economic and Social Impact Analysis / Women in Development (ESIA/WID) Project in the Philippines • Social Services Effectiveness Evaluation in West Virginia • Evaluation of the Economic and Social Consequences of the US Department of Agriculture Extension Education Program • Sampling Manual for Office of Child Support Enforcement Reporting Requirements • Statistical Analysis Group in Education (SAGE) • Elementary and Secondary School Civil Rights Survey • Bossangoa Integrated Rural Development Project Central African Republic

1974-1976	Annandale, Virginia USA	JWK International Cororation	Vice President	Served as Vice President of firm from inception to size of about 30 technical staff. Responsible for all technical projects (supervised all, directed many). Projects included the following: • Analysis of Federal Medicaid Matching Percentage Formula • Economic Policy Analysis for the Government of Haiti (tax policy analysis for major export commodities, coffee, cotton, sisal, mangoes and meat) • Medicaid Standards Impact Assessment • Sampling Manual for Social Services (Title XX) Reporting Requirements • Vocational Rehabilitation Performance Evaluation Standards Study • Cost Benefit Analysis of NIAAA Alcoholism Treatment Centers • Cost Benefit Analysis of NASA Technology Transfer Programs • Day Care Cost Benefit Study • Vocational Rehabilitation Program Administration Review • Vocational Rehabilitation Follow-up Study. • Vocational Rehabilitation State Allocation Study
1972-1974	McLean, Virginia USA	Planning Research Corporation	Principal	Principal of world's then-largest non-legal non-medical contract research firm. Primarily engaged in the development of correlation / tracking algorithms for satellite ocean surveillance systems. <u>US Navy Systems Simulation Program.</u> As part of the effort to design the Naval Satellite Ocean Surveillance System, determined methods for performing correlation/tracking and multisensor fusion of surveillance data. This work is described in the reports, *Correlation/Tracking Performance Study* and *Improvements to the Systems Simulation Program*, Navy Space Systems Activity (NAVELEX).
1967-1972	Arlington and McLean, Virginia USA	Lambda Corporation / General Research Corporation	Member of the Technical Staff	Member of the technical staff of Lambda Corporation (later General Research Corporation), a contract research firm specializing in solving optimization and game-theory problems in defense and industrial applications. Lambda Corporation was founded by Hugh Everett III, the American physicist who developed the Parallel Universe (Many Worlds) interpretation of quantum mechanics and the Generalized Lagrange Multiplier (GLM) method for solving large constrained optimization problems, such as resource-allocation problems and games. The GLM method is useful for solving problems in which the objective function is nonlinear, nonconvex, and noncontinous. The GLM optimization method was used in many of the projects conducted by the firm. For a large operations research study of alternative modes of pharmaceutical manufacturing, developed Box-Jenkins models to simulate product demand. Following this project, developed *TIMES*, the first commercially available general purpose statistical program package for analyzing time series data using the Box-Jenkins (Autoregressive Integrated Moving Average, ARIMA) models. Conducted the following studies, all of which involved application of the GLM methodology: • Subtractive Overlapping-Island Missile Defense with Imperfect Interceptors

				• Optimal Ballistic Missile Point (Local) Defense with Imperfect Interceptors • HARDSITE Defense Model • Naval Combat Damage Model: Multiple Resource-Constrained Game Solution • Box-Jenkins Filter Feasibility Study (Evaluation of Alternative Missile Tracking Systems) • Conflict, Negotiation and General-Sum Game Theory The last project found an approximate, but explicit, solution to Nash's bargaining solution to a general-sum game (Nash's theory presented only an existence proof, not a constructive proof, of the bargaining solution). This work involved basic research in game theory. A reprint of the original report is posted at Internet website http://www.foundationwebsite.org/Conflict.htm.
1964-1966	Research Triangle Park, North Carolina USA	Research Triangle Institute (RTI)	Operations Research Analyst	Conducted operations research studies in civil defense applications. Participated in national sample survey of fallout shelters (field survey work, data analysis and reporting), analysis of radiological defense, post-nuclear attack health and medical issues, vulnerability of the national electric power system to nuclear attack, and post-attack countermeasures.

15. Other relevant information: (e.g. conferences, seminars, publications)

Teaching and Technical Training

Dr. Caldwell served as adjunct professor of statistics at the University of Arizona, where he taught the graduate course in sample survey design and analysis and the basic statistics course for all students of business, management, management information systems, and public administration (500 students per semester).

As director of the *Economic and Social Impact Analysis / Women in Development* project in the Philippines, Dr. Caldwell trained university professors in the theory and methodology of impact evaluation. As part the project to develop the Personnel Management Information system for the civil service of Malawi, he trained IT professionals (in the Office of the President) in the methodology for development and maintenance of a national-level management information system. In Zambia, he trained staff of the Ministry of Education in the technology of development and maintenance of the national Education Management Information System. As Director of Management Systems for the Bank of Botswana (Botswana's central bank), he was responsible for professional development and training of the Bank's information-technology staff.

Dr. Caldwell has developed and presented a number of statistics courses relating to monitoring and evaluation (*Statistical Methods for Monitoring and Evaluation: A Comprehensive Survey Course*). These courses have been presented on an advertised basis and as in-house courses at client facilities (US Bureau of Labor Statistics; National Opinion Research Center; Bahamas Department of Statistics). Course notes for this course are posted at Internet websites
http://www.foundationwebsite.org/StatCourse1&2SampleSurvey3DayCourse.pdf
http://www.foundationwebsite.org/StatCourse3ReviewOfStatisticalInference.pdf
http://www.foundationwebsite.org/StatCourse4&5CausalInferenceAndMatching.pdf
http://www.foundationwebsite.org/StatCourse6&7StatisticalDesignAndAnalysisForEvaluation2DayCourse.pdf
http://www.foundationwebsite.org/StatCourse8SampleSizeDetermination.pdf
http://www.foundationwebsite.org/StatCourse9MissingData.pdf
http://www.foundationwebsite.org/StatCourse10SmallAreaEstimation.pdf

Computer Software in Statistics and Demography.

Computer Software for Time Series Analysis, Forecasting and Control. Dr. Caldwell developed the first commercially-available general-purpose Box-Jenkins computer-forecasting package (*TIMES*, described at http://www.foundationwebsite.org/BoxJenkins.pdf , http://www.foundationwebsite.org/TIMESVol1TechnicalBackground.pdf).
A computer program for developing the most common Box-Jenkins models is posted at http://www.foundationwebsire.org/BoxJenkinsForecastingProgram.exe.

Computer Software for Demographic Analysis and Synthetic Estimation. Dr. Caldwell developed the *DESTINY* microcomputer software for making demographic projections (cohort-component, synthetic estimation) (described at http://www.foundationwebsite.org/DestCapINTL.pdf; similar to USAID's *RAPID* population-projection program, but extended to handle multiple regions and ethnic groups). The *DESTINY* system uses the cohort-component method of population projection to produce estimates of population by age, sex, race and region, and applies the method of synthetic estimation to determine forecasts of variables related to population.

Statistical Methodology for Evaluation. An article describing Dr. Caldwell's approach to the design of analytical surveys (e.g., for impact evaluation of economic and social development programs) is posted at http://www.foundationwebsite.org/SampleSurveyDesignForEvaluation.pdf, and a computer program for determining sample sizes for complex surveys is posted at http://www.foundationwebsite.org/JGCSampleSizeProgram.mdb (a Microsoft Access program). An illustrative example of use of this program is presented in the article *Determination of Sample Size for Analytical Surveys, Using a Pretest-Posttest-Comparison-Group Design*, posted at http://www.foundationwebsite.org/SampleSizeEstimationAnalyticalSurveysGeneric.htm.

Annexes

Biography

Joseph George Caldwell III was born in Kingston, Ontario, Canada on 23 March 1942 to Joseph George Caldwell Jr. of Belleville, Ontario, and Evelyn Phyllis Barter Caldwell of Grand Cascapedia, Quebec. His great-grandparents were Joseph Caldwell (1853-1931) and Edna Mary Conant (1855-1916) of Belleville, Ontario. Edna Mary was a direct descendant of Roger Conant ("Roger Conant the Pilgrim", bapt. 1592-1678) who came to America on the Anne (second ship, following the Mayflower) in 1623 and became the first Governor of Massachusetts Bay Colony under the British Crown. The Conant family history is documented in Thomas Conant's books *Upper Canada Sketches* (William Briggs, 1898) and *Life in Canada* (William Briggs, 1903) (both available on the Internet, at http://archive.org/download/uppercanada00conauoft/uppercanada00conauoft.pdf and http://archive.org/download/lifeincanada00conauoft/lifeincanada00conauoft.pdf). Following the American Revolution, Roger Conant's descendant, also Roger Conant (b. 1748), moved his family to Canada in 1778-92, as part of the United Empire Loyalist movement.

Joseph moved with his family to the United States in January, 1953. His family lived in Lakeland, Florida, and Newark, Delaware, before settling in Spartanburg, South Carolina, in June of 1956. He graduated from Spartanburg High School in 1958. He attended Carnegie Institute of Technology (now Carnegie Mellon University) and received a BS degree in mathematics in 1962. He attended the University of North Carolina at Chapel Hill and received a PhD degree in mathematical statistics in 1966. For his doctoral dissertation, he developed the best known class of codes for correcting both additive and synchronization errors in noisy communication channels. His dissertation advisor was the renowned Indian-American mathematician, Raj Chandra Bose, who co-invented the Bose-Chaudhuri-Hocquenguem (BCH) codes and who disproved Leonhard Euler's 1782 conjecture about the existence of certain Graeco-Latin squares.

In his professional career he worked both as an independent consulting statistician and researcher and manager for contract-research consulting firms. He was a Member of the Technical Staff of Lambda Corporation, founded by Hugh Everett III (creator of the "Parallel Universe" or "Many Worlds" theory of quantum mechanics and the constrained optimization theory of Generalized Lagrange Multipliers). In that role he developed a practical method for obtaining approximate solutions to John Nash's Bargaining Solution to General-Sum Games. Other positions he held included Principal of Planning Research Corporation (PRC); Manager of Research and Development of the US Army Electronic Proving Ground's Electromagnetic Environmental Test Facility; Adjunct Professor of Statistics at the University of Arizona; Director of Management Systems for the (Central) Bank of Botswana; and President of Vista Research Corporation. In the field of software engineering, he developed the Civil Service Personnel Management Information System for Malaŵi and the Education Management Information System for Zambia.

He was the author of several books and numerous articles on divers topics, including statistics, population and the environment, politics, religion and music (guitar). His hobbies included snow and water skiing, SCUBA diving, Tae Kwon Do, running, and music (guitar, trombone and baritone horn (euphonium)). In recent years he served as a consulting statistician to the National Opinion Research Center (NORC) of the University of Chicago, constructing sample survey designs for impact evaluation of large economic development programs in foreign countries in Africa and Latin America. He lived in a number of places, including Alexandria and Fairfax, Virginia; Clearwater, Florida; Charlotte, North Carolina; Toronto, Ontario, Canada; Cairo, Egypt; Lilongwe, Malaŵi; Gaborone, Botswana; Lusaka, Zambia; Spartanburg, South Carolina, and Tucson, Arizona.

He is married to Jacquelyn Anne Reed Caldwell of St. Louis, Missouri. His first wife (deceased) was Timothy Gale Tinsley (1939-1989) of Spartanburg, South Carolina. He had three children, Joseph George Caldwell IV (deceased), Christopher Scott Caldwell and Steven Lindsay Caldwell.

Summary of Professional Experience

Management Experience. Organizational, contract and project manager. Management approach: Standards-based quality management (ISO 9000). Management positions include: Manager of contract research firm (seven years); successful bidder on numerous technical contracts, including four Small Business Innovation Research (SBIR) contracts. Director of more than twenty technical projects. Adjunct Professor of Statistics at the University of Arizona, Tucson, Arizona; Director of Management Systems (chief information officer) with the Bank of Botswana (Botswana's central bank); Manager of Research and Development and Principal Scientist of US Army Electronic Proving Ground Electromagnetic Environmental Test Facility.

