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Carroll Round Proceedings
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Additionally, we are grateful for the support of Georgetown University’s Edmund A. Walsh School of Foreign Service, the Department of Economics, the Carroll Fellows Initiative, and the Office of the University Counsel at Georgetown University. We also thank the Federal Reserve Board of Governors for hosting us every year, and Professors Michael Seeborg of Illinois-Wesleyan University and Nancy Marion of Dartmouth College for enthusiastically encouraging their students. We would also like to express special appreciation to all the faculty members and economists who dedicated precious time to chairing conference sessions:

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David Denny, US Trade & Development Agency
Robert Hussey, S.J., Georgetown University
Kristine Kalanges, Georgetown University
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Rodney Ludema, Georgetown University
Anna Maria Mayda, Georgetown University
Paul McNelis, Georgetown University
Anders Olofsgard, Georgetown University
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Brooks Robinson, Bureau of Economic Analysis
Susan Vroman, Georgetown University
Holger Wolf, Georgetown University
Tarik Yousef, Georgetown University

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Mr. Philip A. Vasta
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Ms. Susan Porter
Mr. and Mrs. John Kelly
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Mr. Philip A. Vasta
Mr. Yunho Song
Mr. and Mrs. John Kelly
Mr. James E. Moore
Ms. Kaede Hara Kaneda

The Carroll Round owes its tremendous progress to a history of impressive participants with unique research contributions and all past committee members who invested hours of
planning and dedication to bring this conference and now this publication to life. Beyond the committee and participants, the following people have advanced the Carroll Round:

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<td>Daniel Powers</td>
<td>Jennifer A. Willis</td>
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We also could not have achieved the same intellectual forum without incredible speakers, so we would like to thank them for believing in the strength and potential of undergraduate international economics students:

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<td>Donald L. Kohn</td>
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Last but certainly not least, the Carroll Round enjoyed unwavering support from several outstanding individuals. We would like to thank Dean Robert Gallucci for his constant encouragement, Dean Elizabeth Andretta for backing our endeavors, Dean Mitch Kaneda for his enthusiastic support and guidance all these years, and Ms. Meghan Hogge for working her magic.

From all of us at the Carroll Round, thank you!
INTRODUCTION

A Brief History of the Carroll Round

Whenever I am asked about the history of the Carroll Round, stories about Oxford and the Radcliffe Arms pub usually abound. While there is truth to this aspect of the narrative, the conference's roots extend firmly and unambiguously to the Georgetown University campus. For it was there that a remarkable team of friends and colleagues assembled and launched the Carroll Round five years ago.

During the 1999-2000 academic year, I had the great pleasure of meeting and learning alongside seven outstanding economics classmates. My first meaningful discussions about economics took place that year with fellow students Andrew Hayashi and Ryan Michaels. Andrew and I were both enrolled in Professor Mitch Kaneda's International Trade class that semester, and Ryan suffered with me through Microeconomic Theory as well as a demanding Introduction to Political Economy. I remember feeling intimidated at first by their ever-expanding knowledge of theory and their boundless enthusiasm for learning. Over time, however, I realized the extent to which I was learning from their unique perspectives; their insights often proved more valuable than the content of weekly lectures. I also became acquainted with a group of talented classmates, including Bill Brady, Josh Harris, Kathryn Magee, Brendan Mullen, and Scott Pedowitz. By the spring, our paths all pointed to Europe: Bill, Kathryn, and Scott to the London School of Economics, Brendan to the University of Bristol, and Josh, our resident Slavophile, to Poland and Hungary. Andrew, Ryan, and I planned to spend our year abroad at the University of Oxford studying a mixture of philosophy, politics, and economics. Before departing in October 2000, I knew our shared plans were not the product of mere coincidence—something special would emerge from the experience.

Having established initial ties at Georgetown, Andrew, Ryan and I began meeting on a regular basis to discuss our latest tutorial sessions, grueling problem sets, the future of macroeconomics and, occasionally, the latest gossip about luminaries in the field. Whereas C.S. Lewis, J.R.R. Tolkien, and the Inklings called the Eagle and Child their intellectual home, we adopted the Radcliffe Arms as our haven. Over pints and pub food, Andrew’s twin passions for game theory and philosophy emerged. The future of monetary policy and development began to vex Ryan’s thoughts, while I hoped to better understand the mechanisms of cooperation, or conflict, underlying international trade institutions.

Meanwhile at Pembroke College, I encountered a group of students from universities
across the country also spending their junior years at Oxford. Although I befriended the other economists in our contingent, I also developed close relationships with the physicists, biologists, literary scholars, and art historians. In the Junior Common Room or over traditional English dinners in the dining hall, we shared stories about life at our respective home universities and the latest research we were conducting at Oxford. As thesis and postgraduate plans matured during these conversations, I appreciated ever more my exposure to these alternative experiences and approaches to scholarship. As the year progressed, I worried that my eventual return to the United States would sever these exciting connections.

One evening at the start of my final term in Oxford, I thought about the importance of this dialogue and my growing affinity for international economics. I harbored a distressing feeling that undergraduates, especially in economics, were not afforded adequate opportunities to present their work in a serious research setting. After all, I always felt privileged when Andrew, Ryan, and my fellow Pembrokians shared their original ideas with me. Thus, I reasoned that undergraduate economists from around the country deserved an event in which they could interact significantly with each other and the professional academic community. In March 2001, I composed the memo that outlined my solution: the Carroll Round. The following paragraph from that proposal captures my motivating thoughts:

As they prepare for careers in academia, public service, and business, undergraduate students throughout the country also have joined a momentous dialogue in collegiate, national, and global fora. Many are involved in independent research representing the next generation of critical thought in international relations. Others have enjoyed unique experiences through jobs and internship programs that expose them to the front lines of economic policy-making and statecraft. Young women and men also have championed vociferously environmental and labor-related causes through awareness and service programs. Clearly, these timely economic issues are assuming greater importance for the future of international relations and are reflected in the abundance of attendant student research, interest, and initiative. Therefore, I propose to coordinate and host, in association with Georgetown University’s School of Foreign Service and John Carroll Scholars Program, the next ‘round’ of economic and political discussion and debate—the Carroll Round.

Unsure of their likely reactions, I invited Andrew and Ryan to join me in this endeavor over pints at the Radcliffe Arms. I was confident that if such rising stars believed in the concept, other students would join in time. Having worked out more substantive ideas over the summer, I was finally prepared to call upon the other economics celebrities in my class to collaborate on the project. Bill, Josh, Kathryn, Brendan, and Scott fortunately signed on and completed the senior circle. A few months later we brought on board four underclassmen: Cullen Drescher, Mark Longstreth, Waheed Sheikh, and future Chair Meredith Gilbert to encourage younger students and ensure continuity for the future.

With the unflagging assistance of John Carroll Scholars Program Director John Glavin, the proposal was circulated among university administrators. After gaining their initial support, I asked Mitch Kaneda, my most influential undergraduate teacher and a newly appointed Associate Dean of the School of Foreign Service, to review the proposal.
Without hesitation—and somewhat to my surprise—he offered his assistance, embarking on a five-year stewardship of the Carroll Round. Also during the fall, Deans Robert Gallucci and Betty Andretta extended moral and financial support, which cemented our institutional sponsorship at Georgetown.

The Carroll Round Steering Committee struggled through many difficult decisions regarding conference content, format, and funding. Should submitted papers be limited to topics in international economics? What elements must be included in submissions and presentations? How do we ensure that financial constraints do not influence students’ decision to attend? Over marathon sessions in Healy Hall and at the Tombs, we developed a model for the Carroll Round that has largely remained intact over the last five years. Development Officers Christine Smith and Jim Patti shared our ideas with generous alumni who responded favorably and pledged individual donations. Little by little, our initial concepts materialized into reality. When the Sallie Mae Fund contributed $10,000 to the Carroll Round, we both gained a lead sponsor and secured the long-term future of the conference.

After distributing colorful brochures, contacting the top departments in the country and preparing the Hilltop for the event, applications streamed in during the spring. By late March, we had narrowed our list of invited students to 32. Seniors traveled to Washington from as near as the University of Virginia and as far as Stanford University. The Committee was stunned by the enthusiasm expressed by the participants and their home departments. Among the more notable responses, Illinois-Wesleyan University sent four young economists to the conference and soon after published a special Carroll Round edition of their undergraduate economics journal.

The inaugural Carroll Round officially began on Friday April 5, 2002 and the proceedings came to a close two days later. Participants enjoyed an exclusive audience with then Director of the National Economic Council Lawrence B. Lindsey in the beautiful Riggs Library before hurrying to the Federal Reserve for another private meeting with Vice Chairman Roger W. Ferguson and current Governor Donald L. Kohn. The two monetary policy experts shared candid stories about the effects of September 11, 2001 on the nation’s banking system and the various roles that the Federal Reserve plays in American economic activity. Dr. Lindsey’s speech marked another first—the inaugural Ibrahim Oweiss Lecture in honor of our beloved Georgetown economics professor. Dr. John Williamson of the Institute for International Economics spoke about development issues over a splendid dinner, and Dr. Edwin M. Truman, former Assistant Secretary of the U.S. Treasury for International Affairs, closed the conference with words of wisdom to students considering careers in academia and policymaking.

A total of 28 papers were presented over the weekend, including the impressive work of MIT’s Maria Jelescu in “The Role of Hedge Funds in World Financial Crises,” the noteworthy “The World Food Economy to 2050: A Nonlinear Dynamic General Equilibrium, Two sector, Three Factor Endogenous Growth Approach to Long-Term World-Level Macroeconomic Forecasting” from Stanford’s Benn Eifert, Carlos Gálvez, Avinash Kaza, and Jack Mooreand, and “The Global Integration of Stock Markets” by Yale’s Fadi...
Georgetown professors who served as panel discussants later remarked that the quality of some presentations surpassed the sophistication of recent graduate-level dissertations. Judging by their comments, the conference brought together some of the best young minds in economics as they approached the frontiers of research in the discipline.

I never imagined in March 2001 that the first Carroll Round would attain the heights realized one year later, or for that matter even exist. Over the past five years, the event has grown in size and scope beyond my initial hopes. The participation of Nobel Laureate John F. Nash, Jr. in 2004 marked a special peak in the evolution of the conference, and I hope that over time students from the developing world will be able to attend. I continue to enjoy meeting participants and learning about their research interests. As they share in the excitement of presenting their work and the occasional trepidation of fielding questions, I feel humbled to be among such gifted individuals. In fact, alumni from previous years have advanced to graduate study at Berkeley, Chicago, MIT, Michigan, Oxford, Princeton, Yale, and Wisconsin, as well as top government and finance positions around the country. This group of former conference participants has truly grown into a professional and academic network unlike any other for young economists.

