FY2016 Extended White Paper Project Title.
Economy-wide modeling for analysis of major disruptive events: terrorism, natural disasters and accidents

1-2 sentence summary description  This project focuses on the creation and adaption of general equilibrium models to facilitate the calculation of the economic consequences of terrorism events, counter terrorism measures, natural disasters and accidents. Such models produce results for regions, occupations, industries and the macro economy.

Project Technical Description

1. **Theme Area:** Economics
2. **Principal Investigator (PI):** Peter B. Dixon
3. **Institution:** Centre of Policy Studies, Victoria University, Melbourne
4. **Co-Investigators:** Adam Rose, James Giesecke, Maureen Rimmer, Glyn Wittwer
5. **Research Transition Lead:** Adam Rose
6. **Keywords:** Disruptive events, general equilibrium modeling, regional modeling, quick-response economic modeling

7. **Brief Description:** (1-2 paragraph description)

The Centre of Policy Studies (CoPS) at Victoria University has developed several versions of the USAGE model of the United States and applied them in collaboration with Adam Rose and other colleagues at CREATE in analyses of various terrorism/security-related events including port closures, disease epidemics and localized infrastructure damage. In 2011, CoPS created a bottom-up regional version of USAGE, called USAGE-R. This model identifies the 50 states of the U.S. as 50 separate economies closely linked by interstate trade and interstate movement of people and capital. The initial version of USAGE-R was comparative static. In 2012-13 the model was given a dynamic dimension similar to that in the national USAGE model. Thus it became capable of tracing out effects of a shock over a number of years. In 2013-14 we extended the regional detail of USAGE-R to the county level and in 2014-15 we went to the Congressional district (CD) level. Most terrorism shocks and other disruptive events occur at a localized level (well below the state level). Thus, for analyzing such events, extending the USAGE-R capability to the county and CD levels is an important enhancement. In 2014-15 we are collaborating with Adam Rose and other colleagues at CREATE on a project for DNDO concerned with the CD-level economic effects of nuclear attacks. As explained in sections 8 to 13 below, our plan in 2015-16 is to enhance the policy value of the county and CD-level USAGE-R model by further developing its quick turn-around capabilities.

8. **Research Objectives:** (1-2 paragraphs providing clear expression of purpose and goals.)

The research in 2015-16 will have two objectives. The first objective is general. It is to advance the application of computable general equilibrium (CGE) modeling in the analysis of terrorism and other disruptive events and counter terrorism measures. This requires the introduction to the
CGE framework of new analytical features reflecting innovative theory. If existing models are to survive and continue to be useful in applications relevant to disaster policy, then they must be continuously updated and modified to take on new dimensions. In recent years we have, for example, enhanced models: to deal with illegal immigration by including specifications of labor-supply decisions by illegals and substitution decisions by employers between legal and illegal labor; to deal with a wide-spread terrorism-related closure of U.S. ports by modifying the specification of household behavior to allow for adjustments that would take place in response to sudden severe shortages of imported commodities; to deal with a severe but short-duration H1N1 epidemic by giving a CGE model a quarterly time dimension; and to deal with aversion behavior inhibiting labor supply to a region that has suffered a health-threatening event such as a chlorine attack. The second objective is particular. In 2015-16 we plan to further develop USAGE-R as a quick-response analytical tool. Applications of USAGE-R currently require inputs from expert users of the model. Despite the provision of training courses (see section 9 below), in practical terms this means that extensive inputs are required from the model developers at CoPS. This limits the potential value of USAGE-R for application by DHS in emergency situations where decisions with major economic implications need to be made within a few weeks. We are aware of this problem, and in 2013-14 we have been working on reduced-form representations of USAGE-R. These representations consist of matrices of elasticities showing the likely effects on endogenous economic variables of 1 per cent changes in exogenous variables such as the extent of property damage (capital loss), the number of immediate deaths, and health expenditures required for the injured population. Using a pre-supplied elasticity matrix, analysts can perform a calculation outside the model to obtain an estimate of USAGE results for the effect on macro and regional variables of disruptive incidents of the size that they specify. A weakness of these calculations is that they rely on a linear system that only approximates USAGE-R. However, a more important limitation is that the elasticity matrices are too specific. They refer to a particular type of event in a particular region, e.g. a nuclear attack in downtown Los Angeles. The freedom they give policy advisors to conduct more general analysis is limited to variations in the size of the nuclear device, variations in the number of fatalities and variation in the number of injuries. Policy advisors might also use the elasticity matrix worked out for Los Angeles in an application to a similar downtown location, say in Chicago, but this would be unconvincing. As described in section 13, our research in 2015-16 will improve the generality of quick turn-around computations that can be carried out without inputs from specialists in CGE modeling.

