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The John A. Blume Earthquake Engineering Center

Department of Civil & Environmental Engineering, Stanford University

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WELCOME TO THE 2000-2001 SCHOOL YEAR

The 2000-2001 school year has begun and we welcome all of our new students. Included in this year's Master's class are recipients of the NSF Graduate Research Fellowship, a Stanford Graduate Fellowship, three School of Engineering Fellows and two Diversity Fellows.

BLUME CENTER NEWS

Prof. Greg Deierlein presented a paper on "*Seismic Design of Composite Moment Frame Buildings - Case Studies and Codes Implications*" at the Composite Construction IV Eng. Foundation Conference held in Banff, Canada, May 28-June 2.

Prof. Anne Kiremidjian presented a paper with graduate students **Dimitris Pachakis** and **Mark Audigier** on "A Simulation Model for Seismic Risk Analysis of Port Facilities" at the Symposium on Monte Carlo Simulation, June 17-21.

Dr. Renate Fruchter was guest speaker at the CIT2000: Construction Info Tech 2000 Intl. Conference, Reykjavik, June 2000. Her presentation, entitled "*Knowledge and Information Slider System,*" focused on knowledge management over the building life-cycle.

Prof. C. Allin Cornell attended the ASCE Structures/ Mechanics Specialty Conference on Probabilistic Mehods at Notre Dame in July.

Prof. Eduardo Miranda and grad student **Hessamedin Aslani** conducted a reconnaissance investigation after the September 3 Yountville (Napa) magnitude 5.2 earthquake. A brief report of their investigation can be found at http://www.eerc.berkeley.edu/yountville/.

Prof. Anne Kiremidjian participated in the NEHRP Strategic Plan Workshop, Sept. 6-7 in Reno, sponsored by FEMA in cooperation with NSF, USGS and NIST.

Dr. Renate Fruchter organized the 2nd Student Competition "Computing in Action" sponsored by Autodesk Inc. in conjunction with the ICCCBE-VIII conference. Thirty outstanding contributions from Europe, US, and Asia were presented and prizes were awarded.

2001 AFFILIATES MEETING

The 2001 Blume Center Affiliates Meeting will be held April 6, 2001. More information will be sent out in January.

THE JOHN A. BLUME DISTINGUISHED LECTURE

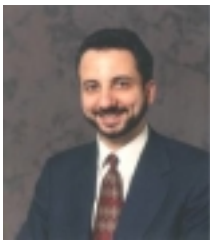
The Blume Center at Stanford University is pleased to announce the first **John A. Blume Distinguished Lecture** on October 25, 2000.

This will be the inaugural lecture in an annual series in honor of Dr. John A. Blume by a structural engineer whose career best exemplifies Dr. Blume's outstanding achievements. Our first lecturer, **Tom Paulay**, Professor Emeritus of the University of Canterbury, New Zealand, will be speaking on "*Compatibility Criteria Relevant to Displacement Ductility*". Professor Paulay has been a teacher in structural design and structural mechanics for 28 years, has published extensively and is the recipient of several prominent awards.

For more information please see the Blume Center Web Page (http://blume.stanford.edu).

2000/2001 UPS VISITING PROFESSOR

This fall, the Blume Center is pleased to welcome Jerry Hajjar as the 2000/01 UPS Foundation Visiting Professor in CEE. Hajjar is an Assoc. Professor at the Univ. of Minnesota and is a graduate of Yale University (BS 1982) and Cornell University (MS 1985, PhD 1988). Prior to joining the Univ. of Minnesota he was a structural engineer with Skidmore, Owings and Merrill. His major research interests are in computational analysis, experimental testing and design of steel and composite structures. His recent projects include the performance of steel buildings and connections during the Northridge earthquake and field instrumentation and testing of composite bridge girders. While visiting the Blume Center over the coming year, he looks forward to co-teaching a course in nonlinear structural analysis, offering several research seminars, and engaging in research discussions with graduate students and faculty.



PROFESSOR LOWES GOES TO WASHINGTON

Professor Laura Lowes accepted a position as Assistant Professor at the University of Washington and left Stanford in September. We wish her the best of luck in her new position.