In closing, I would like to thank the Kazanjian Foundation for their generous support, which made the publication of these Carroll Round Proceedings possible. I also would like to extend my unwavering gratitude to the members of the inaugural Carroll Round Steering Committee without whom this history would have remained fiction. I have great respect and admiration for successive Chairs Seth Kundrot, Meredith Gilbert, and Erica Yu as they assumed leadership of the conference. And, I am particularly grateful to current Chair Marina Lafferriere for joining the Committee as a freshman, carrying on the Pembroke tradition, and returning to lead the Carroll Round as a senior. Other past and present Committee members have tirelessly ensured the success of the conference each year and deserve our appreciation. Finally, I must thank Mitch Kaneda who has miraculously preserved my vision for the Carroll Round over the years and watched over past Committees as they built upon its initial success and join the ranks of distinguished alumni. With his continued collaboration and the eagerness of future Georgetown students, I expect that the next chapter in the history of the Carroll Round will far surpass the first five years.

Christopher L. Griffin, Jr.
Georgetown Class of 2002
Carroll Round Founder
LETTER FROM THE CARROLL ROUND

Dear Reader,

It is with great pleasure that we present to you the first annual *Carroll Round Proceedings* (CRP), a partial documentation of the research presented at the Carroll Round: An Undergraduate International Economics Conference at Georgetown University. This publication—the result of efforts by the Fourth Annual Carroll Round Steering Committee and a generous grant from the Kazanjian Foundation—represents an important milestone in the development of the Carroll Round, for it will serve as the primary means to capture the spirit of our conference. Over the past five years the Carroll Round has evolved from an ambitious idea among students to a professional student-run conference. Highlighted by distinguished guest speakers and original research presentations, our conferences have created a stimulating forum for new ideas and debate that has attracted top undergraduates, nationally and internationally. This first volume of the *Carroll Round Proceedings* will undoubtedly contribute to further expand and professionalize our conference and will form part of an even more rewarding experience for our participants.

This volume of the CRP is a compilation of synopses and full-length papers from the works presented at the conference in April of 2005. Contributions come from fifteen outstanding undergraduate economics students from eleven major universities in the United States, Canada, and Europe. All of these students were chosen as a result of their demonstrated achievements and the high quality of their papers to participate in the Fourth Annual Carroll Round, where they presented their work and were reviewed by professors and their peers. These synopses and papers represent only a fraction of the works presented last spring; nonetheless, the sample herein included accurately reflects the overall degree of sophistication exemplified in the work of all our participants.

The topics covered in this volume of the CRP range from economic growth and development to terrorism and hostage negotiations. The format of individual synopses varies by length and detail, however, all synopses and papers follow a basic structure with an introduction of the topic in question, a brief account of the literature review, the hypotheses and models, an explanation of the methodology, and a presentation of results. The synopses are arranged in the order they were presented in the conference followed by the full-length papers. Also, because this is our first edition of the *Carroll Round Proceedings* we have included several appendices that provide more details on the presentation schedule for the Fourth Annual Carroll Round, past guest speakers, former Steering Committee members, the Advisory Panel, and conference participants over the past four years.

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LETTER FROM THE CARROLL ROUND

In the future we plan on showcasing all of the excellent work produced by our conference participants by including contributions from every one of them, either in synopsis or full-length format. For this first edition, unfortunately, this was not possible due to time-constraints and other impediments. Having recognized our limitations, however, our goal with this issue has been to set the foundations for future bigger and better volumes as we continue to grow and expand. We are confident that future generations will carry out our objectives and will keep innovating and improving upon our efforts, guided by their commitment to the principles of our organization.

With that said, it is our honor to present to you the first ever Carroll Round Proceedings, a collection of outstanding undergraduate research.

Sincerely,

Héber M. Delgado-Medrano

Editor-in-Chief, Fifth Annual Steering Committee
Georgetown Class of 2006

Marina Lafferriere

Chair, Fifth Annual Steering Committee
Georgetown Class of 2006
CARROLL ROUND PROCEEDINGS
The Fourth Annual Carroll Round
Undergraduate Economics Conference
A Steady Rain: 
The Impact of Migrant Remittances on Economic Development

Jonathan Kirschner
Georgetown University, SFS 2005

I. Introduction: Remittances as a Force in Development
Remittances are the money that immigrants send back to their home countries, usually out of wages earned abroad. Typically, each remittance transaction is of between US$100 and US$300. With over 175 million people who have left their homelands for economic reasons, the annual flow of official remittances is near US$100 billion, over half of which flows to developing countries. According to Wimaladharma, Pearce, and Stanton (2004), the unofficial amount is likely to be twice as large and has continued to grow ever since the late 1990s. This tremendous resource flow holds a great potential as a source of finance for development. Remittance flows are an important policy concern because they are large in size, relatively stable, they cushion economic shocks, and they are unique in that they provide direct benefits for households. The stability of remittances is like a “steady rain” that consistently provides the recipient with extra capital.

The previous literature leaves a puzzle with regard to the impact of remittances on development and this paper uses traditional growth regressions to assess their significance. Initial regressions indicate that the impact of remittances is negative, but the regressions provide an inconsistent picture and the results are not robust to all specifications. Further investigation disaggregates the effect of remittances on growth and reveals important channels through which remittances have counteracting impacts. The results here suggest that remittances have a negative impact on economic development through labor force participation, domestic savings, and secondary education. Their positive impact flows through domestic credit expansion, access to improved sanitation, and a decrease in the percentage of the population that suffers from malnutrition.

II. Theory: Understanding the Role of Remittances
The literature specifically on remittances provides a conflicting picture of their impact on economic growth in the recipient countries. On the positive side, (see Orozco (2001), Taylor (1999), Martin (2001), Adams and Page (2003), and Wimaladharma et al (2004)) scholars emphasize economic improvement, greater freedom from local barriers and constraints, considerable local investment, decreasing interurban inequalities, and considerable recycling of remittances within the local region. Studies that focus on the positive aspects of remittances describe them as improving recipients’ standard of living, produc-
ing money for basic needs such as food, clothing, housing improvements, and education, and providing hard currency for consumer goods, such as small household appliances. For example, Durand et al. (1996) find that each $1 remitted to Mexico produces an increase of $2.90 in the GDP and an increase of $3.20 in economic output.

On the negative side, scholars argue that emigrant regions suffer long-term economic decline and dependency, consumption as opposed to investment, increasing interfamilial inequalities, and the externalization of consumption expenditures (see P. Martin (1990), Sharon Russell (1986), and Chami et al (2003)). The general thinking here is that remittances are spent on consumer items and are rarely invested in productive activities that would lead to growth in the recipient countries’ economies. There is also a fear that these developing countries may become dependent on the inflow of remittances, which could reduce their incentives to invest in domestic income-generating activities.

III. Methodology: Approaches to Understanding Remittances

The econometric relationship used here is very straightforward, with a standard Ordinary Least Squares (OLS) regression to measure the impact of remittances on economic growth. Generally speaking, remittances are not taken into account in growth regressions, so the choice for a standard OLS is motivated by the desire to maintain consistency with the overall growth literature (see Barro, 1991 and Sala-i-Martin, 1997).

\[ \Delta \text{GDP} = C + \beta_1 \text{REMIT} + \beta_2 \text{GDP70} + \beta_3 \text{ICRGE80} + \beta_4 \text{OPEN6590} + \beta_5 \text{LAC} + \beta_6 \text{SSAFRICA} + \epsilon \]

One of the main shortcomings of the approach taken here rests in concerns regarding the endogeneity of migration in the model. The model basically assumes that the stock of migrants is exogenously given. Migrants, however, are likely to vary on several dimensions: in number, in the amount they earn, and in the amount they send home. Specifically, as countries develop and their wage differential decreases relative to developed countries
(or others where they typically migrate), they are likely to send fewer migrants abroad in search of work. This facet of the growth-migration relationship implies that fewer remittances will flow into countries as they reach higher levels of development. According to this logic, the direction of causation flows in the opposite direction and remittances depend on the growth rate. The potential for reverse causality also provides motivation for the second part of the analysis which provides somewhat of a control for this endogeneity.

The initial set of regressions, with $\Delta$GDP as the dependent variable are a blunt instrument if one is hoping to understand more precisely how remittances affect economic growth. The second stage of the regression analysis disaggregates the effect of remittances on growth and reveals the important channels through with remittances have counteracting impacts. It first takes intermediate variables from the theoretical literature and tests to see the impact of remittances on them. These intermediate or channel variables are then regressed against $\Delta$GDP to test for their impact. The channels, domestic saving and domestic credit, labor force participation, health, and education, are discussed in further detail in section V. A basic test for a dependency channel is also included.

IV. Findings
In the baseline regression, REMIT comes up with a negative sign, but is statistically insignificant. The introduction of various control variables does not establish any consistent statistically significant relationship between remittances and economic growth. In particular, the addition of regional dummies effectively makes remittances statistically insignificant in all further regressions. REMIT$^2$ is entered into the regression making REMIT statistically significant and negative while REMIT$^2$ is statistically significant and positive. The positive coefficient on the squared term indicates that while their positive impact on growth is likely greater at lower levels of development, it then tapers off, even potentially becoming negative. The current paper does not pursue this finding further, but it is a promising area for further research.

In the second stage findings, the channel approach builds on the methodology of Tavares and Wacziarg (2001), who apply it to the impact of democracy. It seems appropriate to follow their basic approach here, but the final stage, where they calculate the overall impact is omitted to avoid drawing too strong of conclusions on limited data.

Savings-Credit Channel: Gross domestic savings reflect the proportion of the GDP that is devoted to savings. Domestic credit provided by the banking sector, again as a percentage of GDP, measures the actual credit that is created. Remittances have a highly statistically significant and negative effect on domestic savings as they likely crowd out domestic savings. Recipients know that they can rely on remittances coming from abroad and have less of an incentive to save their own funds. At the same time, remittances have a statistically significant and positive effect on domestic credit. This suggests that while domestic savings are going down (which would normally provide the backing for domestic credit) remittances are now taking their place in serving as the basis for credit expansion. Remittances appear to have counteracting effects through this savings-credit channel.