Management Consultant / Consulting Statistician / Research Director / System Developer. Consultant in statistics (experimental design; sample survey design and analysis; descriptive and analytical survey design; time series analysis); optimization (constrained optimization; Lagrangian optimization; game theory); operations research; information technology (systems and software engineering; system development; management information systems (MIS); database design; geographic information systems (GIS); information technology (IT) management); demography (population projections, synthetic estimation); economics (tax policy analysis; cost-benefit analysis; econometrics); program planning, monitoring and evaluation; policy analysis; strategic planning and analysis. Consultant to US government agencies, state governments, corporations and foreign governments. Experience in many application areas, including economics, banking, health, education, social services, industrial operations research and military systems. Director / supervisor of projects in the areas of:

- monitoring and evaluation (M&E); program impact evaluation; planning and policy analysis of government programs in health, education, human services, urban problems, rural development, agriculture and environment; economics (public finance, tax policy analysis, cost-benefit analysis, econometrics); institutional development
- information technology: systems and software engineering; developer of computer models and software packages; management information systems / geographic information systems design and implementation; personnel management information system (PMIS); education management information system (EMIS); database system design and development; data modeling; experienced in use of software development standards, ISO-9000 Quality Management, ISO 12207 Information Technology, Carnegie-Mellon University Software Engineering Institute Capability Maturity Model); engineering (communications-electronics; coding theory).
- international development in Jamaica, Honduras, Ghana, Namibia, Burkina Faso, Guinea, Liberia, Timor-Leste, Zambia, Botswana, Bangladesh, Malawi, Egypt, the Philippines, and Haiti
- operations research and systems analysis in the textile and pharmaceutical industries, civil defense and military applications
- military weapon systems analysis (US Department of Defense and Departments of the Navy, Army and Air Force) in the areas of ballistic missile warfare; naval general purpose forces; naval ocean surveillance; tactical air warfare; communications-electronics; test and evaluation; simulation and modeling; optimization and game theory; system development and automated scenario generation

Teaching and Technical Training. Adjunct Professor of Statistics at University of Arizona; developer and presenter of technical seminars in *Sample Survey Design and Analysis* and *Statistical Design and Analysis in Evaluation*. Training of information-technology professionals (institutional development) in Malawi, Zambia and Botswana (management information systems in Malawi and Zambia, and banking applications in Botswana). Training of professors in impact evaluation in the Philippines.

The following paragraphs describe Dr. Caldwell's experience and approach in four areas, in greater detail: (1) management approach; (2) statistical applications in monitoring and evaluation; (3) operations research, systems analysis and statistics in industrial, commercial and military applications; (4) systems and software engineering.

1. *Management Approach: Standards-Based Quality Management*

Management Consulting / Business Experience. Dr. Caldwell has substantial experience in management consulting to industry, including consulting, training, and system development in forecasting, quality control, product improvement, process control, and economic analysis of production alternatives. He founded and managed his own contract research firm (Vista Research Corporation, operated full-time for seven years), and set up a ladies' fashions importing/retailing firm (Sonora Marketing Corporation). In these efforts, Dr. Caldwell designed, implemented and managed all major functional components of the operations (marketing, production, and finance).

Standards-Based Quality Management. For larger projects, Dr. Caldwell employs a "standards-based quality management" approach to project management. This approach makes full use of internationally recognized management and technical standards that are applicable to the effort. Examples of projects that he directed that employed this approach are the following:

- Manager of Research and Development and Principal Scientist, US Army Electronic Proving Ground's Electromagnetic Environmental Test Facility. In this role, all of the engineering and software

development efforts directed by Dr. Caldwell were conducted in conformance with applicable US military standards (software development, systems engineering, test and evaluation).

- Personnel Management Information System (PMIS) for the Government of Malawi. This project, which developed the personnel management information system for the Malawi civil service, was conducted in strict compliance with the leading software development standard at the time, the US Department of Defense's Defense Systems Software Development, DOD-STD2167A, which was the predecessor to today's international information-technology standard, ISO 12207, Software Life Cycle Processes.
- Research in Artificial Intelligence for Noncommunications Electronic Warfare Systems. The purpose of this project was to develop an automated system for generating military scenarios for use in testing of military electronic-warfare systems. This project was developed in full compliance with the DOD-STD2167A Defense Systems Software Development Standard.
- Director of Management Systems for the central bank of Botswana. As Director of Management System for the Bank of Botswana, Dr. Caldwell introduced a number of quality-management initiatives, including:
    - Direction of the Bank's Year-2000 program using guidelines published by the US General Accounting Office ("Year 2000 Computing Crisis: Business Continuity and Contingency Planning") and the Bank for International Settlements. As a result of this program, the Bank did not experience a single "Year 2000 date change" problem.
    - Use of the ISO 12207 Information Technology Standard to guide all major software development and acquisition efforts (such as the effort to acquire a national code-line clearing system based on magnetic-ink character recognition of checks, and the project to acquire a computer network management system for the Bank).
    - Initiation of an effort to have the Bank's Management Systems Department operate in compliance with the ISO 9000 Quality Management Standard.
    - Assessment of the software development capability of the Bank's staff and its software suppliers using the Carnegie Mellon University Software Engineering Institute's Capability Maturity Model (CMM) (predecessor of the ISO 15504 Standard, Software Process Improvement and Capability Determination ("SPICE")).
    - Direction of the project to develop the Bank's Business Continuity Plan / Disaster Recovery Plan, using the Business Continuity Planning Guidelines issued by the Texas Department of Information Resources.
    - Direction of the project to develop an information technology security plan, using the US General Accounting Office's Information Security Risk Assessment guidelines.

In addition to providing assurance that work conducted in compliance with international professional standards will be of high quality, one of the other distinct benefits of using standards-based quality management is that staff members benefit greatly from being provided the opportunity and experience of working in compliance with quality management and technical standards.

2. Statistical Applications in Program Monitoring and Evaluation

Dr. Caldwell developed the design for many national sample surveys and statistical reporting systems. He specializes in the development of analytical survey designs to collect data for model development, and developed new techniques for handling nonresponse in longitudinal surveys. An article describing Dr. Caldwell's approach to the design of analytical surveys (e.g., for impact evaluation of economic and social development programs) is posted at http://www.foundationwebsite.org/SampleSurveyDesignForEvaluation.htm , and a computer program for determining sample sizes for complex surveys is posted at http://www.foundationwebsite.org/JGCSampleSizeProgram.mdb (a Microsoft Access program).

Program monitoring surveys and reporting systems include:

- Zambia Education Management Information System (EMIS)
- Ghana Trade and Investment Program Survey
- Malawi Annual Primary School Enrollment Survey
- Malawi Civil Service Personnel Management Information System (PMIS)
- National Center for Health Services Research Hospital Cost Data Study
- Professional Standards Review Organization Data Base Development Study
- Study of Impact of National Health Insurance on Bureau of Community Health Service Users
- 1976 Survey of Institutionalized Persons

- Sampling Manual for Utilization Review of Medicaid
- Sampling Manual for Social Services (Title XX) Reporting Requirements
- Sampling Manual for Office of Child Support Enforcement Reporting Requirements
- Dept. of Housing and Urban Development Housing Market Practices Survey
- Research Design for the Urban Arterials Section of the Highway Capacity Manual
- Elementary and Secondary School Civil Rights Survey

Evaluation Research / Impact Evaluation. Dr. Caldwell developed analytical sample survey designs for impact evaluations in the US, Jamaica, Honduras, Ghana, Burkina Faso, Namibia, Benin, Malawi, Zambia, and Côte d'Ivoire:

- Impact Evaluation of the Programme of Advancement through Health and Education (PATH), Jamaica (a conditional cash transfer program)
- Evaluation of Performance and Impact of Rehabilitation and Intensification of Olive Plantations in Rain-fed Zones, Morocco (Millennium Challenge Corporation)
- Agricultural Data Collection in the Sourou Valley and Comoé Valley, Burkina Faso (Millennium Challenge Corporation)
- Community-Based Rangeland and Livestock Management Household Income and Expenditure Surveys, Namibia (Millennium Challenge Corporation)
- Conservancy Support and Indigenous Natural Products Household and Organisational Surveys, Namibia (Millennium Challenge Corporation)
- Impact Evaluation of Water Supply Activity, Ghana (Millennium Challenge Corporation)
- Monitoring and Evaluation of the Competitive African Cashew Value Chains for Pro-Poor Growth Program in Benin, Burkina Faso, Côte d'Ivoire, Ghana and Mozambique (Deutsche Gesellschaft für Zusammenarbeit (GTZ))
- Monitoring and Evaluation of the Competitive Action Cotton for Pro-Poor Growth Program in Benin, Burkina Faso, Côte d'Ivoire, Zambia, Ghana and Malawi (Deutsche Investions und Entwicklungsgesellschaft (DEG))
- Impact of Feeder Roads Activity, Ghana (Millennium Challenge Corporation)
- Farmer Training and Development Activity, Honduras (Millennium Challenge Corporation)
- Transportation Project, Honduras (Millennium Challenge Corporation)

and directed or supervised the following impact evaluation studies:

- Economic and Social Impact Evaluation / Women in Development in the Philippines
- Manager of Evaluation for Local Development II - Provincial Project in Egypt
- Measuring the Effectiveness of Social Services in West Virginia
- Day Care Cost-Benefit Study
- Vocational Rehabilitation Evaluation Standards Study
- Cost-Benefit Analysis of National Institute for Alcohol Abuse and Alcoholism Treatment Centers
- Medicaid Standards Impact Assessment

Public Finance. In addition to his work in tax policy analysis and cost-benefit analysis, Dr. Caldwell directed studies to develop alternative allocation / matching formulas for major state/federal programs:

- Vocational Rehabilitation State Allocation Formula
- Medicaid and AFDC Matching Percentage Formula

Dr. Caldwell is author of the book, The *Value-Added Tax: A New Tax System for the United States* (1987, 2000). An online copy of this book is posted at Internet web site http://www.foundationwebsite.org/VAT.pdf . This work not only describes a new tax system for the United States, but also presents a new methodology (based on the principles of systems engineering, and called "Tax Engineering") for designing tax systems.

3. Operations Research, Systems Analysis and Statistics in Industrial, Commercial and Military Applications.

Dr. Caldwell applied a wide variety of operations research and statistical techniques to solve practical problems in industrial, commercial and applications. Applications include the use of simulation and modeling, optimization and statistical methods to solve problems in process control, forecasting, economic analysis and optimal allocation of resources in industrial, commercial and military applications (textile and pharmaceutical manufacturing, banking, ballistic missile defense, naval ocean surveillance, test and evaluation of military electronic systems and equipment (communications and noncommunications)). These applications often involved the use of state-of-the-art technical methodologies such as (1) application of the Box-Jenkins time-series modeling method for demand forecasting (several years prior to publication of the Box-Jenkins book, *Time Series Analysis, Forecasting and Control*); (2)

application of the Generalized Lagrange Multiplier (GLM) optimization methodology and game theory for solving complex resource allocation problems in military applications and banking (variable-rate loan pricing strategies); (3) application of the just-introduced ArcView 3.0 geographic information system to identify good locations for automated teller machines (ATMs); and (4) application of artificial intelligence and expert systems methodology to develop automated scenario generation models for use in testing of noncommunication electronic warfare systems.

Much of Dr. Caldwell's work involved application of modern methodology to solve difficult problems in resource-constrained optimization, such as applications involving nonlinear, nonconvex and noncontinuous objective functions (in which cases standard techniques such as linear programming are not useful). In some instances, no satisfactory existing solution methodology existed, and new theory was developed. For example, in his work in ballistic missile defense, he developed a computationally feasible method for determining approximate solutions to John Nash's bargaining solution to a general-sum game (Nash's theory presented only an existence proof, not a constructive proof, of the bargaining solution). This work involved basic research in game theory. A reprint of the original report produced by this effort is posted at Internet website http://www.foundationwebsite.org/Conflict.htm.

4. Systems and Software Engineering

Dr. Caldwell's work in software engineering includes development of national management information systems, director of information technology for a central bank, and development of specialized computer software programs and packages. Large systems were developed in accordance with applicable software development standards.