9. Research Transition Objectives: (1-2 paragraphs providing clear expression of research transition goals.)

Our main transition objective is to make it possible for DHS to use the rapid-response tools developed in our 2014-15 research for CREATE and which will be further developed in the 2015-16 research proposed here. The transition process was commenced at a seminar on November 17, 2014 held in Washington DC for the DHS Consequence Focus Group no. 4. At the seminar Peter Dixon explained a series of USAGE results on the effects of various hypothetical terrorism events and how spreadsheet analysis could be undertaken to test the sensitivity of these results to variations in assumptions concerning the number of immediate deaths, the number of delayed deaths, cleanup costs, property damage, and the shutdown period. The seminar was organized by Jim King (Senior Research Scientist, Chemical Security Analysis Center (CSAC),Department of Homeland Security, Science & Technology Directorate). About 20 DHS officials were in attendance including: Tony Cheesebrough (Headquarters), Jessica Cox
(Chemical Security Analysis Center) and Scott White (Headquarters). The presentation was received enthusiastically and a follow up meeting was arranged for December 5.

In May 2015 we will include a segment for DHS in the annual course held in Washington DC on the USAGE model. In this segment we will cover USAGE analysis of disruptive events and the rapid-response tools that will make it possible for DHS officials to extend this analysis. We will promote the course strongly with our contacts in DHS. In 2015-16 we will continue to promote analysis of disruptive events using the USAGE model and associated rapid response tools. We plan to do this through seminars and the annual USAGE course in Washington DC.

10. Interfaces to Current CREATE Projects: (Identify which and how your project will integrate with other Center projects).

My main collaborator at CREATE is Professor Adam Rose. The collaboration with Adam commenced six years ago with an introduction from Bryan Roberts (then of DHS). With my colleagues Maureen Rimmer and James Giesecke at CoPS, I have since established a successful working relationship with Adam. This collaboration has produced five CoPS/CREATE collaborative refereed publications, the latest being Giesecke et al. (2014). In 2014-15 we collaborated with Adam and his colleagues on the production of a report for DNDO. The division of labor was as follows. First, Adam and his team created detailed specifications for 5 terrorism scenarios: a 1 kiloton nuclear detonation in downtown Los Angeles; a 0.1 kiloton nuclear detonation at a sports event in the American Airlines arena in Miami; a week-long evacuation of downtown Seattle based on a false alarm; a major interruption of US/UK trade caused by a large-scale terrorism event in London; and the introduction of costly inspection procedures for all incoming containers to the U.S. following a security scare in Singapore. Second, my colleagues and I at the Centre of Policy Studies used the county/CD version of USAGE-R to translate Adam’s scenarios into economic outcomes at the macro, industry and regional levels. In making the translation, we used USAGE’s flexible aggregation facility (developed in previous research for CREATE). This facility makes it possible to vary the regional dimension to emphasize the regions of interest, e.g. downtown Los Angeles, the area surrounding the American Airlines arena in Miami, etc. With flexible aggregation, regional and industry detail are retained where they are relevant, but suppressed where they are not. In this way, we produce regional models that are readily manageable from a computational point of view.