The next stage is to assess their impact on GDP growth. When regressed on GDP
growth independently, holding the set of variables developed in the previous section as controls, domestic savings has a statistically significant and positive impact on growth. Domestic credit actually enters with a negative sign and is statistically significant in some specifications, although it is not nearly as robust as the impact of savings. When they are entered together, they are both statistically significant with savings positive and credit negative. It seems that the impact of remittances actually does not cancel itself out through this channel, as was conjectured above, but is negative in both cases.

**Labor Force Participation Channel:** The evidence here supports the theory that remittances have a statistically significant and negative impact on labor force participation. The findings are not robust to all specifications, however. Specifically, the findings are dependent on controlling for the percentage of the population that lives on US$2 a day and for inflation. Nevertheless, they all show remittances to have a negative impact on labor force participation. Controlling for initial GDP does not seem to affect these results although it substantially increases the R-squared.

When regressing labor force participation (LFP) on ΔGDP LFP is positive and statistically significant in a variety of specifications. By combining the evidence that labor force participation rate has a significant impact on growth with the impact of remittances on LFP it appears that this is another important transmission channel. While the rationale behind this may be an issue of moral hazard, whereby remittance recipients shirk their work responsibilities because the remittance money creates perverse incentives, the negative impact of remittances on labor force participation may enter into the issues of endogeneity discussed above. Countries with fewer opportunities for work may send more migrants abroad and then receive more remittances.

**Health Channels:** Given the argument of S. Martin (2005) that remittances are largely used to defray health expenditures it is reasonable to believe that remittances would be spent on building up an infrastructure at the local level that would enhance health standards. Since there is data available on the percent of the population with access to improved sanitation facilities, this is used. Remittances have a statistically significant and positive impact on access to improved sanitation facilities. This improved access, in turn, has a statistically significant and positive impact on GDP growth. The relatively robust evidence supports the idea that improved access to sanitation facilities is an important channel for remittances.

A second set of health-related variables examined spending on health. Remittances are shown to have a statistically significant and positive impact on private health spending as a percent of GDP. At the same time, however, remittances have a statistically significant and negative impact on public health expenditures as a percentage of GDP. The impact of private health expenditures on GDP growth is positive and statistically significant in a variety of specifications. Public health expenditure is not as statistically significant, but it is negative in some specifications. The picture here suggests that the composite of health spending may have an important impact on growth and that remittances affect this allocation in a positive way by shifting spending from public to private.

In terms of health outcomes, measures of infant mortality and malnutrition were used. While no significant relationship arose between remittances and infant mortality, remit-
tances do have a statistically significant negative impact on the percent of children under five years old who suffer from malnutrition, as measured by weight for age. The interpretation is that more remittances lead to fewer children suffering from malnutrition. The money provides recipient families with the ability to feed their children and this allocation of resources takes a high priority. Malnutrition also has a statistically significant negative impact on GDP growth.

*Education Channels:* remittances are also likely to be spent on the education of the recipients’ families. The regressions on education hint at a plausible underlying theory, but the evidence is not truly robust enough to make any firm conclusions. After controlling for central government savings, remittances appear to have a positive impact on the percentage of the labor force with a primary school education. Excluding the measure of central government savings, CGB7090, however, shifts this to a negative impact, so the finding is not very robust. What appears to be more robust is the statistically significant negative impact remittances have on the percent of the labor force with a secondary education. The R-squared for this regression is also much better.

This finding indicates that greater remittances lead to a lower percentage of the workforce with a secondary school education, possibly because the marginal difference in pay relative to a primary school education is dampened by the impact of remittances. More precise data should be used in investigating this relationship further. In addition, there are potential problems of reverse causation. Countries with less-developed education systems may be those that provide fewer work opportunities for their population and produce the most migrants who then send remittances home.

The impact of education on growth does not show up as statistically significant here, but broad measures of human capital have been shown to be important in other studies, most notably Barro and Lee (1991). Part of the problem is that the measure of the percentage of the labor force with a given level of education represents past decisions, instead of current enrollment rates. This would be a more effective measure for future work.

V. Conclusions: Remittances and the Future for Development
Remittances have become one of the largest flows of money into the developing world and they hold great potential as a tool for development. To unlock that potential will require a deeper understanding of their relationship with economic growth and what people do with the resources when they receive them. This paper adds to the rapidly increasing literature on remittances by using cross-country regressions to empirically test some of the competing theories. In this way, it connects the literature on remittances to the broader growth literature.

In conclusion, remittances are a hugely important flow to the developing world but are still not well enough understood. Increasing efforts at data collection are definitely worthwhile. The potential to leverage the flows toward economic development is truly great, and hopefully this paper will help enhance the understanding of remittances by breaking down some of its most important transmission channels. Remittances also provide the recipient populations with a higher degree of ownership and control than other forms of capital flows like FDI and aid. If remittances are used appropriately, these billions of dol-
lars every year have the potential to be one of the most important financial forces behind development.

References


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EVALUATING THE EFFECTS OF FOREIGN OWNERSHIP IN THE CROATIAN FINANCIAL SECTOR: A DEA APPROACH

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Georgetown University, SFS 2005

ABSTRACT

This paper seeks to answer whether foreign, as opposed to domestic ownership of a firm affects the efficiency of the firm. In order to investigate the hypothesis that foreign entry in a sector can enhance its efficiency, this paper studies a panel of Croatian commercial banks, including banks owned by foreign and domestic investors. Drawing data from banks’ public financial statements from 2000 to 2004, this paper derives an efficiency score for each bank in the sample over the time period by applying Data Envelopment Analysis (DEA). The findings show that foreign-owned banks are on average more efficient and also, that the average efficiency of both foreign and domestic banks has been increasing since the foreign entry. These results suggest that the liberalization of a country’s financial sector can contribute to sustained economic development.

Keywords: Banking, Ownership, Efficiency, Efficiency Frontier, Data Envelopment Analysis, Transition, Economic Development, Croatia.

I. Background and Motivation for Study

This paper is motivated by large-scale privatizations in many transitional economies during the 1990s, which attracted an influx of foreign investor capital. Generally accepted theories hail the benefits of foreign investment, showing that it increases capital formation, and so drives economic growth in the host economy. Alongside such theories, certain studies note that, in contrast to greenfield FDI (foreign investment in new productive assets), foreign acquisitions of existing assets create two concerns. For one, the transfer of ownership to foreign investors does not directly contribute to gross domestic investment in the host economy. Secondly, even if one assumes that the influx of foreign capital creates a one-time boost in growth or productivity, the benefits of liberalization to the host economies may end with the conclusion of large scale privatizations.
This study hypothesizes that, even though cross-border acquisitions do not necessarily increase the amount of productive assets in the host economy, foreign ownership may lead to better utilization of existing assets. As foreign investors enhance the productivity of acquired enterprises by transferring intangible goods, such as technology and “know-how,” their presence contributes to economic growth in the host economy. Furthermore, this study hypothesizes that domestic firms can benefit from the foreign presence via “spill-over” effects by replicating products, production processes, management and marketing techniques. As this is likely to be a gradual process, foreign presence contributes more than a one-time boost—it creates sustained benefits for the host economy.

The financial services industry in Croatia represents a suitable case with which to test the above hypotheses. The percentage of total Croatian banking assets majority owned by foreign investors increased from 1% in 1994 to 91% in 2004. This was achieved chiefly through ownership transfer from the state to foreign investors, rather than greenfield foreign investment. By comparing the efficiencies of banks privatized to domestic investors and those acquired by foreigners, and tracking the trends in the firms’ efficiencies over time, we can gain much insight into the two hypotheses above.

The ease of discerning ownership type via public records and the availability of high quality data for a large sample of the Croatian banking population allows for the estimation of the productive efficiency of banks across ownership type and over time. The results of the estimation show significant differences in efficiencies of firms across ownership type, suggesting that ownership type does affect productivity. Moreover, the results show a trend of increasing efficiency of both types of firms over time, which suggests that foreign presence can lead to sustained economic benefits.

II. Methodology

This study draws on theoretical concepts originally introduced in a groundbreaking study by Farrell in 1957, which evaluate the efficiency of a decision-making unit (DMU) relative to an efficiency frontier, representing best practice. In 1978, Charnes, Cooper and Rhodes developed Data Envelopment Analysis (DEA), a non-parametric technique that, given data inputs for a set of DMUs, determines the location of the efficiency frontier for the sample and computes the efficiencies of all units in the reference set relative to the frontier. Mathematically, DEA solves multiple linear programming problems for each observation, where the efficiency score of the DMU is a function of its input-output combination relative to the input-output combinations of all the DMU’s under observation. Each DMU’s efficiency score is a measure of its distance from the efficiency frontier, with a score less than one implying that the DMU is inside the frontier (a relatively inefficient DMU) and a score equal to one implying that the DMU is efficient.

Farrell’s concepts are singular in that they estimate efficiency on a micro-level, the level of the firm. Thus, we are able to gain much valuable insight by splitting a sample of firms along chosen criteria and analyzing differences accords the samples. A second advantage of DEA is that it constructs the efficiency frontier solely on the basis of observed data and therefore does not require a priori specification regarding the form of the production function, making the probability of misspecification of the production tech-
nology zero. The third advantage of DEA is that it does not impose a set of input and output weights on the data. The fourth advantage is that it can handle multiple input and multiple output models, where inputs and outputs can have very different units. The main disadvantage of DEA is that, being non-parametric it assumes that random errors do not exist and that all deviations from the frontier indicate inefficiency. Thus, DEA is very sensitive to data quality, in particular extreme observations and measurement errors. A second disadvantage is that, being a nonparametric technique, statistical hypothesis tests are difficult with DEA—they are the focus of ongoing research.

III. Data

For each bank, the output data consists of revenue, loans and other liquid assets; the input data of labor, fixed assets and interest expenditures. Input and output figures for the period 2000-2004 were collected from publicly available quarterly financial statements for a sample of commercial banks in Croatia. The sample accounts for more than 90% of the total banking assets in Croatia. In order to analyze trends prior to 2000, this paper draws on a study that computed efficiencies for Croatian banks for the years 1995-2000, also employing DEA.

Two limitations of the data set could create sample selection bias. Firstly, as all banks under observation were still in business in 2004, the estimated average efficiency of the banking sector could be biased upward as the firms that exited were likely to be least efficient. However, during the time period of observation only 5 banks underwent bankruptcy, and four of those exited in 2000, limiting any significant bias to that year. Secondly, one could argue that the banks that were acquired by foreigners were the more efficient banks from the start, creating an upward bias in the estimated efficiencies of foreign banks. However, the privatization process in Croatia was relatively competitive and it appears that the number one criterion in target selection by foreigners was bank size, rather than existing efficiency at the time of acquisition.