Level of Operation. In his information-technology (IT) work, Dr. Caldwell has operated at all organizational and technological levels, from administration, supervision and project direction through system design and implementation. As Director of Management Systems (chief information officer) at the Bank of Botswana, he directed a staff of 16 IT professionals and many projects, including the Year 2000 project, the project to set up a bank disaster recovery / avoidance system, the project to acquire a computer network management system for the Bank, and the project to acquire a magnetic-ink character-recognition (MICR) code-line clearing system for the country's bank checks. As Manager of Research and Development and Principal Scientist at the US Army Electronic Proving Ground's Electromagnetic Environmental Test Facility he directed a staff of 16 scientists and engineers in test and evaluation of military communications-electronics systems, and conducted all work in accordance with US Department of Defense military standards. As manager of Vista Research Corporation he was engaged in all aspects of computer systems development (systems and software engineering), from requirements specification and top-level design through coding and testing. He conducted all aspects of development of the Personnel Management Information System (PMIS) for the Government of Malawi and the Education Management Information System (EMIS) for the Government of Zambia.

Management Approach. For larger projects or operations, he is a strong proponent of "standards-based quality management," which makes heavy use of international standards (ISO 9000 Quality Management, ISO 12207 Information Technology Standard and its predecessors (the US Department of Defense's Software Development Standards (DOD-STD-2167A and MIL-STD-498)), the Carnegie-Mellon University Software Engineering Institute Capability Maturity Model (CMU SEI CMM), and ISO/IEC 15504 (Software Process Improvement and Capability Determination, or "SPICE").

Design Approach. He has directed numerous software engineering projects, applying the modern principles of systems and software engineering. This approach includes user needs analysis, requirements specification and analysis, technology review, synthesis of system alternatives, cost-effectiveness analysis of alternatives and selection of a preferred alternative, detailed design, implementation and test. For the software subsystem he utilizes top-down, structured design combined with rapid prototyping (iterative development).

Here follows a summary of software development projects, ranging from national-level management information systems, general-purpose software programs and packages, and special applications.

National Management Information Systems

- Civil service Personnel Management Information System (PMIS) for Malawi
- Education Management Information System (EMIS) for Zambia

General-Purpose Software Programs and Packages

- Computer program for estimating sample sizes for complex surveys

- *TIMES*, the first commercially available general purpose Box-Jenkins time-series-analysis computer program
- The *DESTINY* system for making population projections and synthetic estimates of quantities related to population
- The *MICROSIM* prototype microsimulation forecasting model for estimating caseloads and budgets in human-service applications
- *SCENARIST* prototype automated scenario generating system (artificial intelligence, expert systems, GRASS geographic information system)

Special Applications

- Computer programs for implementing statistical matching and marginal stratification using variable probabilities of selection
- Variable-rate bank loan pricing model (based on Generalized Lagrange Multipliers (GLM))
- ATM Placement Model (SAS, ArcView GIS)
- Vocational Rehabilitation State Allocation Model
- Correlation / Tracking Model for Naval Ocean Surveillance System
- Terminal Missile Defense with Imperfect Inteceptors (GLM)
- Subtractive Overlapping Island Defense Model (GLM)
- Program for obtaining approximate solutions to John Nash's Bargaining Solution for a General Sum Game (GLM)
- HARDSITE Defense Model (GLM)
- Naval Combat Damage Model (GLM)
- Multiple Resource-Constrained Game Model (GLM)

Details on System Development and Programming Experience

Technology: Development Environments, Operating Systems, Programming Languages and Packages. Dr. Caldwell has extensive hands-on system development experience. His computer experience includes mainframe, mini- and microcomputer applications. He has much experience in applications programming in Fortran, C, Visual C, Visual Basic, dBASE/FoxPro, Microsoft Access and SQL on mainframe computers, minicomputers and microcomputers under a variety of operating systems (MS-DOS, Microsoft Windows, UNIX, IBM, CDC, UNIVAC, Sun Microsystems Solaris and others). Most of his microcomputer development work used the Microsoft Visual Studio Integrated Development Environment (IDE) / .NET Framework. He is experienced in application of database systems (SQL-based relational database systems such as Microsoft Access, Oracle and Informix and Xbase systems such as dBASE and FoxPro), and of statistical program packages (e.g., Stata, SAS and SPSS). He has some experience on Unix operating systems (e.g., Sun Microsystems Solaris) and some familiarity with Unix-related open-source systems (Linux, Apache, MySQL, PHP ("LAMP")). He is familiar with a variety of commercial microcomputer software applications (e.g., word processing, electronic spreadsheet, data base, desktop publishing, web page development, accounting), including the Microsoft Office suite of products (Word, Access, Excel, PowerPoint, FrontPage (HTML web page development system, replaced in 2006 by Microsoft Expression Web and Sharepoint Designer) in both standalone and network environments.

Application Areas (in Software Engineering)

Computer Models for Forecasting and Demographic Analysis. Dr. Caldwell developed *TIMES*, the first commercially-available general-purpose Box-Jenkins computer-forecasting package and the *DESTINY* microcomputer software system for making demographic projections (cohort-component, synthetic estimation) For the US Department of Health and Human Services (HHS), he directed the project to develop a prototype microsimulation forecasting model and a statistical reporting system to provide the data required by the model. The model -- called *MICROSIM* -- was developed to forecast caseloads and expenditures for HHS programs under various policy assumptions.

Artificial Intelligence / Expert Systems / Geographic Information Systems. For the US Army Communications-Electronics Command, he directed a project to develop a prototype expert system, named *SCENARIST*, to position military units and equipment, taking into account the location of friendly and opposing forces, mission, tactical combat rules, and digital terrain data. The system (which included 50,000 lines of C code) incorporated the NASA-developed C-Language Integrated Production System (*CLIPS*) expert system and used digital mapping data extracted from the US Army's Geographic Resources and Services System (*GRASS*) geographic information system (GIS). The system

was developed for MS-DOS-based 80x86 microcomputers, and included a comprehensive graphical user interface (mouse, windows, and menus).

Banking / Finance. He developed a geographic information system application (ArcView 3.0 GIS, SAS) to identify good locations for bank automated teller machines (ATMs). He developed a simulation / optimization system, based on Generalized Lagrange Multipliers, to determine optimal loan pricing strategies (Windows NT, Microsoft Visual Basic 5.0).

Program Evaluation; Civil Service and Education Management Information Systems. Dr. Caldwell personally conducted all of the software and database design and most of the programming for the statistical and information systems work in the Egypt, Malawi (civil service Personnel Management Information System) and Zambia (Education Management Information System) applications mentioned above.

PROFESSIONAL AFFILIATIONS: Institute for Management Sciences and Operations Research (INFORMS), American Statistical Association, Institute of Mathematical Statistics.

HONORS / AWARDS: Tau Beta Pi National Engineering Honorary Society, General Motors Scholarship (Carnegie-Mellon University, Pittsburgh), NASA Fellowship (University of North Carolina at Chapel Hill).

CIVIC ACTIVITIES: Scoutmaster (11 years), Boy Scouts of America; letters to editor of local newspapers on political topics; active in local-government issues affecting the community; play guitar and sing each week at assisted-care facility; Tuba Christmas (Columbus, NC); Cochise County (Arizona) Community College Band.

HOBBIES: Writing, music (guitar, baritone horn, trombone); golf; running; SCUBA diving; snow and water skiing; archery; Tae Kwon Do; Toastmasters; classic cars (1972 Karmann Ghia, 1971 Datsun 240Z, 1980 Cadillac Seville, 1966 Ford Mustang, 1978 Chevrolet Corvette; mechanical work and painting); travel; foreign languages; sailing; gardening / landscaping; dogs.

Project Descriptions

Date from - Date to	Location	Company: Donor/ Contracting Company and Reference person contact details (since 2007)	Position	Description: Name of the project; Responsibilities
2016	Tucson, AZ	The Mitchell Group, Washington, DC / USAID; Ms. Elaine Clark, elainec@the-mitchellgroup.com	Statistical Consultant	2016, Statistical Consultant, The Mitchell Group. Expert consultant in statistics; sample weighting specialist. SAREL project (USAID). The Sahel Resilience Learning Project (SAREL) and the Resilience in the Sahel Enhanced (RISE) Initiative Baseline Survey are efforts to increase the resilience of chronically vulnerable populations in the agro-pastoral and marginal areas of Burkina Faso and Niger. The RISE survey was a probabilistic household survey o 2,500 households across villages in the Sahel. The survey was a complex sample survey consisting of a stratified first-stage sample of 100 villages and a second-stage sample of 25 households in each selected village. Advised on specification of proper statistical procedures for analyzing the collected survey data, using Stata (*svy* module).
2015	Spartanburg, SC and Tucson, AZ USA	National Opinion Research Center of the University of Chicago (NORC), Bethesda, MD, Ms. Varuni Dayaratna, Dayaratna-Varuni@norc.org	Statistical Consultant	Sample survey design consulting services (statistical power analysis for sample size determination; sample allocation and selection; calculation of survey weights) to proposals and projects in international development (USAID Burundi Village Savings and Loan Association (VSLA) child welfare project; IADB Honduras Bono 10 Mil conditional cash transfer project; USAID Liberia Electoral Access and Participation (LEAP) project).

Mar 2014 – July 2014	Nassau, Bahamas and Spartanburg, SC USA	Inter-American Development Bank / Bahamas Department of Statistics / Ms. Cypreanna Winters cypwin@yahoo.com	Statistical Consultant	Development and presentation on a training course on small-area estimation, for the Bahamas Department of Statistics. The purpose of the course is to describe statistical methodology for making estimates of unemployment for the Bahamas Labour Force Survey (conducted in May and November of each year), for small islands or island groups for which the sample size for a particular survey round is small or zero.
Jun 2011 – Nov 2012	Kingston, Jamaica and Spartanburg, SC USA	Government of Jamaica / Sanigest, Costa Rica / Mr. James Cercone, jcercone@sanigest.com	Economist and Statistical Analyst	Impact Evaluation of the Programme of Advancement through Health and Education (PATH), Jamaica. Responsible for evaluation and sample survey design used to collect household data to evaluate Jamaica's PATH conditional cash transfer (CCT) program. Adopted the Neyman-Rubin ("potential outcomes," "counterfactuals") causal-modeling approach for the evaluation design, and constructed a sample survey design to support this approach. The sample design was an "analytical" sample design intended to provide data useful for estimating program impact and the relationship of impact to explanatory variables. It was a "matched pairs" design that included matching of eligible households on a number of socio-economic characteristics, prior to selection of probability samples of treated and untreated households. Statistical power analysis was used to determine a sample size sufficient to provide a high level of power for detecting impacts of specified magnitude ("minimum detectable effects"). The precision of impact estimates and the power of statistical tests about those impacts were increased by the use of marginal stratification to assure adequate variability on explanatory variables related to outcomes of interest. The marginal stratification was implemented by setting variable probabilities of selection for each household of the population.

Sep 2010 – Sep 2012	Spartanburg, SC USA	Millennium Challenge Account - Maroc / Agence du Partenariat pour le Progrès / National Opinion Research Center of the University of Chicago (NORC) / Dr. Sara Hughes, Hughes-Sarah@norc.org	Evaluation Expert and Statistician	Evaluation des performances et de l'impact de l'activité de rehabilitation et d'intensification des plantations d'oliviers au niveau des zones pluviales. Responsible for sample survey design and selection of samples for an impact evaluation of an olive development project in Morocco.
Aug 2010 – Jul 2012	Ouagadougou, Burkina Faso and Spartanburg, SC USA	Millennium Challenge Account – Burkina Faso / NORC / Dr. Michael Reynolds, Reynolds-michael@norc.org	Evaluation Expert and Statistician	Agriculture Data Collection in the Sourou Valley and Comoé Valley. Responsible for construction of sample survey design and selection of samples for an impact evaluation of two agricultural development projects in Burkina Faso.
Aug 2010 – Nov 2011	Windhoek, Namibia and Spartanburg, SC USA	Millennium Challenge Account – Namibia / NORC / Mr. Kareem Kysia, Kysia-Kareem@norc.org	Evaluation Expert and Statistician	Community-Based Rangeland and Livestock Management Household Income and Expenditure Surveys. Responsible for construction of sample survey design and selection of samples for an impact evaluation of a rangeland management project in Namibia.