To facilitate our on-going cooperation with CREATE, Maureen Rimmer and I have paid week-long visits to USC on several occasions to work with Adam. James Giesecke spent 4 months at USC from November 2008 to March 2009 during which time, as well as collaborating with Adam, he established an ongoing working relationship with Bill Burns (Cal State, San Marcos) of CREATE who works in psychology and decision sciences. We will continue regular visits to CREATE.

11. Previous or current work relevant to the proposed project, why is DHS interested, identify/who are your expected DHS users.

At CoPS we have a 39-year history in practical policy-oriented CGE modeling. This is described in Dixon et al. (2013). In the U.S., CoPS works not only with CREATE but also with the U.S. International Trade Commission, the U.S. Departments of Commerce, Agriculture, Homeland Security, Energy, and Transportation, and the Mitre Corporation. Using versions of the USAGE model, CoPS has completed a large number of studies for these organizations covering topics in trade, environment, immigration, energy, macro-economic
stabilization and infra-structure. Currently we have ongoing projects with USITC, Commerce, Agriculture, Transportation and Mitre. In the specific field of disruptive events, we have completed CGE analyses of the economic effects of: RDD and chlorine attacks in Los Angeles; a severe H1N1 epidemic; and a security-related widespread closure of U.S. ports.

We aim for policy relevance. With regard to disaster/security issues this means making our work known to DHS. Maureen Rimmer and I visit Washington twice a year. We maintain contact with officials at DHS Headquarters. In 2012 we had meetings with Tony Cheesebrough, Ryan Wise, Joel Piper, Marvin Fell and Katie Foreman and in December 2013 Tony Cheesebrough attended the annual training course that we conduct at the USITC. We also rely on our CREATE colleague Adam Rose to keep our work in front of DHS. We are currently working with Adam on a specific application project for DNDO.

As outlined in section 9 above, we have extended and intensified our contacts in DHS during 2014-15. It appears that our USAGE work, especially the regional aspects that have been developed with funding from CREATE, is of intense interest to the DHS Consequence Focus Group. Under this proposal we will continue to produce products relevant to DHS groups working on consequence analysis. Of particular interest will be our generalized rapid response tool described in section 13.

12. Major Deliverables, Research Transition Products and Customers: (What are the major products, and who are the primary clients that are interested in the results.)

Our products are state-of-the-art economic models together with reports and academic papers describing these models and particular applications. Deliverables from our 2015-16 research will consist of a report describing rapid response techniques for gaining USAGE insights plus associated software.

As outlined in sections 9 and 11, our research is of considerable interest to DHS officials working on consequence analysis. These officials are located in various parts of DHS including, the Headquarters in Washington DC, DHS Chemical Security Analysis Center, DNDO and the Science and Technology Directorate. Also as outlined in section 9, our effort in 2014-15 and 2015-16 is very much focused on facilitating transition of our modeling techniques and results to DHS officials through seminars and formal hands-on training (the USAGE course).

13. Technical Approach: (Detail the technical approach to achieve research objectives and Research Transition Products.)

In creating the county and CD versions of USAGE-R we used Census data to identify the industrial structure (up to 500 industries) of economic activity in most of the 3,077 counties of the U.S. Then using gravity formulas we estimated inter-county trade flows. In theory, this was sufficient to create a 3,077-region bottom-up regional model. In practice, such a model is far too unwieldy for use in a policy situation. Consequently, as we have done with the state-level version of USAGE-R, we have equipped the county version with a flexible aggregation facility. Users of the model are able to choose both the industry and regional aggregation to suit their application. Nevertheless, the model remains too technically demanding for routine use outside the modelling group at CoPS. As explained in section 8, we have responded to this problem by creating a reduced-form elasticity approach to approximating USAGE simulation results.
The core of this approach is a matrix showing the elasticities (sensitivities) of macro, industry and regional variables with respect to the resource loss and behavioral consequences of terrorism events. Mathematically, the core is the matrix $A$ of elasticities in the equation

$$ y = A \times x $$

where

$y$ is the vector of percentage changes in endogenous variables describing national, regional and industry level results; and

$x$ is the vector of percentage changes in exogenous variables describing the resource losses (casualties, capital damage, business interruption, productivity losses, medical expenses) and behavioral fear effects (compensating wage premiums, investor risk premiums, willingness to pay losses) associated with a terrorism event.