IV. Summary of Results

- With an aggregate average efficiency of 0.895 in 2004, the Croatian banking sector has increased in efficiency rapidly since 1995, when average efficiency stood at 0.445. An efficiency of 0.895 indicates that a perfectly efficient firm could produce the same amount of output as the observed firm using only 89.5% of the inputs.

- Over the period from 2000 to 2004, the average efficiency of foreign banks was 0.938, while that of domestic banks was 0.831. However, significant variation in efficiency exists across firms within the same ownership type. For example, in 2000 the efficiency for domestic banks ranges from a low of 0.540 to a high of 1.000. The efficiency for foreign banks ranges from 0.440 to 1.000 in that year.

- The efficiencies of both types of banks are increasing over time. The increase in average efficiency that we observe for domestic banks is gradual rather than a one-shot phenomenon; this is in line with the spillover hypothesis, which suggests that benefits
from knowledge spillovers are realized over time. The increases in average efficiencies of foreign banks may reflect better knowledge of local conditions and practices. Again, we notice a gradual increase in efficiency, rather than a one-time increase. In addition, both domestic and foreign firms may be registering efficiency increases stemming from an increasingly competitive banking sector.

- Classifying the sample of banks by size, the results show that the largest banks tend to be most efficient, likely due to the existence of economies of scale in banking. As six out of seven largest banks in the sample are foreign owned, it is possible that this finding could drive the overall results. As a robustness check, the largest banks are excluded from the sample and average efficiencies are calculated for the remaining population of banks. The previous insights still hold.

V. Implications and Further Study
This study suggests that the opening of a developing economy’s financial sector to foreign investors is beneficial from an economic perspective. One must be aware that though economically sound, foreign ownership in strategically important and profitable industries can lessen a nation’s sovereignty over its policy and may create social turmoil. It would be interesting to extend the study to developed countries and ask whether industrialized nations also benefit from the entry of foreign investors. Another question to ask is whether foreign entry represents a positive force in all economic sectors or only those that are knowledge-intensive. In a globalizing world, where counties are faced with decisions on how to treat foreign investors eager to seize international opportunities, empirical studies of such nature could offer powerful policy advice.

References


### Table 1: Efficiencies of Banks in Croatia (2000-2004) – DEA Model

<table>
<thead>
<tr>
<th>Bank</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>Foreign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banka Kovanica</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>0.970</td>
<td>0.773</td>
<td></td>
</tr>
<tr>
<td>Banka Sonic</td>
<td>0.538</td>
<td>0.658</td>
<td>0.866</td>
<td>1.000</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Centar Banka</td>
<td>0.795</td>
<td>0.824</td>
<td>0.926</td>
<td>0.998</td>
<td>0.770</td>
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<tr>
<td>Credo Banka</td>
<td>0.816</td>
<td>0.832</td>
<td>0.732</td>
<td>0.752</td>
<td>0.808</td>
<td></td>
</tr>
<tr>
<td>Dresdner Bank</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>0.572</td>
<td>X</td>
</tr>
<tr>
<td>Erste Bank</td>
<td>1.000</td>
<td>*</td>
<td>0.821</td>
<td>1.000</td>
<td>0.979</td>
<td>X</td>
</tr>
<tr>
<td>Gospodarska Banka</td>
<td>1.000</td>
<td>0.787</td>
<td>0.842</td>
<td>1.000</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Harvatska Postanska Bank</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Hypo Bank</td>
<td>1.000</td>
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<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>X</td>
</tr>
<tr>
<td>Imex Banka</td>
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<td>*</td>
<td>1.000</td>
<td>*</td>
<td>*</td>
<td>X</td>
</tr>
<tr>
<td>Istarska Banka</td>
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<td>1.000</td>
<td>0.900</td>
<td>0.998</td>
<td>*</td>
<td></td>
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<tr>
<td>Jadranska Banka</td>
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<td>0.698</td>
<td>0.624</td>
<td>0.676</td>
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<tr>
<td>Karlovacka Banka</td>
<td>0.648</td>
<td>0.428</td>
<td>1.000</td>
<td>0.855</td>
<td>0.967</td>
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<tr>
<td>Kreditna Banka</td>
<td>0.547</td>
<td>0.550</td>
<td>0.588</td>
<td>0.699</td>
<td>0.845</td>
<td>X</td>
</tr>
<tr>
<td>Kvarner Banka</td>
<td>1.000</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>X</td>
</tr>
<tr>
<td>Medimurska Banka</td>
<td>1.000</td>
<td>0.862</td>
<td>0.725</td>
<td>0.983</td>
<td>1.000</td>
<td>X</td>
</tr>
<tr>
<td>Nava Banka</td>
<td>1.000</td>
<td>1.000</td>
<td>*</td>
<td>1.001</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Nova Banka</td>
<td>0.781</td>
<td>0.757</td>
<td>0.741</td>
<td>1.000</td>
<td>0.871</td>
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<tr>
<td>Partner Banka</td>
<td>0.791</td>
<td>0.770</td>
<td>0.833</td>
<td>1.000</td>
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<tr>
<td>Podravsk Banka</td>
<td>0.567</td>
<td>0.771</td>
<td>0.807</td>
<td>0.753</td>
<td>0.771</td>
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<tr>
<td>Pozeska Banka</td>
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<td>0.593</td>
<td>0.598</td>
<td>0.646</td>
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</tr>
<tr>
<td>Primorska Banka</td>
<td>1.000</td>
<td>1.000</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>X</td>
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<tr>
<td>Privredna Banka</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
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</tr>
<tr>
<td>Raiffeisenbank</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
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<td>1.000</td>
<td>X</td>
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<tr>
<td>Samoborska Banka</td>
<td>0.758</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
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<tr>
<td>Slatinska Banka</td>
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<td>0.592</td>
<td>0.519</td>
<td>0.988</td>
<td>0.800</td>
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<tr>
<td>Slavonska Banka</td>
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<td>1.000</td>
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<td>Stedbanka</td>
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<td>*</td>
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<td>VABA</td>
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<td>*</td>
<td>*</td>
<td>X</td>
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<td>Volksbank</td>
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<td>1.000</td>
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<td>Zagrebacka Banka</td>
<td>*</td>
<td>*</td>
<td>1.000</td>
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<td>1.000</td>
<td>X</td>
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<tr>
<td><strong>Average</strong></td>
<td>0.868</td>
<td>0.848</td>
<td>0.866</td>
<td>0.933</td>
<td>0.895</td>
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<tr>
<td><strong>Standard Deviation</strong></td>
<td>0.248</td>
<td>0.279</td>
<td>0.204</td>
<td>0.209</td>
<td>0.213</td>
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</tr>
</tbody>
</table>

* Data not available/efficiency could not be computed.
Table 2: Summary Statistics – DEA Output

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Number of DMUs</td>
<td>39</td>
<td>42</td>
<td>45</td>
<td>48</td>
<td>47</td>
<td>30</td>
<td>27</td>
<td>26</td>
<td>27</td>
<td>24</td>
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<tr>
<td>Average Efficiency</td>
<td>0.777</td>
<td>0.791</td>
<td>0.844</td>
<td>0.849</td>
<td>0.868</td>
<td>0.868</td>
<td>0.848</td>
<td>0.866</td>
<td>0.936</td>
<td>0.895</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.252</td>
<td>0.217</td>
<td>0.168</td>
<td>0.166</td>
<td>0.166</td>
<td>0.171</td>
<td>0.168</td>
<td>0.156</td>
<td>0.124</td>
<td>0.124</td>
</tr>
</tbody>
</table>

Note: The efficiencies for the years 1995-1999 are estimates from Jemric and Vujcic (2002).

Table 3: Summary Statistics for Foreign Banks – DEA Output

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
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<tr>
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<td>13</td>
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<td>13</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Average Efficiency</td>
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<td>0.841</td>
<td>0.860</td>
<td>0.908</td>
<td>0.917</td>
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<tr>
<td>Standard Deviation</td>
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<td>0.153</td>
<td>0.144</td>
<td>0.111</td>
<td>0.083</td>
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Table 3: Summary Statistics for Domestic Banks – DEA Output

<table>
<thead>
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<th></th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
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<td>Number of DMUs</td>
<td>16</td>
<td>14</td>
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</tr>
<tr>
<td>Average Efficiency</td>
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<td>0.753</td>
<td>0.767</td>
<td>0.832</td>
<td>0.822</td>
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<tr>
<td>Standard Deviation</td>
<td>0.183</td>
<td>0.179</td>
<td>0.167</td>
<td>0.143</td>
<td>0.133</td>
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</tbody>
</table>

Graph 1: Summary Statistics

Graph 2: Summary Statistics
UNEMPLOYMENT, INEQUALITY, AND TERRORISM: ANOTHER LOOK AT THE RELATIONSHIP BETWEEN ECONOMICS AND TERRORISM

Kevin B. Goldstein

Dartmouth College, Class of 2005

I. Abstract
This paper builds on existing research on the determinants of terrorism by looking at new measures of poverty in addition to political freedom, population fractionalization, and other country characteristics. The findings of this paper reinforce the conclusions of the existing literature that political freedom is a key determinant of terrorism, with the greatest risk coming from countries that are middling between liberal democracy and authoritarian control. Further, this paper supports recent conclusions that linguistic fractionalization and geography are both related to terrorist risk as well. The primary new finding in this paper is that adult unemployment rate is also a significant predictor of the overall terrorist risk in a country. This paper further suggests that the Gini Index of economic inequality may also have a significant correlation with terrorist risk. The results overall imply that exclusion from the economy can be a motivator for terrorism just as exclusion from politics can be, regardless of the overall wealth of a country.

II. Introduction
Recent empirical work on the causes of terrorism has suggested that in contrast to studies on political coups and civil wars, economic factors are not significant predictors of terrorism. If these results hold up to further testing, the implications for governmental policy are potentially tremendous. This paper will build on work by Alberto Abadie (2004) to test the robustness of his conclusions and to see if economic factors have a causal relationship with the risk of terrorism.