Aug 2010 – Mar 2012	Windhoek, Namibia and Spartanburg, SC USA	Millennium Challenge Account – Namibia / NORC / Mr. Kareem Kysia, Kysia-Kareem@norc.org	Evaluation Expert and Statistician	Conservancy Support and Indigenous Natural Products Household and Organisational Surveys. Responsible for construction of sample survey design and selection of samples for an impact evaluation of an indigenous natural products project in Namibia.
Jul 2010 – Sep 2010	Spartanburg, SC USA	Millennium Development Authority – Ghana / NORC / dayaratna-varuni@norc.org	Evaluation Expert and Statistician	Impact Evaluation of Water Supply Activity. The Water Supply Activity project was undertaken by the Millennium Development Authority – Ghana (MiDA) as part of its Compact with the US Millennium Challenge Corporation (MCC) to improve infrastructure in selected agricultural areas in Ghana. The goal of the water supply activity improvements was to improve the quantity and quality of water in MiDA program areas, and thereby improve the health and economic status of communities in those areas. Of particular interest were effects on household health outcomes, time savings, and income levels. The purpose of the evaluation project was to conduct a rigorous impact evaluation of the program to assess the extent to which it was achieving its goals. The evaluation design was a pretest-posttest-comparison-group design, and the basic measure of program impact was a double-difference estimate based on this design. Dr. Caldwell constructed the evaluation and survey design for the evaluation project.

Nov 2009 – Oct 2010	Frankfurt, Germany and Spartanburg, SC USA	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH / NORC / Mr. Jeff Telgarsky, telgarsky-jeffrey@norc.org	Evaluation Expert and Statistician	Monitoring and Evaluation of the Competitive African Cashew Value Chains for Pro-Poor Growth Program. Here follows a brief summary of the project, taken from the project grant proposal: "The project will contribute to sustainably reducing rural poverty in five African countries (Benin, Burkina Faso, Côte d'Ivoire, Ghana and Mozambique). An estimated 2.5 million mainly smallholder farmers grow cashew in Africa. Annually production of almost 750,000MT they supply about 40% of the world's cashew crop. But only about 12% of cashew nuts are processed into cashew kernels in Africa. The cashew project aims to improve the quality of raw cashew nut cultivation, increase farmer productivity, improve linkages between smallholder farmers and the marketplace, build African processing capacity and promote a sustainable global market for African cashews. The project's goal is to help 150,000 smallholder cashew farming households in Benin, Burkina Faso, Côte d'Ivoire, Ghana and Mozambique increase their incomes by 50 percent by 2012." The goal of the program was to increase income and employment for cashew farmers. The purpose of the evaluation project was to conduct an economic impact evaluation of the program to assess the extent to which it was achieving its goals. For the evaluation, surveys were conducted in all five countries of the program. Dr. Caldwell constructed the evaluation and sample survey designs for all program countries except Mozambique. The measures of program impact were double-difference estimates based on pretest-posttest-comparison-group evaluation designs. Sample sizes were determined by statistical power analysis to assure high power for detecting impact effects of specified size. A two-stage sample design was employed, with selection of a first-stage sample of villages and a second-stage sample of farmers within sample villages. The sample design used matching to increase precision of estimates and power of tests of hypotheses. Marginal stratification, implemented through the use of variable probabilities of selection, was used to assure adequate variation in explanatory variables.
Mar 2009 – Mar 2013	Frankfurt, Germany and Spartanburg, SC USA	Deutsche Investions und Entwicklungsgesellschaft (DEG) GmbH / NORC / Mr. Jeff Telgarsky, telgarsky-jeffrey@norc.org	Evaluation Expert and Statistician	Monitoring and Evaluation of the Competitive African Cotton for Pro-Poor Growth Program ("COMPACI"). The purpose of the project was to conduct an economic impact evaluation of the "Cotton Made in Africa" initiative. For the evaluation, surveys were conducted in six countries: Benin, Burkina Faso, Côte d'Ivoire, Zambia, Ghana and Malaŵi. Under the program, cotton farmers were provided training and services so that their cotton may be certified as having been produced under the "Cotton Made in Africa" (CMiA) program. The goal of the program was to increase income and employment for cotton farmers. Dr. Caldwell constructed the evaluation and sample survey designs for all program countries. The measures of program impact were double-difference estimates based on pretest-posttest-comparison-group evaluation designs. The sample designs for the cotton project were similar to those described above for the cashew program (statistical power analysis, matching, marginal stratification, variable probabilities of selection).

Feb 2009 – Feb 2011	Accra, Ghana and Spartanburg, SC USA	Millennium Development Authority – Ghana / NORC / dayaratna-varuni@norc.org	Lead Statistician	Impact Evaluation of Feeder Roads Activity. The purpose of the project was to conduct an impact evaluation of the MiDA Feeder Roads Activity in eight of its 23 program districts. The evaluation determined the impact of feeder roads improvements on input costs, product prices, and passenger fares and goods' tariffs that are associated with reduced travel time and vehicle operating cost. The primary data for the impact evaluation consisted of three market surveys, similar in scope to the Consumer Price Index (CPI) survey, examining changes in price over time in localities different distances from the improved road segments. The sample design involved matching of treatment and control localities using a "nearest neighbour" technique with a data set enhanced with GIS methods. The impact of the roads improvements was determined employing a double-difference estimator applied to changes in prices over the next two years. Dr. Caldwell was responsible for providing advice on the strengths and weaknesses of particular evaluation designs, devising sampling strategies and designs, estimating sample sizes, drawing the sample for data collection activities, preparing weights to apply to the price and fare observations, and advising on data analysis plans.

May 2007 – Sep 2013	Tegucigalpa, Honduras and Spartanburg, SC USA	Millennium Development Authority – Honduras / NORC / dayaratna-varuni@norc.org	Evaluation Expert and Statistician	Program Impact Evaluation. Technical advisor to provide evaluation research design and analysis services in support of an economic impact evaluation of roads-improvement and farmer-development projects (Farmer Training and Development Activity (FTDA) and Transportation Project) funded by the Millennium Challenge Corporation in Honduras. Dr. Caldwell developed the evaluation and sample survey designs for the two projects, and conducted the final data analysis (after completion of two survey rounds). For both projects, statistical power analysis was used to determine sample size. Using this approach, the sample size was determined so that the probability (power) of detecting an effect (impact) of a specified size was high. Both projects involved a "panel" sample design in which the survey was administered before and after the program intervention, i.e., the basic design was a "pretest-posttest" design. The conceptual framework for the impact analysis was the "Neyman-Rubin causal model", or "potential outcomes model," or "counterfactuals model." For the FTDA farmer assistance project, eligible villages ("*aldeas*") were classified into sets of "matched pairs," and one member of each pair was randomly selected to receive program services. The matching was done on a number of variables believed to affect outcomes of interest, and available prior to the survey. The matching was done prior to randomized selection for treatment, to increase the precision of impact estimates and the power of tests of hypothesis about them. A probability sample of matched pairs was selected using the technique of marginal stratification, to ensure adequate variation (spread, balance) in the design variables. The randomized-assignment-to-treatment sample was supplemented by a sample selected for treatment in the usual fashion by the program implementer, after a low response rate was encountered. The data analysis included development of a "two-step" model, in which the first step was a binary selection (propensity-score / logistic regression) model and the second step was an outcome model that included the selection probability estimated in the first step. The principal impact estimate of interest was the Average Treatment Effect (ATE), or average effect of the program intervention on an eligible farmer. The ATE was a "regression adjusted" or "covariate adjusted" double-difference estimate. In all, five alternative impact estimators were examined: (1) basic propensity-score-based estimator of ATE; (2) regression-adjusted propensity-score-based estimator of ATE; (3) modified regression-adjusted propensity-score-based estimator of ATE; (4) regression estimator of ATE, not based on the propensity score; and (5) instrumental-variable (IV) regression estimator for ATE, based on the estimated propensity score. The data were analyzed under both "random effects" and "fixed effects" assumptions. Because of the complexity of the model, resampling techniques (bootstrapping) were used to estimate standard errors of estimates. The analysis was conducted following *Econometric Analysis of Cross Section and Panel Data*, 2nd edition by Jeffrey M. Wooldridge (MIT Press, 2010, 2002). The analysis was conducted using the Stata statistical program package (e.g., procedure *xtreg*).

				The data analysis supported the hypothesis that the FTDA program has a positive effect on income, expense, net income and expenditures for labor for "other" crops (the category that includes those addressed by the FTDA program). The survey design for the Transportation Project included selection of a probability sample of *caserios* (administrative units generally smaller than villages), where marginal stratification was once again used to assure adequate variation in variables believed to affect outcome. In particular, the selection probabilities were set to assure adequate variation in the estimated change in travel time to be caused by the program intervention (road improvements). The estimated change in travel time was calculated from a geographic information system (GIS) road-network model that included all official roads in Honduras. The survey data were used to develop an estimate of the Partial Treatment Effect (PTE) (relationship of impact to travel-time variables) and, from the PTE, the Average Treatment Effect (ATE). The data analysis was conducted in two ways, first using binary treatment variables defined in terms of travel times to places of interest, and then using continuous treatment variables (travel times to places of interest. In all, three estimators were analysed: (1) Ordinary-Least-Squares (OLS) regression estimator of the average treatment effect (ATE) based on binary treatment variables (derived from a GIS travel-time model); OLS regression estimator of partial treatment effect (PTE) based on continuous treatment variables (derived from the GIS travel-time model), and an estimator of the average treatment effect derived from this model; and (3) Instrumental-variable (IV) estimator of PTE based on continuous treatment variables (GIS-model travel times used as instrumental variables for questionnaire travel-time variables). The data analysis provided evidence that the Transportation Project road improvements are associated with decreased travel times to some places of interest, but that the changes are small and are not associated with substantial increases in income or improvements in school attendance, use of health care services, or employment.
May – Jun 2008	Spartanburg, SC USA	World Bank / KPMG / Manitou Incorporated	Statistical Consultant	Analysis of Poverty and Social Impact of Education Sector Reforms in Mozambique. Developed the data-entry program to be used for a national sample survey of households, to assess the economic and social impact of education sector reforms. The US Bureau of the Census CSPro software system was used for this application. The questionnaire and corresponding data-entry forms were in Portuguese.

Dec 2007 – Feb 2008	Monrovia, Liberia	US Agency for International Development (USAID) / Segura Consulting	Systems Integration Consultant	Governance and Economic Management Assistance Program (GEMAP). Technical advisor (systems integration consultant) to a project funded by the US Agency for International Development to develop a computer system to automate tax payments. The goal of the project is to establish a "One-Stop Shop" at the National Port, where importers can settle their tax obligations quickly. Developed system requirements specifications and procurement documents. The system includes radio communication links among the National Port, the Ministry of Finance, and the Central Bank.
Jun 2007	Conakry, Guinea	USAID / Management Systems International	Consultant in Information Technology and Statistics	Guinea Baseline Survey, Indefinite Quantity Contract for Democracy and Governance Analytical, Support and Implementation Services. Technical advisor to develop a design for a database to store data required in support of USAID's Performance Monitoring Plan (PMP) reporting and management needs, and for a statistical sample survey to collect data to be stored in the database. Advised on the database design (e.g., static Word files, static HTML files, standalone Microsoft Access database, networked database, web-based dynamic system (e.g., MS ASP.net, Adobe ColdFusion, Sun Java Server Pages, Linux operating system / Apache web server , MySQL database, PHP web page (LAMP)), selection of sample survey data-entry software (e.g., Epi Info, CSPro, Viking, SPSS), and sample survey design (a two-stage sample survey design using Census enumeration districts as primary sampling units (PSUs) was recommended, to provide data in support of a pretest-posttest comparison-group quasi-experimental design). Statistical power analysis was used to determine the survey sample sizes (number of sample PSUs, number of sample households within PSUs).
Mar – Sept 2006	Dili, Timor-Leste and Lisbon, Portugal	United Nations Development Program (UNDP)	Information Technology Advisor in Personnel Management Information Systems	Source Selection for Civil Service Personnel Management Information System. Technical advisor to advise the Government of Timor-Leste on the selection of a software developer to develop a civil-service Personnel Management Information System (PMIS). The software developer was selected and the system was successfully implemented. (In early 2012 this system was selected by UNDP as third best of all of UNDP's projects.)
Feb 2002 – Apr 2005	Lusaka, Zambia	USAID / Academy for Educational Development	Technical Advisor in Education Management Information Systems	Development of Education Management Information System. Technical advisor (management information system developer) to a project funded by the US Agency for International Development, to develop an Educational Management Information System (EMIS) for the Zambia Ministry of Education. The purpose of the EMIS is to collect, store, and retrieve data (produce reports) from the Annual School Census, in support of program planning and analysis by the Ministry and donor agencies. Applications were developed using the Microsoft Access database development system, the Academy for Educational Development's EdAssist system, and the ArcView geographic information system (GIS). The project included training of host-country counterpart staff in Microsoft Access database development, maintenance and use.