RESEARCH SPOTLIGHT

ECONOMIC CONSEQUENCES OF CATASTROPHES

By T.L. Murlidharan and Haresh C. Shah

INTRODUCTION

How closely are catastrophes and developmental processes related? Do catastrophes actually retard economic growth? How important and how long lasting are the various effects likely to be? What trends do past data on catastrophes suggest and can theoretical models replicate these trends? How will a regional economy behave after a catastrophic event? What measures will best help the affected community to recover?

Catastrophes are not caused by the extremes of nature alone. A catastrophe is fundamentally a social phenomenon; it involves the intersection of the physical processes of a hazard agent with the various ongoing economic, social, and political processes. For large segments of the world's underdeveloped population, occurrence of a natural hazard may worsen an already deteriorating or fragile situation. The effect of a catastrophe on the developmental process is complex, especially for developing regions.

This article, based on a doctoral dissertation of the first author, presents an attempt to answer these questions.

THEORETICAL MODELS OF ECONOMIES AFFECTED BY CATASTROPHES

Theoretical formulations based on extensions of Ramsey's economic growth model were used to analyze the dynamic effects of a catastrophic event. The models simulate the behavior of a typical economy when perturbed by an unanticipated and large change in the capital stock followed by an arbitrarily complex change in the affected region's productivity. The results indicate the initial impact on investment, consumption, and production.

In an economy, construction activity of some kind is almost always going on. Capital in an economy can be classified into two categories – the maturing capital and the productive capital. The capital that is being invested for constructed facilities does not become immediately productive. For example, it takes time to plan, build and commission a bridge before it becomes fully functional. It is crucial to model the effects of speed with which the maturing capital becomes productive capital. Typically, after a catastrophic earthquake, productive capital including buildings and infrastructure will be damaged or destroyed. Reconstruction activities start some time after an event. With the reconstruction efforts gaining momentum, the conversion of maturing capital to productive capital may temporarily exceed its normal values for a period of time depending on the inflow of investment in the affected region. The model described below tries to simulate this behavior of an economy.

MODEL

The representative agent will chose a consumption path, $c(t)$, capital accumulation, $k_2(t)$ such that he maximizes his utility:

(1) $$\varsigma(\kappa_0) = \mu\alpha\xi \int_0^{\infty} \varepsilon^{\gamma\tau} u(\chi)\delta\tau$$

such that:

(2) $$\dot{\kappa}_1 = \phi(\kappa_2) - \chi\in\kappa_1$$

(3) $$\dot{\kappa}_2 = \alpha\kappa_1 - \beta\kappa_2$$

In Eq. 1 and 2, k_1 is the maturing capital and k_2 is the productive capital. Eq. 2 states that the maturing capital grows from investment ($f(k_2)$) but is partly offset by the consumption (c) and partly by conversion into productive capital (αk_1). Eq. 3 states that the productive capital grows depending on a portion of the maturing capital (αk_1) but the growth is negatively affected by the depreciation of the productive capital (βk_2). It is assumed that prior to the occurrence of a catastrophe the economy is at equilibrium.

A catastrophe is modeled by a discontinuous change in capital, for a period after the occurrence of an event. This is accompanied by a change in productivity associated with post-event reconstruction, an increase in external aid to the region, and a change in the rate at which maturing capital is converted to productive capital.

The simulation results point to the importance of modeling the efficiency of the reconstruction processes after an event. Unless the process whereby the maturing capital is converted to productive capital is modeled correctly, the fact that post-event growth rate is negatively correlated with the magnitude of loss cannot be explained. Fig.1 shows the results obtained from simulating a perturbed model of Eqs. 1-3. The catastrophe occurs at t = 0.5, accompanied by a discontinuous change in economic growth. At t=1 there is a change in the rate of conversion of maturing capital to productive capital. Results corroborate with empirical evidence. Empirical evidence, based on data from 32 countries in which catastrophes have occurred, strongly suggest that greater loss is associated with smaller post-event growth rates (Fig. 2). Additional evidence is presented regarding an extensive set of pre-event conditions that are important in post-event recovery. These factors proxy the changes in productivity and the conversion factor that are assumed in simulation models. Models also indicate the fall in consumption levels after the event. Greater the loss, lower is the post event consumption. Empirical evidence indicates that consumption changes are positively related to changes in income after an event. Greater changes in productivity are reflected in the post-event changes in output.