Currently there are two general schools of thought on the root causes of terrorism. The side usually endorsed by the current U.S. administration believes primarily that spreading freedom and democracy will eat away at the political frustration and lack of rights that cause marginalized groups to lash out with terrorism. To quote from President Bush’s 2005 State of the Union Address, “The only force powerful enough to stop the rise of tyranny and terror, and replace hatred with hope is the force of human freedom.” The European Union tends to take the other perspective, that terrorism can successfully be fought at its root causes, and that these causes include poverty and inequality, though they also acknowledge the importance of political rights. It is important to realize that these are not necessarily two dramatically opposed views, but rather can constitute a spectrum in
which some countries weigh economic opportunity as more important than political freedom, and vice versa.

If the recent suggestions that political rights alone determine the level of terrorism prove correct, then it could add additional justification to calls for the toppling of oppressive governments and the use of force to spur transition to democracy. However, if economic opportunity is also shown to have a relation to terrorism, then more peaceful methods of preventing terrorism may be available. It is evident from this ongoing debate that the questions this paper asks are extremely important.

III. Review of Literature

Until very recently, almost all empirical work done on the causes of terrorism had a focus on transnational terrorism. The few exceptions tend to be anomalous case studies, usually of Israel and Palestine, one of the few hotbeds of terrorism where data are available and good. Studies such as in Krueger and Laitin (2003) find that GDP per capita and GDP growth rate are not significant predictors of transnational terrorism, but that politically free countries are likely to be targeted by agents from politically oppressed countries, regardless of wealth. Other studies like Krueger and Malecková (2003) go further against conventional wisdom that assumes poverty is a source of terrorism, concluding that among Palestinians wealthier and more educated individuals are actually more likely to be terrorists than poorer individuals.

International terrorism is extremely important to study, but according to the MIPT Terrorism Knowledge Base, funded by the U.S. Department of Homeland Security, international terrorism has only accounted for 10-15% of the total global number of terrorist acts in each of the last three completed years (2002-2004). This means that these studies are only looking at one narrow kind of terrorism. While it may be the case that international acts have drawn the most attention since the September 11 attacks, it is worth noting that the second most deadly attack on U.S. soil, the Oklahoma City bombing, was a purely domestic act of terrorism.

Very recent work by Abadie (2004) is able to make significant improvements on previous work because he uses an inclusive and robust measure of terrorism as his dependent variable. Rather than using U.S. Department of State data which only count instances of transnational terrorism, Abadie (2004) chose country-level index data assessing the combined risk of both domestic terrorism within a country and transnational terrorism on that country’s territory at home and interests abroad. This index allows consideration of a much wider and more realistic range of terrorist activities, in addition to expanding the number of countries that can be considered. Nonetheless, the Abadie (2004) paper points to conclusions similar to those in earlier transnational studies, finding that GDP per capita has little to do with terrorism and that political freedom is the most important determinant of such acts.

Despite its strengths, Abadie’s study (2004) still leaves room for further improvement. In measuring economic factors, only GDP per capita was considered, though the UN Human Development Index and the Gini Index were tested for robustness. Other hypothesized predictors of terrorism that have been tested in previous literature, such as GDP
growth and unemployment level, were not investigated.

The determinants of international terrorism have been investigated very thoroughly, but it remains to be seen to what extent those results apply when domestic terrorism is also considered. This paper builds on Abadie (2004) by introducing an updated dataset and including a variable for total adult unemployment rate. Replicating much of the Abadie (2004) methodology, this paper finds that unemployment is a significant predictor of terrorism in addition to political freedom, population fractionalization, and geography.

IV. Data
Following Abadie (2004), as my measure of the risk of terrorism I use the World Market Research Centre’s Global Terrorism Index 2003-2004 (GTI). The GTI includes domestic and transnational acts that fall under a broad definition of terrorism as “The unlawful and premeditated use of violence intended to coerce or intimidate a government or civilian population as a means of advancing a political or ideological cause.” The GTI also rules out any acts by sovereign states as not constituting terrorism. The GTI rates 186 countries on a possible scale of 1-100; higher numbers indicate greater risk of terrorism to a country and its assets abroad in the 12 months following the index’s publication. The risk score is composed of five factors which forecast terrorism, differently weighted depending on significance: motivation (40%), presence (20%), scale (20%), efficacy (10%), and prevention (10%).

Improving on the sample size in Abadie (2004), I use data from World Bank as provided to the United Nations (UN) on 2002 GDP per capita in purchasing power parity (PPP) as a measure of poverty. Though this data is from 2002, as opposed to the 2003 data that Abadie uses, the greater completeness of the data allows for observations on over a dozen countries that were dropped in earlier studies and constitutes an improvement over Abadie. Furthermore, per capita PPP is a more accurate measure of poverty than just looking at the raw GDP. The weakness of using slightly older data is that while in most countries changes were likely very small, some salient examples like Iraq or Afghanistan have likely changed more dramatically. However, examples such as those are rife with endogeneity problems and that makes it hard to say if they would actually be better.

To ensure that the results are robust and maintain ease of comparison to Abadie (2004) this paper will use the most recent UN Human Development Index (HDI) or the Gini Index in place of GDP in some regressions. The HDI weighs life expectancy, adult literacy, combined enrollment ratios for all levels of schooling, and GDP to give each country a value from 0-1 with higher numbers representing the most development. The Gini Index is a measure of inequality in a country; it is defined as the area between the Lorenz curve and a hypothetical line of absolute equality, expressed as a percentage. A value of 0 represents perfect equality and 100 represents perfect inequality.

To measure the degree of political freedom in each country, I use Freedom House’s Freedom in the World 2004 Political Rights Index. This rates countries from 1-7 with a lower score representing greater freedom. Perhaps because I used 2004 data, as opposed to 2003, I managed to improve on the sample size over Abadie (2004) with data on territories and disputed areas in addition to the independent countries that he considers. As
such, this paper is not forced to drop Hong Kong, Macau, Puerto Rico, the Palestinian Authority, or North Korea. The Freedom House also reports a Civil Liberties Index which was used by Krueger and Laitin (2003); however this index is highly collinear with the Political Rights Index used by Abadie (2004) and would provide almost exactly the same result. Regardless, in order to keep comparability between this paper and Abadie (2004) at a maximum, I opted to stick with the political rights measure.

Just as Abadie (2004) did, I take linguistic, ethnic, and religious fractionalization indices from Alesina et al (2002). The indices represent the probability that any two individuals chosen at random from a country belong to different linguistic, ethnic, or religious groups. There are two important things to keep in mind with these data. Firstly, ethnic and linguistic fractionalizations are significantly correlated. It is not surprising that individuals of different ethnic groups are more likely to speak different languages than people of the same ethnic group. Secondly, when they measure linguistic fractionalization—which proves to be the most important of the three indices in this paper’s regressions—Alesina et al (2002) look at data on first languages only. They do not look at whether individuals are likely to share a common language. Somewhere like Montreal, where residents move comfortably between French or English, will have a fairly high linguistic fractionalization index even if there is no real difficulty in communication. Thus, it may be the case that the linguistic fractionalization variable is proxying for some combination of linguistic, ethnic, and other cultural factors. Regardless of its precise makeup, there is little reason to think that it may be correlated with any of the other variables tested in this paper and it maintains its usefulness as a measure of social division within a country.

Geographic data come from Gallup, Mellinger, and Sachs (2001) and measure country land area, average elevation, and the fraction of land area in the Köppen-Geiger tropics.

Finally, I include data from the International Labor Office (ILO) on the total adult unemployment rate in a country. The data are the annualized values for the most recent year available, which is 2003 in the vast majority of cases. Unfortunately, data were only available for 117 of the 186 countries in this study. The countries that are left out are consistently very poor, have highly fractionalized populations with few political rights and are often involved in violent conflicts. However, the distribution of terrorist risk in the group without data is roughly similar to the distribution of risk in the sample with unemployment data reported. The list of countries without adequate unemployment data however includes Iraq, Afghanistan, and much of Africa.

V. Empirics and Results
To begin my empirical work, I use the country-level cross-section data described above in a series of Ordinary Least Squares regressions. The general form of the estimating equations is:

\[
\ln(\text{terrorist risk}) = \beta_0 + \beta_1 \ln(\text{GDP per capita}) + \beta_2 \mathbf{X} + \epsilon
\]

The vector \( \mathbf{X} \) includes all of the potential predictors of terrorism previously described: lack of political rights, unemployment, geographic variables, and linguistic, ethnic, and religious fractionalization. All regressions also include an exhaustive set of regional dummy
variables based on the groupings used in the WMRC-GTI.

For my initial series of regressions, I considered the maximum number of observations available as I went along. Thus, as more variables are added in, the number of observations in the regressions has the unfortunate trend of decreasing. The results of these regressions are reported in Table 1. Columns (1) – (5) mirror estimations in Abadie (2004), and produce very similar results even with my slightly modified data set. The coefficient on log GDP in column (1) is significant and shows that a 1% increase in GDP per capita is associated with a 0.19% reduction in terrorist risk.

Columns (2) and (3) add in the index for lack of political rights and show the non-monotonic relationship of political rights and terrorist risk as found in Abadie (2004). This relationship shows that countries on both ends of the political rights spectrum are the least likely to suffer terrorist attacks. Liberal countries with many political freedoms and authoritarian countries where people are highly regulated have the least risk; but middle-ranking countries, often in a state of political transition, have the greatest risk.

The three fractionalization indices are added in column (4) and we find that only linguistic fractionalization bears a significant coefficient. Also in this column, the coefficient on GDP remains negative, but becomes statistically insignificant. In column (5) the ethnic and religious fractionalization indices are removed, causing two major changes in the estimation. Firstly, the coefficient on linguistic fractionalization becomes significant at the 1% level, where it had previously only been at the 5% level. This is not surprising because of the degree of colinearity with ethnic fractionalization may previously have divided some of the relationship between the two variables. Secondly, we see that the coefficient on log GDP per capita has returned to significance, marking the first serious departure from the results in Abadie (2004) yielded by the different data set in this paper. Regardless, further tests still manage to reduce the coefficient on log GDP per capita to insignificant levels.

In column (6), I introduce my novel variable of total adult unemployment rate into the estimation equation. The previously included variables all remain significant to at least a 10% level and unemployment is found to be highly significant at a 1% level. The regression estimates that a 1% increase in the adult unemployment rate is associated with a 0.02% increase in the risk of terrorism in a country.

Due to concerns about possible endogeneity, because terrorism can certainly weaken an economy, in columns (7) through (12) this paper tries to go a step beyond the level of GDP per capita. In those columns, I include geographic variables for country size, average elevation, and tropical climate with the rationale that several studies have related geography and climate to wealth, and that certain types of geography may lend themselves more to terrorism than others. For example, the mountains of Afghanistan have proven notoriously difficult to flush terrorists out and have definitely contributed to Afghanistan’s 6th place ranking out of the 186 countries in the GTI.