Jan 1999 – Jan 2001	Gaborone, Botswana	Bank of Botswana	Director of Management Systems	Director of Management Systems. Responsible for management of all information technology operations for the Bank of Botswana, Botswana's central (reserve) bank (IT vision, strategy, policy, procedures, operations, acquisition, training, staff development). The Bank's computer system was comprised of over 300 networked microcomputers running under Windows NT/95/98/2000, Novell 4.1 and UNIX operating systems. Managed a group of 16 information technology specialists to operate and support the Bank's computer hardware and software applications (network management; Microsoft Office Suite; Internet/intranet; banking operations; accounting; investment portfolio / foreign reserve management; financial data services; economic analysis; human-resources management; and asset management. Introduced modern management and software engineering practices based on standards-based quality management (ISO 9000 Quality Management standard, ISO 12207 Information Technology standard, Carnegie Mellon University Software Engineering Institute Capability Maturity Model (CMM), DOD-STD-498 Software Development and Documentation). Responsible for system development (design, implementation), procurement, training, operations and maintenance (annual budget approximately USD3 million, exclusive of staff salaries, training, and noncomputer facilities and equipment). Responsible for setting Bank's IT vision, strategy, policy, procedures, security. Supervised approximately 30 IT projects. Directed the Bank's Year-2000 date-change ("Y2K") program, in accordance with international standards (Bank for International Settlements and US government) (no date-change problems encountered after the century date change). Directed preparation of the Bank's first disaster-recovery plan. Supervised the development of the Bank's first web page, and acquisition of the country's first "code-line clearing" system (for magnetic-ink character recognition (MICR) of bank checks). Participated in all meetings of the Bank's Executive Committee and Board of Directors; reported to the Governor and Deputy Governor.
Apr – Oct 1998	Dacca, Bangladesh	Asian Development Bank / Academy for Educational Development	Information Technology Specialist	Education Management System Design for Secondary Education Sector Development Project. Developed top-level requirements for the Educational Management Information System (EMIS) to be developed under a multi-year development program funded by the Asian Development Bank. Assignment included review of current systems, identification of user information needs, and identification and comparative evaluation of alternative systems.

Sep 1997 – Mar 1998	Toronto, Ontario, Canada	Canada Trust (now Toronto Dominion Bank)	Consultant in Risk Management	Consultant in risk management to Canada Trust Bank. Responsible for the development of analytical models for risk management of the Bank's loan products. Developed a model for risk-based variable-rate pricing of loans, using the techniques of Generalized Lagrange Multipliers (GLM) and mathematical simulation. The methodology determines pricing strategies that are optimal with respect to the allocation of capital to the Bank's investment opportunities, taking customer, market, and policy factors into account. The computer simulation approach is used as an efficient framework for exploring alternative pricing strategies; the GLM method is used to determine pricing strategies that maximize stockholder value added (profitability) subject to constraints (on capital reserve requirements, probability of exceeding loss provisions, and other factors). The variable-rate pricing model was implemented as an easy-to-use Visual Basic microcomputer program (Windows NT, UNIX, SAS, VB5).
May 1996 – Jul 1997	Charlotte, North Carolina USA	First Union National Bank (later Wachovia, now Wells Fargo)	Statistical Consultant	Statistical Consultant to First Union National Bank (US sixth largest bank, later Wachovia, now Wells Fargo), conducting statistical analysis to develop customer segmentation models in support of bankcard marketing initiatives. Developed optimization model for identifying profitable locations for automatic teller machines (ATMs). Used SAS statistical analysis software and ArcView 3.0 geographic information system (spatial analyst) to develop logistic regression and discriminant analysis models to identify likely customers for PC banking. Models used a wide range of economic and demographic data at the block group and ZIP-code levels (population, income, employment, sales, shopping centers, crime statistics, traffic counts, ATM locations and characteristics). Windows 95 and UNIX (Sun Solaris SPARCcenter).
Nov 1995 – May 1996	Accra, Ghana	USAID / Sigma One Corporation	Survey Statistician	Income and Employment Survey for Ghana Trade and Investment Program. As part of the US Agency for International Development's Trade and Investment Program in Ghana, Dr. Caldwell designed and analyzed the survey to estimate the employment and income associated with every $1,000 of exports in non-traditional areas. The survey was designed to produce national estimates and estimates for selected product sectors (pineapples, pineapple juice, tuna loins / canned tuna, and cashew nuts). The sampling plan involved a probability sample of 300 exporting firms selected with probabilities proportional to a measure of size (export value) without replacement. Developed the statistical software (using dBASE) to determine the sample design, select a probability sample, and compute all survey estimates and standard errors.

May – Jun 1995	Lilongwe, Malawi	USAID / Academy for Educational Development	Sample Survey Design and Sampling Statistician	For the Malawi Ministry of Education, Dr. Caldwell developed the sample design for the Annual Primary School Survey. Previously, the annual school survey was a census of all 3,400 schools and three million students; the amount of time and effort required to collect and process all of these data was placing a serious burden on the Planning Unit resources. The sampling plan involves a probability sample of 500 schools selected with probabilities proportional to a measure of size (the previous year's enrollment) using the Rao-Hartley-Cochran method. With the probability sampling approach, all of the information required by the Planning Unit will be available for a fraction of the effort required by the previous approach. Developed the statistical software (using dBASE) to determine the sample design, select a probability sample, and compute all survey estimates and standard errors.

Jun 1993 – Dec 1994	Lilongwe, Malawi	USAID / Academy for Educational Development	Personnel Management Information System Developer	Civil Service Personnel Management Information System Development Project. For the Malawi Department of Human Resources Management and Development, Dr. Caldwell designed and implemented the Malawi Civil Service Personnel Management Information System (PMIS). The system was developed using the dBASE database management information system, for use on microcomputers (standalone or networked) using the MS-DOS operating system. The system includes a variety of demographic and employment-related data for Malawian civil servants, and offers the users (personnel officers) a wide range of easy-to-use data entry and query/report capabilities. Experienced database users may generate queries and reports using SQL (Structured Query Language) commands or any of dBASE's automated query and report-generation features, but the system is designed with a powerful graphical user interface (GUI) so that a nontechnical user may generate all standard queries and reports without the need for any programming or entering of complicated commands, simply by making selections from a suite of menus. Data entry is facilitated by a series of easy-to-use data entry screens, with ample on-line help and validation of all entered data. Employee records may be displayed on the screen or printed. The system development effort was conducted in full compliance with the DOD-STD-2167A software development standard (predecessor of today's ISO 12207 Information Technology Standard), and included the production of almost 1,000 pages of detailed system documentation, including a *System Design Document, Software Requirements Specification, Software Design Document, Software Programmer's Manual, Software Product Specification,* and *Software User's Manual*. The project included on-the-job training of members of the Department's Management Information Systems Unit (systems analysts, programmers) in systems engineering (requirements analysis, technology assessment, synthesis of alternatives, specification of evaluation criteria, selection of a preferred alternative, top-level design, detailed design (optimization), implementation, and test), the modern software engineering discipline (structured, top-down design), management information system design, dBASE, software development project management, and basic microcomputer upgrading and repair; and classroom instruction for system users (personnel officers) in use of the system for data entry and retrieval (queries and report generation). In a follow-up check ten years after completion of the system, it was still in operation.

Mar 1993 – Feb 1995	Sierra Vista, Arizona, USA	Western Research Company	Statistical Consultant	Automated Receiver Operating Characteristic System; Diagnostic Imaging Systems. Conducted requirements analysis and specification for the statistical system of an automated receiver operating characteristic (ROC) system. The goal of the development effort was to develop an easy-to-use, microcomputer-based system for facilitating the design, implementation and analysis of receiver operating characteristic experiments. (A ROC experiment is an experiment designed to determine and describe the accuracy of a diagnostic system, such as a computer imaging system. The system is to make a decision about what alternative state of nature is true, based on an (image) observation. A ROC curve is a two-dimensional plot of the true positive rate (or sensitivity) vs. the false positive rate (one minus the specificity, or true negative rate). The ROC methodology lends itself well to graphical presentations on microcomputer screens, e.g., in medical diagnostic imaging systems or military multisensor fusion applications.)
Mar 1991 – Oct 1992	Cairo, Egypt	USAID / Chemonics	Manager of Monitoring and Evaluation	Local Development II - Provincial Project. Served as manager of Monitoring and Evaluation for the USAID-funded Local Development II - Provincial (LDII-P) project, which provided technical assistance in the development and maintenance of USAID-funded infrastructure projects in Egypt (potable water, waste water, roads, buildings, rolling stock, environment, and information systems). The LDII-P project was the largest USAID local development project in the world, having funded the development of over 16,000 local-level projects. In addition to infrastructure development, a major goal of the project was to promote government decentralization and increase the capacity of local governments to plan, finance, implement, and maintain local projects. Principal activities included: (1) the design and implementation of a nationwide project monitoring survey to assess the implementation, operating, and service status of projects; (2) the development of an indicators system to assist local officials in the assessment of need for public services, the availability of services, and the identification and prioritization of local development projects; (3) the design and implementation of a governorate project monitoring system to assist governorate detection and follow-up of implementation and operational problems. On this project, Dr. Caldwell made heavy use of automated management information system tools (dBASE, SPSS) to store, process, and retrieve data on project status and needs assessment (including continuous monitoring of project status indicators), and applied the techniques of sample survey (questionnaire development, stratified random sampling) and rapid appraisal techniques (focus group interviews) to assist end-of-project evaluation, as well as continuous monitoring of indicators. Dr. Caldwell lectured on the use of geographic information systems (GISs) in development planning, and supervised training of development planners in use of the PC-ARC/INFO GIS.

1988 - 1991	Tucson and Sierra Vista, Arizona USA	Vista Research Corporation	Founder and President	Founded and operated contract research firm specializing in strategic and tactical analysis, simulation and modeling, program monitoring and evaluation, artificial intelligence applications, and software systems development. Winner of four Small Business Innovation Research (SBIR) contracts. Projects included the following: Research in Artificial Intelligence for Noncommunications Electronic Warfare Systems; Geographic Information Systems; Expert Systems (1989-1991). Directed project for the Electronic Warfare / Reconnaissance, Surveillance, and Target Acquisition (EW/RSTA) division of the US Army Communications-Electronics Command (CECOM), to develop the Scenarist, a prototype knowledge-based system to generate scenarios for use in evaluating electronic warfare systems and concepts. The Scenarist positions military units and equipment on maps using rules that take into account tactical doctrine, geographic features, friendly mission, and enemy threat. The system uses digital mapping data and is based on an object-oriented parametric representation of military units. The system, coded in C (50,000 lines) and operating on MS-DOS or UNIX-based microcomputers, contains an easy-to-use graphical user interface. The system used digital terrain data extracted from the US Army's Geographic Resources and Services (GRASS) geographic information system (GIS), and incorporated the US Army Corps of Engineers' C-Language Integrated Production System (CLIPS) expert system. (The GRASS GIS is a free, open-source geographic information system originally introduced in 1982 by the US Army Construction-Engineering Research Laboratory (USA-CERL), a branch of the US Army Corps of Engineers.) Tactical Theater Air Warfare Methodologies (1988-1989). Directed project for the Air Force Aeronautical System Division / Wright Aeronautical Laboratories (ASD/AFWAL) at Wright-Patterson Air Force Base, to develop an analytical theory for the generation of tactical air warfare scenarios to be used as a basis for evaluation of air warfare tactical systems and concepts. The approach involved the development of a rigorous mathematical framework for tactical combat; it incorporated elements of game theory (resource-constrained nonzero-sum games) and artificial intelligence (knowledge-based simulation). Fast Algorithms for Real-Time Estimation, Prediction and Control (1985-1986). Directed project for the Office of Naval Research to investigate improved algorithms for real-time estimation, prediction and control. Improved algorithms are needed to provide a solution to a critical problem faced in both industrial and defense applications -- the fact that the algorithms used to implement state-of-the-art statistical estimation, prediction and control techniques are too slow and failure-prone for many real-time or near-real-time applications of high interest (such as correlation / tracking of missiles), even using the fastest computers. Under this project, a new estimation algorithm was developed and analyzed. The algorithm was demonstrated by applying it to solve multiple linear regression problems in "ill-conditioned" situations, such as the case of a singular or near-singular design matrix (multicollinearity).