EMPIRICAL EVIDENCE

The results of model simulation suggest various hypotheses that are tested using cross-country study data from 32 countries from all income groups affected by different types of natural hazards (earthquakes, floods, hurricanes, and droughts). These included 52 events in all. Based on an econometric model, statistical regularities were inferred that corroborated the theory-generated hypothesis. These inferences are summarized below:

- Direct loss is negatively correlated with the post-event annual percentage economic growth rate.
- Greater direct losses result in greater rate of debt growth, immediately after the event.
- Direct losses are associated with an increase in the budget deficit, immediately after the event.
- Direct losses as a result of catastrophes are associated with increase in inflation and decrease in real interest rates.
- Changes in income due to occurrence of the catastrophe result in changes in consumption.
- Evidence shows that catastrophes change ex-ante saving behavior at least temporarily after the event.

A simple cause-effect relation cannot explain the interaction between the occurrence of a catastrophic event and its impact. The empirical results enumerated above generally imply that catastrophes retard economic growth, increase the external debt, budget deficit and inflation. However, these effects are only temporary, since two years after the event the effect of the catastrophe on the economic growth rate is statistically insignificant. Nations and regions affected by catastrophe start rebuilding immediately after the event. However, the recovery process may be complex. The pre-event socioeconomic conditions to a large extent determine the magnitude of impact and the 'coping' strategy of the affected community. The strategies adopted for coping, in turn, determine the post-event socioeconomic conditions.

Catastrophes and Regional Economies

Having discerned patterns of economic slow down immediately after the event followed by growth, the next part uses a regional economic model to explain the post event behavior of an affected region. A standard regional economic model was used to simulate three historical events. The three events were the 1989 Loma Prieta earthquake, 1992 Hurricane Andrew, and 1994 Northridge Earthquake. Actual observed personal incomes of the affected counties, as reported by Bureau of Economic Analysis, were compared with the model generated personal incomes for validation. The model performed well with a mean absolute percentage error not exceeding 3%. Fig.3 illustrates the model performance for Hurricane Andrew.

The model was then used to study the effects of scenario earthquakes in the Bay Area (11 county San Francisco – San Jose – Oakland CMSA) that is assumed to occur in the year 2000. Various direct loss and job loss levels were studied. Simulation results indicate that for a $30 billion capital loss and 25,000-job loss scenario, the Bay Area's gross regional product would be down by 14% without any reconstruction and aid (worst case scenario) during the year of the event. With minimal aid, investment and local government spending show declines during the first two years and then rapidly grow as the economy recovers. These results concurred with the simulation of the theoretical model of interacting regions.

Catastrophes cause myriad problems in the short run, including slower growth and lower levels of consumption. Efficient reconstruction policies result in better production techniques for the affected communities. This results in the affected communities emerging as less vulnerable and reconstruction assumptions, the gross regional product will be lower by 7% and will have totally recovered by the year 2002. Consumption, economically stronger regions in the long run. This brings out the importance of reconstruction policies that again depend upon pre-event socioeconomic factors such as mitigation measures including disaster preparedness. To achieve this efficiency catastrophe management has to be intimately linked with development policies.

Fig. 1 Impact of capital loss severity on economic growth -Model simulation

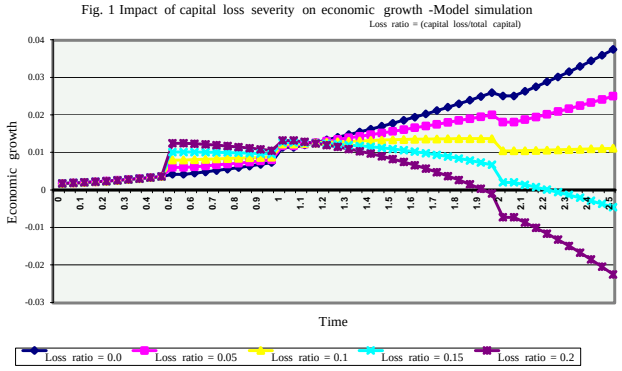


Fig. 2 Loss ratio vs. post event growth
(correlation = -0.4)