In column (7), with the unemployment variable left out, the geographic variables essentially overwhelm the rest of the included factors. The regression coefficients on all three geographic variables are significant at a 1% level. Linguistic fractionalization remains significant, but now only at a 10% level and political rights and GDP fall out of
the range where they can be statistically distinguished from zero.

However, when we add back in unemployment as a regressor in column (8), the degree of political freedom becomes once again significant, but now linguistic fractionalization is no longer significant. It is difficult to speculate about the reason for the phasing in and out of significance of political freedom and linguistic fractionalization. The two variables are not collinear to any mentionable degree with each other or with unemployment, so why they interact as they do is not obvious.

Instead of GDP per capita, in columns (9) and (10) poverty is measured with the UN Human Development Index. The HDI is a broader measure and includes health and education components in addition to GDP. Column (10) yields results very similar to column (8), with unemployment and geographic variables once again highly significant. This suggests a degree of robustness to the results obtained with GDP per capita.

However, in columns (11) and (12) where poverty is now measured with the Gini Index, the coefficient on the index is significant as are the coefficients on all other estimation variables. The coefficient on the Gini Index is negative which surprisingly suggests that wealth inequality may be associated with a reduction in terrorist risk even though overall average wealth in a country is not. If there were causality here, it would mean that countries with a high degree of equality are actually more at risk of terror than very unequal countries. This result is contrary to other evidence which concludes that characteristics that make people feel marginalized make them more likely to resort to terrorism. This may just be the result of a small sample size and the skewing effect of a large number of extremely unequal African countries that do not draw the ire of any terrorist groups, though the included regional dummies should insulate the results from such effects. However, there is a chance that there is a genuine relationship between equality and terrorism, as counterintuitive as it seems.

It is interesting to note that in column (11) the results of this paper differ from those of Abadie (2004) despite running almost exactly the same regression as he does at one point. The Abadie (2004) paper does not find Gini coefficients to be significant. To look deeper at this problem, the only difference between my data and that in Abadie (2004) is that my data on linguistic fractionalization is 1 year more recent and contains one fewer observation. Whichever country was dropped, it may be an outlier in its Gini coefficient or in some other way. This should give us further caution before drawing any conclusions about economic inequality and terrorist risk.

Overall, the results on the OLS regressions found in Table 2 show that when country characteristics for linguistic fractionalization, political freedom, unemployment, and geography are considered, neither GDP per capita nor human development have significant relationships with terrorist risk.

VI. OLS Robustness

Unemployment rate was shown to have a highly statistically significant association with the risk of terrorism in the above OLS regressions. However, there are several potential complications to be addressed before any hard conclusions can be drawn.

One immediately apparent problem is the number of observations in regressions con-
taining an unemployment variable is noticeably lower than the baseline regressions building up to it. This is because unemployment data is unavailable for a large number of less developed countries or countries in the midst of domestic strife. Regardless of the reasons for the reduced number of observations, the problem is that changes in the dataset may cause significant changes across the board, causing one column not to be comparable to its neighbor.

In order to address this problem, I created a second, limited dataset containing only the 105 countries for which I had a complete set of data on all tested variables. A quick comparison shows that the two data sets exhibit very little difference in mean and standard deviation for dependent variable, terrorist risk, as well as many of the right-hand side variables. The two most prominent differences are in GDP per capita and in political freedom. The omitted countries tend to be a little poorer and a little less politically free.

When looking at the regressions on the 105 country sample, we should keep a few things in mind. First, because GDP per capita ended up not being significant once other characteristics were accounted for in the earlier regressions, we should be skeptical if that result changes. Second, the mean of the freedom index has dropped, indicating more freedom in the 105 country sample, while the terrorist risk statistics have remained basically constant. If the non-monotonic result for political freedom proves to be robust, then we should expect to see the positive coefficient on political rights and the negative coefficient on political rights squared become farther apart, indicating more dramatic sloping to the non-linear curve as we move along the spectrum from liberal states to authoritarian states.

Table 2 reports the estimation coefficients after running the same series of regressions as earlier on the limited 105 country sample. When compared to the earlier results in Table I, the limited sample produces extremely similar estimations. All of the previous conclusions about the complete dataset hold for the smaller set with the possible exception that linguistic fractionalization is not as consistently significant in the 105 country set. From this, I conclude that the 105 country set has no glaring irregularities that distinguish it from the larger set. Overall, this gives strong support for concluding that the highly significant estimation coefficients on unemployment are robust.

VII. Cautions
Prior to drawing final conclusions, let me caution the reader with some of the general weaknesses of this study. First and most important shortcoming is that terrorism is impossible to truly predict. Terrorists operate on a global scale and work actively to strike where they are unexpected. Some like Al-Qaeda have very wide goals and targets around the world; some act solely in their own countries as rebel groups too small to fully start a civil war. This paper hopes only to shed light on some of the factors that correlate with terrorist risk, be it by drawing the attention of international terrorists, as in the case of the United States, or by producing local terrorism as in Colombia.

Another point of caution is that while I have shown that at least one economic variable is significant in addition to social and political factors, the predictive power of unemployment is not as strong as those of the other significant factors. Though highly statistically significant, even if we granted complete causality to unemployment (which would be
the magnitude of the coefficient is small relative to the other significant variables and does not explain the majority of the dependent variable. That said, when the unemployment variable is added beyond all other considered factors in Table I, the $R^2$ value goes from 0.35 in column (7) to 0.47 in column (8); this is not a small jump by any means.

Further, when testing unemployment rates, endogeneity problems may exist. Terrorism has a negative impact on economies and can disturb business, reduce growth, and very possibly raise unemployment as a consequence. This is an extremely difficult problem for which to control. Perhaps a better measure than recent annualized unemployment rate would have been to look at long-term unemployment or rates over a few recent years. Unfortunately, data on unemployment are already scarce for a huge number of countries and I am unable to find long-term unemployment data for more than a handful of countries beyond the OECD. While questions of endogeneity are difficult to resolve empirically, the significant correlation is nonetheless present and there are many good reasons to think that unemployment may indeed have a causal relationship to terrorism.

VIII. Conclusions
Using a more complete dataset than previous studies and testing new variables, I find that the economic variable of unemployment has a significant association with terrorist risk. My results also confirm previous work suggesting that political freedom, population fractionalization and geography are also powerful predictors of terrorism. Like other studies, I find that GDP per capita does not have a statistically significant relationship with terrorism once these other variables are taken into account.

My results also suggest that as a country’s Gini coefficient increases, meaning the gap between rich and poor grows, terrorist risk may be reduced. However, these results are counter-intuitive and never significant beyond the 10% level. Therefore, I hope to do more testing in the future with inequality and Gini coefficients before drawing any hard conclusions about inequality and terrorism.

References


# Table 1: Terrorism and Country Characteristics OLS with Robust Standard Errors

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Notes: Robust standard errors are shown in parentheses. All regression included a comprehensive set of regional dummy variables based on the country groupings used in the WMRC-GTI.

* significant at 10%; ** significant at 5%; *** significant at 1%

UNEMPLOYMENT, INEQUALITY, AND TERRORISM
TABLE 2: TERRORISM AND COUNTRY CHARACTERISTICS WITH LIMITED SAMPLE OLS WITH ROBUST STANDARD ERRORS

<table>
<thead>
<tr>
<th>Dependent variable: Natural log of WMRC Global Terrorism Index</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)*</th>
<th>(9)</th>
<th>(10)*</th>
<th>(11)</th>
<th>(12)*</th>
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<tbody>
<tr>
<td>Log GDP per capita (PPP)</td>
<td>-0.2053***</td>
<td>-0.1730**</td>
<td>-0.0994</td>
<td>-0.1095</td>
<td>-0.1029</td>
<td>-0.1122</td>
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<td>(0.0861)</td>
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<td>Human Gini index</td>
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<td>Lack of Political Rights</td>
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<td>Lack of Political Rights Squared</td>
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<td>-0.0443**</td>
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<td>(0.0174)</td>
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<td>Linguistic Fractionalization</td>
<td>0.5351**</td>
<td>0.3964*</td>
<td>0.3716*</td>
<td>0.2686</td>
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<td>0.2292</td>
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<td>0.3603*</td>
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<tr>
<td></td>
<td>0.0220***</td>
<td>0.0221***</td>
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<tr>
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<td>(0.0163)</td>
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<td>Average Elevation</td>
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<td>0.0270***</td>
<td>0.0292***</td>
<td>0.0287***</td>
<td>0.0269***</td>
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<td>Tropical Weather Percentage</td>
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<td>0.4858**</td>
<td>0.4393**</td>
<td>0.5077**</td>
<td>0.4671**</td>
<td>0.5439***</td>
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<td>(0.1942)</td>
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<td>R-squared</td>
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<td>0.30</td>
<td>0.36</td>
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<td>0.47</td>
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<td>0.48</td>
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<td>Observations</td>
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<td>105</td>
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<td>92</td>
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</tbody>
</table>

Notes: Robust standard errors are shown in parentheses. All regression included a comprehensive set of regional dummy variables based on the country groupings used in the WMRC-GTI.

* significant at 10%; ** significant at 5%; *** significant at 1%; † Identical to regressions in Table II
Over the past two decades, many developing countries have liberalized financial and capital markets in the spirit of globalization. While these countries have benefited from increased access to international capital markets, some countries have found that capital inflows can also be destabilizing. Poorly regulated financial markets are susceptible to boom-bust cycles driven by the herd-like behavior of investors moving their portfolio flows, dubbed “hot money,” across borders without restraint. Overinvestment during a bubble followed by panic and capital flight triggered by the collapse of the bubble can drive exchange rate systems into disarray and disrupt entire economies.

Influential economists, like Nobel laureate Joseph Stiglitz (2003), have argued that premature capital market liberalization was instrumental in causing the East Asian crisis which erupted in July 1997, and which later spread to Russia and Latin America. There was excessive borrowing of foreign short-term capital as the East Asian economies loosened their capital account controls and allowed their banks and firms to borrow abroad. By 1996, capital was flowing into emerging Asia at about US$100 billion a year, more than double the rate just two years earlier. Once the crisis hit, however, capital was flowing out at about the same rate by December 1997.