1982-1986	Tucson, Arizona, USA	University of Arizona	Adjunct Professor of Statistics	Taught the graduate course, Sampling Theory and Methods, and the required basic undergraduate statistics course for all students of business, public administration and management information systems. This class was very large, with about 500 students per semester. Presented lectures to two classes of 250 and supervised five graduate teaching assistants, who conducted homework-review and test-review sessions in small classes (about 30 students per class). Following are student evaluations for the last semester taught: STUDENT EVALUATIONS, SPRING 1986, MAP275 INSTRUCTOR: DR. J. G. CALDWELL (Section 1, 8:00 am) Histogram for responses to "Overall Evaluation of Instructor" 6. One of the best xxxx (8) 5. Excellent xxxxxxxxxxxxx (25) 4. Good xxxxxxxxxxxxxxxx (31) 3. Fair xx (3) 2. Poor (None) 1. One of the poorest (None) Strong points of the instructor (selected responses): 1. Dr. Caldwell is an excellent lecturer. 2. Very well prepared. I liked the way he summarized what we did in the previous class at the beginning of each class. 3. Dr. Caldwell gave very good examples; he made a hard course easier to understand. 4. Always prepared. Very thorough examinations. Summary at beginning of class. 5. Instructor was very clear and cared about his teaching. 6. He understood and explained material well. 7. Very fluent and he was well prepared for class meetings, reasonable reviews. 8. Gave good examples which prepared me very well for tests. 9. Very well prepared, always on time. Very good, organized teacher. 10. Did a good job in explaining and presenting his lecture.

STUDENT EVALUATIONS, SPRING 1986, MAP 275

INSTRUCTOR: DR. J. G. CALDWELL (Section 2, 1:00 pm)

Histogram for responses to "Overall Evaluation of Instructor"

6. One of the best	xxxxxx (18)
5. Excellent	xxxxxxxxxxxxxxxx (52)
4. Good	xxxxxxxxxxxxxxxxxxxxxxxxxxxx (82)
3. Fair	xxxxxxxxxx (29)
2. Poor	x (2)
1. One of the poorest	x (1)

Strong points of the instructor (selected responses):

1. Instructor was always prepared for class and gives very good explanations about the subject.
2. Well prepared, easy to understand (good speaking voice and delivery).
3. Organized, brings material across very well. One of the best instructors at the U of A.
4. He was a great lecturer. He kept our attention and explained everything well.
5. The instructor is very good. He is easy to understand and gives good examples of the concepts.
6. Dr. Caldwell gives clear explanations to the problems. I feel as though he is an excellent instructor. He is also very polite.
7. He always was enthusiastic about teaching. Gave clear lectures of difficult-to-understand material.
8. The instructor had a well organized presentation.
9. He did a good job explaining difficult concepts.
10. I liked this course! Very interesting.
11. Dr. Caldwell was very prepared and understandable. I would recommend other students to have him as a teacher.

1982-1986; 1986-1988	Tucson and Sierra Vista, Arizona USA	US Army Electronic Proving Ground / Bell Technical Operations, Combustion Engineering	Manager of Research and Development and Principal Scientist of USA EPG Electromagnetic Environmental Test Facility	Manager of Research and Development and Principal Scientist of United States Army Electronic Proving Ground (EPG) Electromagnetic Environmental Test Facility (EMETF). Responsible for design and analysis of operational test and evaluation of military electronic equipment. Managed staff of about 16 (mostly PhDs in engineering, science and mathematics). Supervised the design and analysis of development tests of defense communications electronics (C-E) systems. Directed the following projects: • Dynamic Electromagnetic Systems Combat Effectiveness Model. Directed project to develop measures of effectiveness for defense C-E systems and explore means of linking large scale C-E models to large scale tactical combat models. The project made use of queuing models to estimate message delay as a function of system characteristics. • Simulation of Realistic Electromagnetic Environment for Stress Load Testing. Directed project to demonstrate the feasibility of simulating a realistic C-E signal environment for loading the EPG Stress Loading Facility. • Simulation Model Architecture / Intelligence Electronic Warfare (IEW) Model Extension. Directed project to develop a dynamic event driven simulation model architecture for C-E test and evaluation. • Statistical Analysis of Voice Scoring Data. Conducted a components-of-variance analysis of data from voice scoring of data from noisy voice communications. • Requirements Specification for Computer-Graphics Deployment Analysis System. Supervised a systems engineering effort to develop a modern computer graphics system to interface existing EMETF communication system simulation programs.
1986	Tucson, Arizona USA	Singer Systems and Software Engineering	Principal Engineer	Systems and software engineering; new business development.
1982	Tucson, Arizona USA	Consulting Statistician	Consulting Statistician	Provided statistical consulting to a law firm pursuing a case involving the prices that Mexican growers received for produce in Arizona markets. (Data analysis, legal testimony at trial).

1977 - 1981	Alexandria, Virginia and Tucson, Arizona USA	Vista Research Corporation	Founder and President	President and manager of contract research firm. Contracts included the following. <u>Microsimulation Forecasting Model for Human Development Services Programs (1979-1981)</u>. Dr. Caldwell directed the project to develop the MICROSIM microsimulation forecasting model for the US Department of Health and Human Services. The purpose of this contract was to assist the Division of Forecasting and Analysis of the Office of Planning, Research, and Evaluation of the US Department of Health and Human Services (DHHS) Office of Human Development Services, in formulating and implementing a prototype microsimulation forecasting model and developing a prototype statistical reporting system which provides the data required for the forecasting model. The model -- called MICROSIM -- was developed to forecast caseload and expenditures for the following HDS programs under various policy assumptions: Rehabilitation Services Administration, Title XX Social Services (Administration for Public Services), the Administration for Children, Youths, and Families (Child Welfare, Headstart, Runaway Youths), the Administration on Aging, and the Administration for Native Americans. The MICROSIM model simulated future demographic changes to individuals in a large population of individuals (drawn from the US Current Population Survey), simulated the incidence of human-service-related problems for each of the individuals in the simulated population, and estimated caseloads and budgets for the simulated population (corresponding to program and policy assumptions) by direct computation. The system was pilot-tested in Utah. <u>Economic and Social Impact Analysis / Women in Development (ESIA/WID) Project (1979-1981).</u> The purpose of this project, sponsored jointly by the Philippines National Economic and Development Authority (NEDA) and the US Agency for International Development, was to help improve the capability of the Government of the Philippines to monitor and measure economic progress, social change, and the impact of development projects, including the effects on women in their dual role as agents and beneficiaries of development. The contract provided technical services to assist the Philippines Institute of Development Studies (PIDS) to develop and validate analytical frameworks and indicators for analyzing and measuring progress and the impact of development projects on selected areas of concern; to design and field test efficient means for measuring and monitoring project progress and impact indicators; and to determine a better understanding of the mechanisms by which development projects achieve their goals. The development projects included a wide variety of substantive fields -- health, nutrition, and family planning; education; integrated agricultural production and marketing, aquaculture production, and agro-reforestation; integrated area development; feeder roads; ports; local water systems; electrification; small-scale industries, and tourism. The ESIA/WID project identified and evaluated the use of a variety of statistical design and analysis techniques to assist project impact assessment: quasi-experimental designs, sample survey, analysis of variance, multiple regression analysis, questionnaire design, indicator development. For the Philippines Ministry of Health, Dr. Caldwell developed alternative management information system (MIS) designs to support both agency operations and program monitoring. Dr. Caldwell served as chief of party and directed a team of eleven Ph.D. consultants on the ESIA/WID project.

				Social Services Effectiveness Evaluation (1975-1978). The purpose of this project, funded by a three-year grant from the US Department of Health and Human Services Administration for Public Services to the State of West Virginia was to develop systems for assessing the effectiveness of social service programs in West Virginia. This effort involved interaction with program staff to define social service objectives, develop measures of effectiveness, develop instrumentation and sampling plans, conduct training sessions, analyze data report formats. Dr. Caldwell was director of this project. Evaluation of the Economic and Social Consequences of the Extension Education Program (1978). For the Office of the Deputy Director for Extension of the US Department of Agriculture (USDA), conducted (supervised) a mail-survey evaluation of all of the USDA agricultural extension programs in the United States. Sampling Manual for Office of Child Support Enforcement Reporting Requirements (1978). For the Office of Child Support Enforcement of the Office of Human Development (US Department of Health and Human Services), this project developed the sampling manual to be used by state agencies that elect to submit the OCSE quarterly and annual reports on the basis of statistical sampling. These reports are required by Title IV D of the Social Security Act. The manual presents a number of alternative sampling plans, to take into account administrative differences (county administered, state administered) in the state IV D programs. Dr. Caldwell directed this project (subcontract to JWK International Corporation). Statistical Analysis Group in Education (SAGE) Project (1977). Under a contract to Killalea Associates, funded by the National Center for Education Statistics, Dr. Caldwell provided statistical consulting services to the Statistical Analysis Group in Education. Tasks included identification of future NCES research agenda topics and research on subsampling of nonrespondents in longitudinal studies. Elementary and Secondary School Civil Rights Survey (1977). Under a contract to Killalea Associates funded by the US Department of Health and Human Services Office of Civil Rights, Dr. Caldwell constructed the sample design for the biennial civil rights survey of elementary and secondary public schools. Bossangoa Integrated Rural Development Project Central African Republic (1977). For the African Development Bank / US Agency for International Development, conducted (supervised) an assessment of the rural sector of the Bossangoa region of the Central African Republic, for the purpose of identifying studies and projects that are suitable for Bank group financing.

1974 - 1978	Alexandria, Virginia, Fairfax, Virginia, USA	Independent Statistical Consultant	Independent Statistical Consultant	Statistical Consultant to various organizations, primarily in the design of analytical surveys (for the purpose of developing model-based estimates of program impact. Projects included the following. Housing Market Practices Survey (1978). Constructed the sample design for the 1977 Housing Market Practices survey for the National Committee Against Discrimination in Housing, funded by the US Department of Housing and Urban Development. Survey results are presented in *Measuring Racial Discrimination in American Housing Markets: The Housing Market Practices Survey*, US Department of Housing and Urban Development, Office of Policy Research and Development, April 1979. PSRO Data Base Development Study (1977). As a consultant to Systemetrics, Inc. and General Research Corporation, developed the sample design for the PSRO Data Base Development Study. For the Office of Planning, Evaluation, and Legislation of the Health Services Administration, this study was funded to develop a data base that would permit analysis of the impact of Professional Standards Review Organizations (PSRO) concurrent review on hospital utilization. The principal objective of the analysis is to assess the impact of concurrent review on length of stay by diagnostic category. This study was implemented through collection of data from patient record abstracts from a sample of short stay hospitals. Hospital Cost Data Study (1976). As a consultant to SysteMetrics, Inc., for a contract funded by the National Center for Health Services Research (NCHSR), developed the sample design for the NCHSR Hospital Cost Data Study. The purpose of this study was to collect a wide spectrum of data from patient record abstracts to form a data base that could be used to conduct econometric investigations of the relationship of hospital cost to various patient, physician, hospital, and demographic characteristics. An analytical sample survey design was used as a basis for the data collection. Developing Measures of Productivity for the U.S. Employment Service (1976). The purpose of this study, for the Manpower Administration of the U.S. Department of Labor, was to develop procedures for constructing an overall measure of productivity for the Employment Service. The approach adopted was to identify State Employment Service Agency (SESA) missions, goals, and objectives; to develop a production model of SESA; to synthesize and evaluate alternative productivity measures; and to validate the productivity measures. Consulting services in the area of developing the analytical approach to the study were provided to this project under an agreement with the Analytic Systems Division of Mauchly Wood Systems Corporation.