Equation (1) is readily translatable into a rapid-response spreadsheet tool in which $A$ matrices estimated by USAGE are stored in the background and the user specifies $x$ vectors. However, as explained in section 8 this approach has important limitations.

To overcome these limitations we plan a generalized reduced-form approach based on regression analysis. We will conduct a large number of USAGE-R county level or Congressional district simulations covering a variety of events occurring in diverse regions. These events will have different assumed fatality, injury and capital-destruction characteristics. For each simulation we will generate results for macro variables and for variables describing employment by industry in the region in which the incident takes place, in nearby regions, in the rest of the state and in the rest of the U.S. We will then regress these USAGE-R results against the assumed characteristics of the incident. This will give us regression equations into which DHS officials and other policy advisors will be able to insert characteristics of actual events or hypothetical events of interest on the right hand side and compute fitted outcomes for macro and regional variables on the left hand side. These fitted outcomes will approximate the results that would be obtained from a full USAGE simulation.

14. Major Milestones and Dates: (Key progress management steps and schedule, including webinar to present results)

The major milestone for the CoPS team in 2015-16 will be the completion of a report describing the generalized rapid response techniques that will be developed under this research proposal together with associated software. Other milestones will be the delivery of a seminar for DHS officials which we will organize for December 2015 and the inclusion of a segment for DHS officials in the annual USAGE course, the 2015-16 version of which will be delivered in May 2016.

15. References:


16. CVs (PI and up to two Co-PIs): One page maximum for each.

PI: Peter B. Dixon

Current Position
Professor, Centre of Policy Studies, Victoria University, 2014-

Education
Ph.D. (Economics)         Harvard University 1972
A.M.  (Economics)         Harvard University 1970
B.Ec.  (Economics)        Monash University 1968

Summary
Professor Peter B. Dixon, BEc (Monash), PhD (Harvard), was born in 1946. He topped his honours class at Monash in 1967. His PhD was awarded by Harvard University in 1972 and his thesis was subsequently published in the *Contributions to Economic Analysis* series of North Holland (then the world's leading publisher in scientific economics). After working at the International Monetary Fund and the Reserve Bank of Australia, Dixon joined the IMPACT Project in 1975 under the direction of Professor A.A. Powell. With Powell, he was the joint recipient of the 1983 Research Medal of the Royal Society of Victoria given in recognition of the outstanding contribution of the IMPACT Project to social science research in Australia over the preceding 5 years. He was elected a Fellow of the Academy of Social Sciences in 1982 and is one of only 10 economists working in Australia included in *Who's Who in Economics, A Biographical Dictionary of Major Economists, 1700-1986*. Inclusion in the Who's Who is based on international citations. In 1990, he was the Giblin lecturer at the 59th ANZAAS Congress.

Dixon was appointed to the Chair in Economic Theory at La Trobe University in 1978 and to a Visiting Professorship at Harvard in 1983. From 1984 to 1991 he was Director and Professor in the Institute of Applied Economic and Social Research at the University of Melbourne and from 1991 to 2004 he held the equivalent position in the Centre of Policy Studies at Monash University. In July 2004 he became Professor and Principal Researcher in the Centre of Policy Studies. In 2014 he transferred with the Centre of Policy Studies to Victoria University in downtown Melbourne.

Dixon is known internationally for his work in computable general equilibrium modelling. Together with colleagues at the IMPACT Project and the Centre of Policy Studies, he created the ORANI model and its dynamic successor, MONASH. These models have been prominent in the Australian economic debate for 37 years and have been used as templates for the development of other models throughout the world. He is the principal author of the ORANI and MONASH books published in the North Holland *Contributions* series in 1982 and 2002. In recent years he has led the development of the USAGE model of the U.S. which is being used by the U. S. International Trade Commission and the Departments of Agriculture, Commerce and Homeland Security.