The East Asian crisis had a devastating impact on the region. The developing economies of Indonesia, Thailand, and Malaysia were severely affected and even the Asian tigers—South Korea, Singapore, Hong Kong, and Taiwan—were impacted to some degree. The unemployment rate in South Korea quadrupled within 18 months to 8.4% in the first quarter of 1999 (IMF Statistics). In South Korea, urban poverty almost tripled, with almost a quarter of the population affected; in Indonesia, poverty doubled (Stiglitz 2003).

Even though the crisis itself had similar damaging effects on all the affected East Asian countries, the countries did not share a common response. Some countries, like South Korea, Indonesia, and Thailand, continued, and even accelerated, the process of financial liberalization in order to obtain IMF-approved bailouts and loans. Malaysia, on the other hand, chose to restrict capital mobility by imposing controls on outflows, a policy decision that was not welcomed by the IMF. Krugman (1998) argues in favor of adopting currency controls if IMF bailouts, reforms, and high interest rates fail to restore investor confidence. Even though many believe that capital controls dissuade foreign investors from investing in a country, Krugman suggests that such controls may play an important role as
a market stabilizer during a financial catastrophe when self-reinforcing panic is aggravating the situation.

Malaysia offers an interesting case study of the practical impact of capital controls. Malaysia’s economy rebounded, and showed positive real GDP growth in the second quarter of 1999. Opinions about the overall success of Malaysia’s response are, nevertheless, mixed. South Korea and Thailand, which did not restrict outflows, experienced a similar recovery. Dornbusch (2001) asserts that Malaysia was less vulnerable prior to the financial crisis, and should have experienced a faster recovery, but did not. Kaplan and Rodrik (2003), however, argue that in Malaysia, the crisis escalated later than it did in the other two countries. By accounting for differences in the timing of the crisis and in the responses, they concluded that compared to the IMF programs, the Malaysian policies produced faster economic recovery, smaller declines in employment and real wages, and more rapid turnaround in the stock market.

While the macroeconomic effects of capital controls appear to be positive, institutional issues should also be considered. Capital controls are typically neither implemented nor managed by the “benevolent” policy makers of economic theory, but by fallible governments, allowing for the possibility of distortions and the creation of moral hazard (Corsetti, Pesenti, and Roubini 1998). Thus, even though capital controls may help stabilize the economy during a financial panic, they may have adverse effects in the intermediate run by postponing much-needed reforms. For instance, one beneficial side-effect of a crisis is that the damaging effects of cronyism—lending to firms on the basis of political connections—are exposed, making it easier to implement reforms to rid cronyism from the financial system. The imposition of capital controls, on the other hand, isolates a country from international capital flows, allowing relationship-based systems to proliferate (Rajan and Zingales 1998). Johnson and Mitton (2003) argue that the Malaysian capital controls appeared to have provided a screen for cronyism. They find that the imposition of capital controls in September 1998 allowed the government to reinstate political favors to firms with strong ties to former Prime Minister Mahathir Mohamad.

In this thesis, I examine the role of capital controls in protecting crony capitalists from much-needed reforms. Specifically, I compare the difference in performance between politically-connected and non-connected firms in Malaysia, which imposed capital controls, with the difference in performance between connected and non-connected firms in Indonesia and South Korea, which did not resort to capital controls. The primary hypotheses are that politically-connected firms in Malaysia performed much better than their non-connected counterparts during the crisis, and that the difference in performance between these two types of firms is greater in the treated economy (Malaysia) than in the untreated economies (Indonesia and South Korea). My results indicate that Malaysian firms performed significantly better than Indonesian and South Korean firms in the one-year treatment period. In terms of magnitude, the gap of stock market returns between connected and non-connected firms in Malaysia is 32.87 percentage points (annualized) higher than the gap between connected and non-connected firms in the other economies.
References


THE SOCIAL CAPITAL EFFECT ON ECONOMIC GROWTH

José Mustre del Río
Ohio State University, Class of 2005

I. Introduction
This study proposes a new measure of social capital, voter turnout, and attempts to confirm the results of previous studies (e.g. Knack and Keefer [1997] and La Porta, et al. [1997]) that social capital has a positive impact on measurable economic performance. Compared to previous measures of social capital used in the literature, our measure is available over several decades and thus should capture efficiently long-term trends in social capital. Furthermore, our measure should be immune to cultural biases in reporting and responding as compared to measures of trust and civic engagement derived from the World Values Surveys (WVS). Finally, voter turnout measures a behavior rather than a purported belief.

Our empirical results suggest that there is no direct link between social capital and long-run economic growth, questioning previous findings. However, further analysis suggests that social capital can improve government efficiency. We propose that stronger institutions, which help the securing of economic outcomes, are the economic pay-off of social capital. Furthermore, we also suggest social capital as an observable determinant of what Hall and Jones (1999) call “social infrastructure.” Thus, our results may provide empirical evidence for a mechanism that aids the formation of institutions.

II. The Model and Basic Results
Similar to Knack and Keefer’s (1997) baseline specification, our proposed model is the following:

\[
\log GDP_{i,2000} = \beta_0 + \beta_1 vote_i + \beta_2 \log k_{i,2000} + \beta_3 \log GDP_{i,1950} + \beta_4 enroll_i + \epsilon_i
\]

where: \( \log GDP_{i,2000} \) is the logarithm of real GDP per capita in the year 2000 (acting as our measure of income); \( \beta_0 \) is the intercept term (constant over all countries); \( vote_i \) is our voter turnout measure; \( \log k_{i,2000} \) is the natural logarithm of the approximate capital stock per capita in 2000; \( \log GDP_{i,1950} \) is the logarithm of the initial real GDP per capita; \( enroll_i \) is the gross secondary school enrollment ratio averaged over 1960-2000, and \( \epsilon_i \) is the classical error term. The results of estimating this equation appear in the first column of Table 1.
TABLE 1: DEPENDENT VARIABLE LOGARITHM OF GDP PER CAPITA 2000

<table>
<thead>
<tr>
<th>Method</th>
<th>OLS</th>
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<th>IV</th>
<th>IV</th>
<th>IV</th>
</tr>
</thead>
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<tr>
<td></td>
<td>vote</td>
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<td>1.83</td>
<td>0.76</td>
<td>-3.64</td>
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<tr>
<td></td>
<td></td>
<td>(-0.77)</td>
<td>(0.61)</td>
<td>(0.40)</td>
<td>(-0.36)</td>
</tr>
<tr>
<td></td>
<td>log (k_{2000}^i)</td>
<td>0.68***</td>
<td>0.58***</td>
<td>0.65***</td>
<td>0.69***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(11.54)</td>
<td>(4.28)</td>
<td>(7.21)</td>
<td>(5.51)</td>
</tr>
<tr>
<td></td>
<td>enroll</td>
<td>0.32</td>
<td>-0.11</td>
<td>0.07</td>
<td>1.85</td>
</tr>
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<td></td>
<td></td>
<td>(1.19)</td>
<td>(-0.12)</td>
<td>(0.12)</td>
<td>(0.38)</td>
</tr>
<tr>
<td></td>
<td>log (GDP_{1950}^i)</td>
<td>0.15*</td>
<td>0.14</td>
<td>0.16*</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.90)</td>
<td>(1.07)</td>
<td>(1.71)</td>
<td>(0.42)</td>
</tr>
<tr>
<td></td>
<td>(\beta_0)</td>
<td>1.54***</td>
<td>1.41</td>
<td>1.17</td>
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<td>(2.81)</td>
<td>(1.17)</td>
<td>(1.26)</td>
<td>(0.68)</td>
</tr>
<tr>
<td></td>
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<td>N=34</td>
<td>N=36</td>
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<tr>
<td></td>
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<td>R^2=0.88</td>
<td>R^2=0.94</td>
<td>R^2=0.84</td>
<td>R^2=0.9464</td>
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</tbody>
</table>

Note: t-ratios in parentheses. * significant at 10% level, ** significant at 5% level, *** significant at 1% level.

Our results imply that voter turnout as a measure of social capital has no direct impact on final income while, initial income and final capital stock do. Given that social capital may be endogenous, we instrument voter turnout with religion (the percentage of Catholics and Muslims in the 1980 population); legal origin (British, French, or German); the percentage of law students as a fraction of total tertiary students (suggested as an instrument by Knack and Keefer [1997]); and ethnic homogeneity. The results of using these variables as instruments for social capital appear in the second through fifth columns of TABLE 1. These results now imply that even once controlling for endogeneity biases, social capital still has no direct impact on final income—consistent with previous findings.

III. Social Capital’s Impact on Institutions

Given our negative results from the previous section, in this section we consider if our measure of social capital has an indirect effect on economic growth by changing an intermediate determinant of growth such as institutions. Using the following model:

\[
(2) \text{polity}_i = \alpha_0 + \alpha_1 \text{vote}_i + \alpha_2 \log GDP_{1950}^i + \varepsilon_i
\]

Here, we estimate the effect that social capital has on government quality, where polity, can be considered as a measure of democracy, expropriation risk, corruption, etc., and the other variables are defined as in the previous section.

When using voter turnout as an explanatory variable for measures of corruption, contract and law enforcement, and property rights we find that voter turnout is a strong predictor of effective institutional performance. Even when using ethnic homogeneity as an instrument, our findings remain unchanged. These results appear in TABLE 2. Thus, our new results suggest that higher social capital is associated with better performing institu-
tions even when controlling for initial income and the endogenous determination of social capital.

### Table 2

<table>
<thead>
<tr>
<th>Method</th>
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<th>OLS</th>
<th>IV</th>
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<td>Enforcement</td>
<td>Enforcement</td>
<td>Property Rights</td>
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<td>$vote_i$</td>
<td>5.03***</td>
<td>14.30***</td>
<td>4.03*</td>
<td>10.15**</td>
<td>-1.6**</td>
<td>-4.11*</td>
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<td>(1.79)</td>
<td>(2.13)</td>
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<td>(-1.73)</td>
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<td>$log GDP_{i1990}$</td>
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<td>1.01</td>
<td>1.66***</td>
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<td>(4.13)</td>
<td>(1.25)</td>
<td>(3.72)</td>
<td>(1.93)</td>
<td>(-4.84)</td>
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<td>$\alpha_0$</td>
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Note: t-ratios in parentheses. * significant at 10% level, ** significant at 5% level, *** significant at 1% level.