				Workload Reporting Validation Guidelines (1976). The objective of this study for the Commonwealth of Pennsylvania Bureau of Employment Security was to establish validation guidelines that would permit consistent counting of workload budget items among states. The effectiveness of the administration's Cost Model system is dependent on the accuracy of workload reporting. Where inconsistent reporting of workload items exists among states, corresponding inequities will be present in the budget amounts provided to the states for program administration. This study analyzed initial claims, weeks claimed, nonmonetary determinations, appeals, wage records, and subject employers, and developed revised reporting definitions, workload validation guidelines, and sampling guidelines. The sample design for the Unemployment Insurance (UI) validation surveys was developed under an agreement with Analytic Systems Division of Mauchly Wood Systems Corporation. Survey Design for Study of Impact of National Health Insurance on Bureau of Community Health Service (BCHS) Users (1975). As a consultant to SysteMetrics, Inc., directed the project to develop the sample design for a nationwide survey of users of BCHS facilities, to determine the impact of alternative national health insurance plans on the users. A multistage sampling plan, stratified by the major BCHS programs and state Medicaid status, was adopted. The survey questionnaires collected the health, employment, family, and demographic characteristics necessary to determine eligibility and benefit levels under alternative plans. Design Task for Survey of Persons in Institutions (1975). As consultant to General Research Corporation funded by the Assistant Secretary for Planning and Evaluation (ASPE) of the US Department of Health and Human Services, directed the project to develop questionnaires and a statistical survey design for the nationwide Survey of Institutionalized Persons. This survey, implemented by the US Bureau of the Census, addressed a broad range of issues associated with institutionalization, including appropriateness of placement, quality and effect of care, and patient rights. The survey instruments included staff, family, and patient questionnaires. The survey design was stratified by institution size and type. The survey for which the questionnaires and sample design were constructed was conducted by the Bureau of the Census, and documented in the reports, *1976 Survey of Institutionalized Persons: Methods and Procedures*, Technical Paper 42, US Department of Commerce, Bureau of the Census, 1978; and *1976 Survey of Institutionalized Persons: A Study of Persons Receiving Long-Term Care*, Current Population Reports, Special Studies Series P-23, No. 69, US Department of Commerce, Bureau of the Census, 1978.

				Study of Discrimination in Salaries in Academia (1974). The objective of this study was to conduct a thorough analysis of the American Council on Education (ACE) survey data concerning salaries in academia. The survey data had been collected in two different years (1967 and 1973). The analysis centered on the development of parametric models that related salary level to number of years experience, degree, quality of degree program, field of study, age, sex, race, and other variables. Separate models were developed for blacks, whites, males, and females. The data analysis produced estimates of the residual salary differential between blacks and whites, after accounting for all other major explanatory variables. Dr. Caldwell coordinated the data analysis under an arrangement with the Urban Institute and The Hendrickson Corporation. Assessment of Recreational Benefits Accruing from the Clean Water Act (1974). Under a contract to the Bureau of Outdoor Recreation, this study was an in depth analysis of the benefits deriving from PL 92 500, the Federal Water Pollution Control Act. The study assessed the impact of the act on boating, swimming, and fishing, through the development of national and regional econometric models. The models related benefits to a wide range of socioeconomic, demographic, and geographic variables (water quality indices, facilities indices, mode of transportation, age, sex, race, income, family size, occupation, marital status, season, ownership of recreational vehicle, travel distance). Dr. Caldwell supervised the data analysis of the National Recreation Survey under an agreement with the National Planning Association and the Hendrickson Corporation. Budget Justification Model for Federal Energy Administration (1974). For the Federal Energy Administration, this project was directed toward the development of an analytical model to be used to assist the process of allocating funds between competing solar energy programs (wind, ocean thermal, solar electric, solar thermal). Development of a stronger analytical framework for budget allocation was required by the Office of Management and Budget, subsequent to a General Accounting Office analysis of the previous budget justification. Dr. Caldwell provided consulting in the area of decision analysis, under an agreement with Planning Research Corporation. Research Design for the Urban Arterials Section of the Highway Capacity Manual (1974). As consultant to Alan M. Voorhees Company of Planning Research Corporation, constructed an experimental design to specify computer simulation runs for a large-scale highway traffic simulation model. This effort was one of the earliest applications of the use of experimental design to specify “run sets” for large-scale computer simulation models.

1974-1978	Annandale, Virginia, USA; Port-au-Prince, Haiti	JWK International Corporation	Vice President	Served as Vice President of firm from inception to size of about 30 technical staff. Responsible for all technical projects (supervised all, directed many). Projects included the following. Analysis of Federal Medicaid Matching Percentage Formula (1978). For the Social and Rehabilitation Service, directed the study to develop alternatives to the Federal Medical Assistance Percentage (FMAP) formula, which is used to reimburse state Medicaid and Aid to Families with Dependent Children (AFDC) expenses. The analysis effort considered factors such as ability to pay, cost of services, incidence of the target population, and program effort. The analysis was implemented through a time-shared computer program. Economic Policy Analysis for the Government of Haiti (1975-76). Under a contract funded by the US Agency for International Development, this study determined agricultural and tax policy changes that the government of Haiti could employ to increase foreign exchange and increase the income of the small farmer. The study addressed five commodities -- coffee, cotton, sisal, mangoes, and meat (major emphasis on coffee). The project included the use of rapid-assessment sample surveys to collect up-to-date data on commodity prices. A major goal of the project was the transfer of policy analysis capabilities to members of the Haitian Ministry of Agriculture. Dr. Caldwell supervised a team of four Ph.D. consultants (economists) on this project, and conducted the statistical analysis of survey data (surveys of current prices). For a number of years, the coffee study was the definitive work on the economics of coffee in Haiti. Medicaid Standards Impact Assessment (1975-76). For the Health Care Financing Administration, Dr. Caldwell directed the Medicaid Standards Impact Assessment Study, the objective of which was to assess the cost and effectiveness of federal standards for nursing home costs and performance. Under the first year's effort, a computer model was developed to estimate the residual cost impact of requiring full compliance with standards in the State of Minnesota. Data were collected from all Medicaid survey and cost reports for all Skilled Nursing Facility (SNF) and Intermediate Care Facility (ICF) nursing homes in Minnesota. The second year's effort centered on the development of instrumentation to assess the impact of standards on quality of care. Sampling Manual for Social Services (Title XX) Reporting Requirements (1976). For the Office of Information Sciences of the Social and Rehabilitation Services, developed the Sampling Manual that is used by states which elect to use statistical sampling as a basis for completing the eight Social Service Reporting Requirements (SSRR) forms. These quarterly and annual forms are required to be submitted by all states to document their social service program activities funded by Title XX of the Social Security Act.

				Vocational Rehabilitation Performance Evaluation Standards Study (1976). For the Rehabilitation Services Administration, directed project to conduct statistical analysis of vocational rehabilitation (VR) program data submitted by the states as part of their respective VR programs. The objectives of the study were to review and validate the submitted state agency data, to develop performance limits for each of the federal VR evaluation standards, to analyze changes that have occurred (over time) in national and state performance, to develop an analytical paradigm to enable use of the standards data for management purposes to suggest and outline evaluative research or demonstrations, and to develop guidance material for use by states in making future evaluation standards data submissions. Cost Benefit Analysis of NIAAA Alcoholism Treatment Centers (1976). For the National Institute for Alcohol Abuse and Alcoholism, supervised the study to determine the benefit-cost ratio associated with 43 alcoholism treatment centers located in communities across the country. Benefits and costs were calculated from three points of view the economy, the federal government budget, and the local community. The study revealed a high benefit-cost ratio from all three perspectives. NASA Technology Transfer Programs (1975). For the National Aeronautics and Space Administration, supervised several cost-benefit studies of technology transfer for several NASA programs. These analyses were used as input to NASA's budget justification for the Office of Management and Budget (OMB). The first such study concerned an assessment of the desirability of developing a mass spectrometer for analysis of destruction to the earth's ozone layer, reputedly caused by fluorocarbons. The purpose of the study was to conduct an economic assessment of the mass spectrometer, from a cost-benefit standpoint. Apart from the economic analysis of the mass spectrometer, the study asserted that from a cost-benefit standpoint, it was absurd to allow the continuation of widespread release of fluorocarbons into the atmosphere, as long as they were suspected of significant damage. A second analysis was concerned with the terra-forming of Venus through the injection of blue-green algae into the Venusian atmosphere, while a third study concerned a cost-benefit assessment of a highly-reliable airborne computer. Day Care Cost Benefit Study (1974). Directed study for the Department of Health, Education and Welfare (HEW) Social and Rehabilitation Service (SRS) to perform cost benefit analysis of day care services provided under Title IV A of the Social Security Act. This model determined benefit/cost ratios from the societal, government budget, and individual viewpoints, as a function of type of day care (center care, family day care, and in home care), family size, ages of family members, and family income. The model was applied to example data to determine "breakeven" curves, i.e., the family size, income, and age characteristics for which the dollar benefits of various types of care exceed the cost. The project was implemented by constructing a time-shared computer model.

				Vocational Rehabilitation Program Administration Review (1974). For the Rehabilitation Services Administration, directed project to conduct a program administration review, or PAR, of state vocational rehabilitation agencies. The objective of the PAR was to analyze state progress in complying with recent changes in the VR program, the Individualized Written Rehabilitation Program (IWRP) and Post Employment (Post Closure) services. Vocational Rehabilitation Follow-up Study (1974-76). This nationwide follow-up study of former clients of the vocational rehabilitation program sought to determine the extent to which clients retain program benefits. The project was implemented as a statistical sample survey of 6,000 former clients of vocational rehabilitation. The objective of the study was to assess benefit retention in the areas of earnings and employment, health, and family relationships. The effort included a full range of survey methodologies, issue identification, questionnaire development, preparation of the Office of Management and Budget (OMB) clearance package required by the Paperwork Reduction Act, monitoring of the data collection effort (conducted by Opinion Research Corporation), and analysis of the collected data. Dr. Caldwell directed the VR Follow-up Study in its initial phases, prior to field data collection. Vocational Rehabilitation State Allocation Study (1974). For the Social and Rehabilitation Service, conducted study to analyze the allocation formula used by the federal government to allocate approximately $700 million in federal funds to the states. The previous formula was adopted from the Hill Burton hospital construction program of the 1950s, and had never been subjected to a formal economic analysis. The Hill Burton formula was analyzed in detail, to determine the extent to which it adequately implemented the intent of the Vocational Rehabilitation program; the formula was found to have serious deficiencies. The analysis took into account each state's need for services (i.e., the target population), the ability of a state to pay for services, cost of services, program effort, willingness to pay, maintenance of effort, and transitionary provisions. A basic measure, the equity index, was developed to compare the performance of alternative matching formulas. The Hill Burton formula was shown to be seriously deficient, based on a comparison of alternatives using the equity index. Two new formulas were developed that allocated funds in a much more equitable fashion. The results of this study were used by Congress to determine the allocation formula used in legislation.
1972-1974	McLean, Virginia USA	Planning Research Corporation (PRC)	Principal	Principal of world's largest non-legal non-medical contract research firm. Primarily engaged in the development of correlation / tracking algorithms for satellite ocean surveillance systems. US Navy Systems Simulation Program. As part of the effort to design the Naval Satellite Ocean Surveillance System, determined methods for performing correlation/tracking and multisensor fusion of surveillance data. This work is described in the reports, *Correlation/Tracking Performance Study* and *Improvements to the Systems Simulation Program*, Navy Space Systems Activity (NAVELEX).