Dixon's publication list contains about 200 articles and 8 books, including three North Holland Contributions monographs and the two-volume Handbook of Computable General Equilibrium Modeling (Elsevier, 2013, edited with Dale Jorgenson). In 2003, Dixon was awarded the Distinguished Fellowship of the Economic Society of Australia. In 2006 he was appointed Sir
John Monash Distinguished Professor by Monash University. In 2014 he became an Officer in the Order of Australia.

Co-PI: Maureen T. Rimmer

In July 2011 Maureen Rimmer was appointed as Professor in the Centre of Policy Studies, Monash University. In January 2014 she transferred with the Centre of Policy Studies to Victoria University located in downtown Melbourne. She had joined the Centre in 1991 as Research Fellow, became Senior Research Fellow (Senior Lecturer level) in 1996 and Senior Research Fellow (Associate Professor level) in 2001. Her earlier appointments include: Research Fellow at the IMPACT Project at the University of Melbourne, 1989 to 1991; Lecturer in Economics at La Trobe University 1988; and Senior Tutor in Mathematics and Economics at La Trobe University, 1985 to 1987.

Professor Rimmer holds the following degrees from La Trobe University: B. Sc. First class honours, 1973; Ph.D in mathematics, 1978; B. Ec., 1985; and Masters Prelim (economics), 1987. She completed an M. Com. at the University of Melbourne in 1990.

Professor Rimmer is the author and co-author of 60 scholarly published articles, appearing in mathematics and economics journals and edited volumes. Her main area of expertise is in model development and application. She is the co-author of numerous consultancy reports from the Centre of Policy Studies. With Peter Dixon she is the co-developer of the MONASH model of the Australian economy and the co-author of the MONASH book which was published in 2002 in North-Holland’s Contributions to Economic Analysis.

In the last twelve years Professor Rimmer has been a key contributor in the development, application and documentation of USAGE. This is a 500-industry, dynamic model of the U.S. economy, with facilities for generating results for the 50 States and 700 occupations. The model is used in Washington by the U.S. International Trade Commission and the U.S. Departments of Commerce, Homeland Security, Agriculture, Transport and Energy. Apart from the design and implementation of USAGE, Professor Rimmer has made major contributions in applications of the model to key policy areas such as: the replacement of imported crude oil with domestically produced biofuels; legalization of unauthorized immigrants; an analysis of the 2008-9 U.S. recession with and without the Obama stimulus package; and the effects of the President’s National Export Initiative.

In 2009 she was joint winner of a Dean’s Award for Excellence in Research in the Faculty of Business and Economics at Monash University.
Co-PI: James A. Giesecke

With the transfer in January 2014 of the Centre of Policy Studies from Monash University to Victoria university (located in downtown Melbourne), James was appointed as its Director. In 2012 he had been appointed Professor and Deputy Director (then at Monash University). He joined the Centre in 2002 as Senior Research Fellow. Prior to that he held the positions of Senior Research Fellow (1999-02) and Research Fellow (1996-98) at the Centre for Regional Economic Analysis (CREA) at the University of Tasmania. Before commencing at CREA he held positions as Senior Research Economist (1994-1995) at the South Australian Centre for Economic Studies (University of Adelaide) and Consultant (1992-1993) at KPMG and Peat Marwick Management. He has a first class honours degree and a PhD from the University of Adelaide. James’ main areas of expertise are in the development and application of large-scale multi-regional and national computable general equilibrium models, with over a twelve years experience in applying such models to historical, forecasting and policy analysis. James has diverse commissioned research experience, having worked on over ninety commissioned research projects, reporting to organisations such as the Allen Consulting Group, Deloitte Touche Tohmatsu, KPMG, ACIL Consultants, a number of Commonwealth Government departments and agencies, and state government departments throughout Australia. He is the author or co-author of 40 journal articles and book chapters.