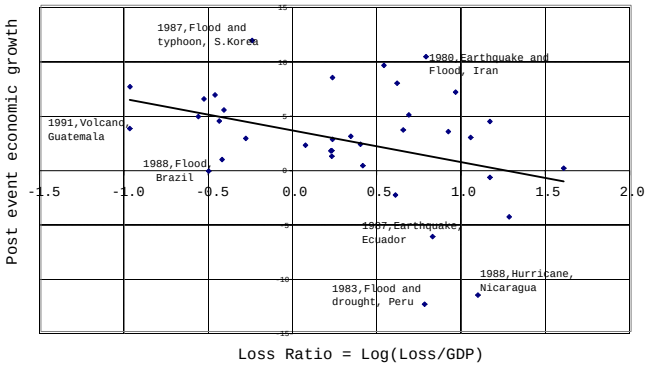
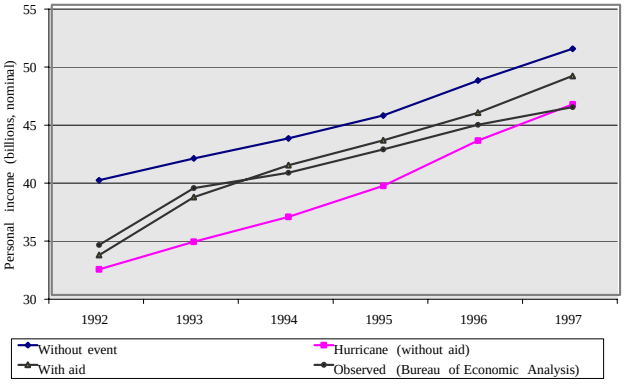


Fig. 3 Effect of Hurricane Andrew on Personal Income of Dade county



PUBLISHED PAPERS

Miranda, E. (2000), "Inelastic displacement ratios for structures on firm sites," *Journal of Structural Engineering*, Vol. 126, No. 10, 1150-1159.

SUMMER 2000 GRADUATES

Congratulations to the Structural Engineering and Geomechanics students who graduated this summer. **Chao Hua (Eric) Lin** and **Keith Porter** both received their Ph.D. degrees. Eric is now working at McKinsey & Company, Inc and Keith is a Post-Doc at CalTech in Pasadena. Also graduating were Masters students **Nuthaporn (Pock) Nuttayasakul** (pursuing his Ph.D. at Virginia Tech), **Janghwan Chung** and **Efstathios Lyberopoulas**.

ADMINISTRATIVE ASSOCIATE KILLED IN CAR ACCIDENT

Liz Marsh, Administrative Associate for the Structural Engineering and Geomechanics Program, was tragically killed in a single car accident on August 20. Liz had only been with the Structures Program since May, but had worked at Stanford Hospital for over five years. She is survived by her parents, Neal and Juanita, and her 15 year old son, Christopher. A fund has been set up in Christopher's name at Star One Federal Credit Union in Sunnyvale, CA, Account #626311-8.

Liz's incredible energy and generosity will be greatly missed by all of us who knew her.

STANFORD SPONSORS ICCCBE-VIII

Dr. Renate Fruchter and **Prof. Kincho H. Law** hosted the ICCCBE-VIII - 8th International Conference on Computing in Civil and Building Engineering *"Bringing the Architecture/Engineering/Construction (A/E/C) Professions Together - Innovation and Solutions in Computing and Information Technology."* at Stanford, August 14-17, 2000.

This Conference attended by 300 A/E/C students, academics, and professionals covered a broad spectrum of topics related to computing in Civil and Building Engineering including: project life-cycle, Internet and data mining, e-commerce, e-code checking, e-learning, A/E/C education, standards, interoperability, CAD, GIS, and GPS, multimedia and virtual reality, 3D and 4D planning in construction, fuzzy sets, neural networks and genetic algorithms, product and process modeling, human factors and future workspaces, structural modeling and analysis, optimization, and transportation.

ALUMNI NEWS

Rachel A. Davidson (MS '94, PhD '97) recently joined the faculty of the Civil and Environmental Engineering Department at Cornell University. She has been an Assistant Professor at University of North Carolina at Charlotte since 1998.

VISTING SCHOLARS

The Blume Center is pleased to welcome **Sung Bo Kim**, from Korea, and **Dario** and **Anna Rinaldis**, from Italy, as Visiting Scholars. Dr. Kim will be doing research on vibration and stability until July 2001, and the Rinaldis are working on ground motion and earthquake incentive policies.

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