1967-1972	Arlington and McLean, Virginia USA	Lambda Corporation / General Research Corporation	Member of the Technical Staff	Member of the technical staff of Lambda Corporation (later General Research Corporation), a contract research firm specializing in solving optimization and game-theory problems in defense and industrial applications. Lambda Corporation was founded by Hugh Everett III, the American physicist who developed the Parallel Universe (Many Worlds) interpretation of quantum mechanics and the Generalized Lagrange Multiplier (GLM) method for solving large constrained optimization problems, such as resource-allocation problems and games. The GLM method is useful for solving problems in which the objective function is nonlinear, nonconvex, and noncontinous. The GLM optimization method was used in many of the projects conducted by the firm. The GLM method is an iterative methodology, implemented using digital computers. Most of the models described below were developed on a Control Data Corporation CDC 1604 48-bit computer (developed by Seymour Cray), one of the first commercial transistor-based computers, and one of the fastest machines on the market. Later models were developed on the CDC 6400 60-bit computer. *TIMES* Box-Jenkins Time Series Analysis Software Package. Dr. Caldwell developed *TIMES*, the first commercially available general purpose statistical program package for analyzing time series data using the Box-Jenkins (Autoregressive Integrated Moving Average, ARIMA) models. Economic Analysis of Alternative Manufacturing Facilities. For Merck and Company, Lambda Corporation conducted a study to assess the economic feasibility of constructing a very large scale modular chemical manufacturing facility. A pilot plant had demonstrated the technical feasibility of the concept. A large-scale microsimulation model was developed to examine the economic returns associated with alternative plants, and alternative phase-in schedules. The analysis indicated that, although the modular procedure outperformed the traditional (line-plant) approach, serious economic difficulties were associated with transitioning from the current mode of manufacturing to the new mode. The analysis made heavy use of the Generalized Lagrange Multiplier method. Dr. Caldwell was in charge of the simulation of product demand. Box-Jenkins time series models were developed from historical data, and used as a basis for developing alternative future demand scenarios. At the time, this contract was the largest non-military operations research contract ever conducted. Derivation of Optimal Ballistic Missile Area Defense. Derived the optimal solution to the problem of allocating imperfect (less than perfect reliability) area interceptors to defense sites. This problem is technically referred to as "subtractive overlapping-island defense with imperfect interceptors." It is technically difficult because it is a two-sided optimization problem (a resource-constrained game) involving a nonlinear, noncontinuous, nonconvex payoff function. The solution to this problem is necessary to compare alternative ballistic missile defense system configurations, and to make decisions about sizing and allocation of interceptor stockpiles. This work is described in the report, *Subtractive Overlapping-Island Defense with Imperfect Interceptors*, US Arms Control and Disarmament Agency Report ACDA/ST-166.

				Derivation of Optimal Ballistic Missile Point (Local) Defense. Derived the optimal solution to the problem of allocating imperfect point-defense (hardsite defense) interceptors to local defense sites. As in the case of area interceptors, this problem is technically difficult to solve, since it involves nonconvex, noncontinuous payoff functions. This solution is needed to compare alternative defense configurations in the case of point defense (e.g., defense of an isolated radar facility, or a target of such importance that its interceptors would not be used to defend alternative targets). This work is described in the report, *Some Problems in Ballistic Missile Defense Involving Radar Attacks and Imperfect Interceptors*, US Arms Control and Disarmament Agency Report ACDA/ST-145. HARDSITE Defense Model. Developed the HARDSITE computer model to analyze ballistic missile defense systems. The model included treatment of imperfect interceptors, reprogramming of interceptors, decoy silos and sites, redundant radars, local (modular) and area defense, multiple reentry vehicles (RVs), decoy RVs, and multiple weapon types. The model determines the optimal preallocated, randomized, (min-max) defense-offense strategies, taking radars into account, and can also be used to determine the value of simple nonoptimal strategies. This work is described in the report, *HARDSITE Defense Model*, Office of the Assistant Secretary of Defense Contract DAHC15-68-C-0187. Naval Combat Damage Model; Multiple Resource-Constrained Game Solution. As part of a project to determine a model to assess the value of naval general-purpose forces, methods were determined for solving matrix games having multiple resource constraints. A solution was determined by combining the method of generalized lagrange multipliers and the Brown-Robinson method of fictitious play. This work is described in the papers, *Naval Combat Damage Model*, ONR Contract N00014-69-C-0282 and Multiple Resource-Constrained Game Solution, ONR Contract N00014-69-C-0282. Evaluation of Alternative Missile Tracking Systems. For the Advanced Ballistic Missile Defense Agency, conducted a study to compare the performance of alternative missile tracking algorithms. The study centered on analysis of the performance of autoregressive integrated moving average (ARIMA, or "Box-Jenkins") models compared to the Kalman filter and alpha-beta trackers. The work is described in the report, *Box-Jenkins Filter Feasibility Study*, Advanced Ballistic Missile Defense Agency, Contract DAHC 60-71-C-0048. This work laid the groundwork for the development of the “Cassandra” tracker, a Bayesian, nonlinear missile tracker subsequently developed by Gary Lucas and Hugh Everett III. (Cassandra is appropriate not only for tracking maneuvering missiles, but for identifying “turning points” in financial markets.)

				Conflict, Negotiation, and General-Sum Game Theory. Developed a computationally tractable general-sum (non zero-sum) game-theoretic solution to war, taking into account the effect of the threat of war on negotiations. This work found approximate, but explicit, solution to John Nash's bargaining solution to a non zero-sum game (Nash's theory presented only an existence proof, not a constructive proof, of the bargaining solution). Game-theoretic formulations arise in the evaluation of weapon systems since it is important to evaluate all systems when optimally deployed. Most war gaming, weapons allocation, and force procurement models have been developed using either zero-sum payoffs (one player's loss is the other's gain), or ignoring the relationship of conflict to negotiation. This work shows how optimal strategies for the difficult mathematical problem of solving a general-sum game (which represents war better than the zero-sum formulation) can be approximated by the solution to a particular zero-sum game derived from the general-sum game. This work is described in the report, *Conflict, Negotiation, and General-Sum Game Theory*, Office of Naval Research Contract N00014-69-C-0282. This work involved basic research in game theory. A reprint of the original report is posted at Internet website http://www.foundationwebsite.org/Conflict.htm. A note on Lambda Corporation is posted at http://www.foundationwebsite.org/HistoricalNote1.htm. A brief biography of Hugh Everett III is posted at http://en.wikipedia.org/wiki/Hugh_Everett.
1966-1967	Spartanburg, SC USA	Deering Milliken Research Corporation	Senior Operations Research Analyst	Conducted operations research studies in textile applications. Primarily engaged in the design of experiments to improve the efficiency of production operations and the quality of products. Statistical analysis was done on a second-generation transistor-based IBM 7094 computer with double-precision arithmetic based on a 36-bit word length, using the IBM Scientific Subroutine Package (FORTRAN) for mathematical and statistical processing (regression analysis, analysis of variance, principal components analysis, factor analysis).
1964-1966	Research Triangle Park, North Carolina USA	Research Triangle Institute (RTI)	Operations Research Analyst	Conducted operations research studies in civil defense applications. Participated in national sample survey of fallout shelters (field survey work, data analysis and reporting), analysis of radiological defense, post-nuclear attack health and medical issues, vulnerability of the national electric power system to nuclear attack, and post-attack countermeasures.

1962-66	Chapel Hill, North Carolina USA	University of North Carolina at Chapel Hill	Graduate Student, Department of Statistics	Completed PhD degree in mathematical statistics at the University of North Carolina at Chapel Hill, North Carolina. The Statistics Department at UNC Chapel Hill was founded in 1948. In 1962, it was the oldest and largest comprehensive statistics department in the United States, and one of the three world-wide Institutes of Statistics. For his PhD work, he studied under Professor Raj Chandra Bose, the "father" of the mathematical theory of experimental design. (Raj Chandra Bose (1901-1987) was an Indian-American mathematician and statistician best known for his work in design theory and the theory of error-correcting codes in which the class of Bose-Chaudhuri Hocquenguem (BCH) codes is partly named after him. He was notable for his work along with S. S. Shrikhande and E. T. Parker in their disproof of the famous conjecture made by Leonhard Euler dated 1782 that there do not exist two mutually orthogonal Latin squares of order 4n + 2 for every n. A brief biography of R. C Bose is posted at Internet web site http://en.wikipedia.org/wiki/Raj_Chandra_Bose.) In PhD dissertation, *Synchronizable Error-Correcting Codes*, developed the best known class of codes for correcting both additive and synchronization errors in noisy communication channels. National Aeronautics and Space Administration (NASA) Fellowship. Invited to International Conference on Coding Theory in Royan, France, 1965. Worked summers at Research Triangle Institute (Operations Research Department).
1958-1962	Pittsburgh, Pennsylvania USA	Carnegie-Mellon University	Student, Department of Mathematics	Awarded a BS degree in mathematics (with honors). General Motors College Scholarship. Lettered in cross-country. Worked at Buhl Planetarium, Amway, and Deering Milliken Research Corporation (summers). Initial work at Milliken involved programming of a punched-card input IBM RAMAC 305 vacuum-tube / relay general-purpose mainframe computer to perform numerical calculations for statistical analysis of variance, at a time when most statisticians were using Monroe, Marchant, and Friden electro-mechanical calculators. This programming was done in assembly language; the computer was an "advanced" model that had automatic multiply and automatic divide. In Numerical Analysis class at CMU, used IBM 650 computer to solve all problems (e.g., matrix inversion, finding of eigenvalues and eigenvectors) in FORTRAN (high-level mathematical-programming language invented by IBM in 1956). Later work at Milliken used a fully transistorized IBM 1401 variable-word-length magnetic-tape-input computer.
1956-58	Newark, Delaware and Spartanburg, South Carolina	Newark High School and Spartanburg High School	Student	Academic diploma. National Honor Society. National Merit Scholar Semifinalist. Key Club. Band (trombone; at Newark, with Robert (Bob) Gore, inventor of Gore-Tex and later CEO of W. L. Gore and Associates, Inc.). Debate team. Cofounded Rocket Club (which built and successfully launched a six-foot zinc-sulphur solid-fuel rocket). Voted Most Intellectual of Class of 1958. Worked summers at Continental Diamond Fiber Corporation, Carolina Cash Company department store and Carolina Machinery Company machine shop. Social / extracurricular activities: Ground Observer Corps; Newark Fire Department Band; Newark Junior-Senior High School Band; Boy Scouts of America; bicycling; appeared on Dick Clark's American Bandstand (1955); Newark Cotillion. Winner of Spartanburg Herald-Journal contest for two-week summer camp (Camp Ney-A-Ti) in Guntersville, Alabama.

Publications

Most of the publications listed below are reports to clients, not articles in peer-reviewed journals. While most of them are applications of mathematical, statistical and computer-science methodology, it some of them contain significant original mathematical research. The articles produced at Lambda Corporation were "peer reviewed" by well-known scientists in the fields of optimization and game theory, including Hugh Everett III, George E. Pugh and John P. ("Jim") Mayberry.

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In addition to the preceding, since 2005 I have produced many reports for clients in the field of impact evaluation. These reports (mainly sample survey design reports) are no longer added to this list of publications. Sample reports include the following, for the Millennium Challenge Corporation Farmer Training and Development Activity and Transportation Projects in Honduras.

1. Design Report, Design and Implementation of MCA Honduras Program Evaluation, NORC at the University of Chicago (Chicago, IL and Bethesda, MD), Millennium Challenge Corporation, Washington, DC., April 10, 2011. Posted at Internet web site http://www.mcc.gov/documents/reports/report-042011-design-hon-transportation-and-farmer-training.pdf.
2. Final Report (Revised), Impact Evaluation of the Farmer Training and Development Activity in Honduras, Millennium Challenge Corporation Contract MCC-10-0133-CON20TO01, NORC at the University of Chicago (Chicago, IL and Bethesda, MD), Millennium Challenge Corporation, Washington, DC, November 26, 2013. Posted at Internet web site http://www.mcc.gov/where-we-work/independent-evaluations/honduras-compact/ .
3. Revised Final Report, Impact Evaluation of the Transportation Project in Honduras, Millennium Challenge Corporation Contract MCC-10-0133-CON20TO01, NORC at the University of Chicago (Chicago, IL and

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