### IV. Concluding Remarks

The purpose of this paper was to propose a new measure of social capital and verify the robustness of results presented in previous articles measuring the social capital effect on economic growth. Compared with previous measures of social capital, voter turnout seems subject to fewer cultural biases in reporting and interpretation. In addition, our measure of social capital should also capture long-run features of the social climate of each country more effectively than the measures used in previous studies, since voter turnout data is available for several decades compared to only two periods of surveying of the WVS. Finally, our measure is inherently easier to quantify than trust and civic norms.

Our results suggest that: (1) the social capital effect on economic performance is different in the short-run and long-run and (2) the results derived from short-run studies (e.g. Knack and Keefer [1997] and La Porta, et al. [1997]) may be overly optimistic of the true impact social capital has on economic performance. This optimism may stem from the inadequacy of the measures of social capital used in these studies derived from the WVS.

Our results also suggest that if social capital has any impact on long-run growth it may be by improving government quality, which subsequently helps in securing of economic transactions. While the absence of formal theory may deteriorate the veracity of our empirical results, further research should attempt to support this claim. Hall and Jones (1999) suggest that a large portion of differences in output per worker between countries can be attributed to social infrastructure. Our results from the third section could suggest that social capital may be an observable determinant of social infrastructure—a result that can be useful in other studies. Following Hall and Jones’ (1999) discussion we can argue that social capital improves the social infrastructure of a nation and thus contributes to growth.

### V. Data Appendix

Voter turnout data were taken from the International Institute for Democracy and Electoral
Assistance for the years 1950-2000. Income and investment data were taken from the Penn World Tables 6.1 for the years 1950-2000. School enrollment rates were taken from Easterly (2001) and the Global Development Finance & World Development Indicators (2000). Legal origin, corruption, law and contract enforcement and, religion data were taken from Levine, et al. (2000) and Political Risk Services. Property Rights data were provided by the Index of Economic Freedom. Finally, data for the number of law students as a fraction of tertiary students were taken from the UNESCO Statistical Yearbook 1965, while ethnic homogeneity data were taken from Sullivan (1991).

Countries used in regressions: Argentina, Australia, Austria, Belgium, Bolivia, Brazil, Canada, Colombia, Costa Rica, Denmark, El Salvador, Finland, France, Guatemala, Honduras, India, Ireland, Israel, Italy, Japan, Mexico, Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Peru, Sri Lanka, Switzerland, Thailand, Trinidad & Tobago, Turkey, United Kingdom, Uruguay, United States of America, and Venezuela.

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Effects of Land Titling on Child Nutritional Status: Evidence from Lima, Peru

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According to a recent UN report (UN-HABITAT 2003), slum dwellers now account for 32 percent of the world’s urban population, a figure that increases to 43 percent in less-developed countries (LDCs). With urbanites projected to become the majority of the world population in the imminent future, this issue confronts the current generation of development policy-makers with one of their greater challenges as they attempt to improve the lives of the urban poor.

Recent policy trends point to an increasing conviction that property formalization is an integral step in achieving this goal (Baharoglu 2002). Western economic thought has long subscribed to the view that property institutions play an essential role in market efficiency and economic development, but recent work by de Soto (1989, 2000) has spurred a renewed interest in this position across disciplines. With a focus on informal settlements in urban areas of the developing world, de Soto argues that poorly defined property rights represent the major obstacle to economic progress. Much at his urging, governments around Latin America—and, to a lesser extent, the world at large—have undertaken massive land titling projects in their efforts to alleviate urban poverty.

These policies are thought to improve credit access, real estate market dynamism, and residential tenure security, with the broader objective of increasing well-being and economic freedom among the poor (Deininger 2003). De Soto contends that property reform allows market-oriented development to become “a truly humanistic cause and an important contribution to the war on poverty” (2003, p. 185). However, the specific effects of these property interventions in promoting “humanism” and freedom, as well as alleviating the myriad deprivations associated with poverty, remain unclear.

My research considers the effects of urban land formalization on children’s nutritional status, an important correlate and long-term determinant of well-being, economic freedom, and poverty. Although formalization campaigns rarely cite nutrition as an explicit goal, it is closely related to their overall aims. Certainly, nutrition affects health status, an indicator of well-being; if titling improves (or worsens) children’s health, this would be important in itself. However, nutritional deprivation in childhood also is associated with poorer cognitive development, decreased learning capacity, lower educational attainment, and heightened morbidity and mortality risks that last into adulthood. Furthermore, adults who were malnourished as children attain smaller body size (Martorell 1999), which can
harm productivity (see Strauss and Thomas 1998). Land titling arguably remedies one market distortion—poorly defined property rights—but in considering its effectiveness as a long-run panacea to poverty and promoter of economic freedom, we should take into account its impact on childhood deprivation.

Previous work on urban land formalization has suggested that titles allow squatter households to increase labor force participation, primarily because they no longer need to keep an adult ‘guard’ at home to protect informal property rights (Field 2002). Using data from an urban land-titling program in Peru, Field finds that the average squatter household devotes 16.2 hours per week to protecting property rights. Land titling thus leads to a 17 percent increase in weekly household labor hours and a 47 percent reduction in the likelihood that household members work at home. When Field decomposes her results by gender, she finds no average effect on woman’s work, but female labor hours are more elastic than male with respect to residential tenure length and household size.

While most have seen Field’s finding as a sign of welfare improvement, the implications for children are not straightforward. As time allocation incentives change, so too may the nature of child nutrition and care. Although Field does not specifically consider mothers’ labor hours, the potential impact of a shift in maternal time allocation, if one has occurred, should raise concern. On the one hand, mothers engage in a range of time-intensive activities that improve their children’s health and nutrition, so their labor force participation could hurt their children; on the other, insofar as their incomes boost household resources, employment could also have positive consequences. Research across a range of disciplines has investigated which of these effects dominates in a given setting—with under-nutrition usually the outcome of interest in LDCs—but no clear verdict has emerged (for reviews, see Leslie 1989; Glick 2002).

To investigate the effect of land titling on child nutritional status, I surveyed 27 Lima communities that have participated in Peru’s urban land-titling program, the same program that Field has analyzed. A wide-reaching natural experiment, the Peruvian program has distributed formal property titles to 1.4 million households in the country’s informal settlements over an 8-year period. In order to gauge the nutritional effects of this exogenous change in tenure status, I conducted a cross-sectional health survey designed to exploit community-level variation in the timing of program intervention.

To the best of my knowledge, the recent paper by Galiani and Schargrodsky (2004) is the only existing analysis of child health and nutrition in the urban land rights literature. Using data from a small-scale expropriation in an Argentine locality, the authors find that land-titling is associated with increases child weight-for-height, but height-for-age remains unchanged. They conjecture that their results imply a change in short-term, but not long-term, nutritional status, which is consistent with the accepted wisdom on child growth patterns (Falkner and Tanner 1986), and then conclude that land titling enables households to invest more heavily in human capital, acknowledging that the effects are probably modest. However, this conclusion runs counter to an important point: wasting, or thinness, is generally not a problem in Latin America, nor is it a problem in their sample. The authors make note of this in their discussion, but they do not recognize its implications: with the average child in their sample slightly overweight, it is unclear that an
increase in weight would represent a health improvement.

Consistent with Galiani and Schargrodsky’s results, I find title-related increases in weight but not height. These results are compelling in their consistency with those of Galiani and Schargrodsky, but given the high prevalence of stunting (short stature) and the low prevalence of wasting in Peru, they set forth ambiguous implications for children’s health and well-being. Indeed, my results also indicate that titling is associated with increased risk of being overweight or obese, with the association strongest among children whose mothers work. In Latin American cities, where excess weight is a growing public health concern, these effects do not necessarily imply an improvement in human capital, as Galiani and Schargrodsky propose. More broadly, however, my findings highlight the need for greater attention in both policy-making and economic research to the coexistence of under- and over-nutrition in the same settings, even the same individuals.

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DO MICRO-CREDIT PROGRAMS LEAD TO FEMALE EMPOWERMENT?
AN EMPIRICAL STUDY OF PIPELINING AND MICRO-CREDIT PROGRAM PARTICIPATION

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There is a widespread debate in the current literature surrounding the effects of micro-credit programs on women’s empowerment. Many programs specifically target women in an attempt to help them overcome social and economic inequalities relative to their male counterparts. One of the central arguments against the effectiveness of the programs in raising empowerment is the idea that pipelining, or the transfer of managerial control over a loan from a female borrower to a male relation, reduces the empowerment benefits of participating in a credit program. This paper first attempts to model female empowerment in relation to both credit program participation and pipelining and then evaluates the combined the effects of both on women’s empowerment in rural Bangladesh. A series of regressions and various approaches confirm that the interaction between pipelining and program participation is significantly negative and thus effectively counteracts the gains in empowerment derived from borrowing, suggesting that micro-credit programs, even when explicitly targeting women, are at best only marginally empowering if a woman is susceptible to pipelining.

Micro-lending programs first appeared in the early 1980s as an instrument for poverty relief. Following the local cultural and social traditions, the programs mostly targeted men. However, women borrowers displayed a high propensity to repay their loans, quickly proving to be better credit risks than their male counterparts; as a result, the programs soon began to target women. Not long after, attention began to shift to the program’s positive effect on women’s empowerment; today, most claim that they specifically pursue women borrowers in an attempt to overcome prevalent social and economic inequalities and attitudes. In July 2004, the Grameen Bank of Bangladesh claimed that 96 percent of their 3.7 million borrowers were women and that the empowerment of women in the household was one of the principal aims of the program.

Most of the recent economic literature has focused on establishing a causal relationship between micro-loans and female empowerment in various theoretical and empirical frameworks; however, the range of studies has been characterized by contradicting conclusions. At the forefront of the pro-empowerment effects group are studies by Pitt et al. (2003), Hashemi et al. (1996), and Mizan (1993). Each of these studies finds that women who borrow from micro-credit programs derive significant gains in personal empower-
The general reasoning is that the programs provide women with the means to achieve greater economic autonomy and share of economic contributions to the household, which in turn has a spillover effect on decision-making within the household and other measurements of empowerment. However, empowerment proves to be a difficult phenomenon to measure. While all of the studies attempt to model a general concept of empowerment, each tests the effects of loans on a specific and, therefore imperfect, empowerment indicator. Therefore, much of the discrepancy in results concerns the mere complexities of defining empowerment.

One of the most convincing arguments against the empowering effects of credit programs, first introduced by Goetz and Sen Gupta (1996), focuses on the existence of pipelining, or the transfer of managerial control from the female borrower to male members of the household. Pipelining is potentially detrimental to female empowerment because it implies that women not only suffer a loss in the share of both personal and household decision-making but are also forced to assume the burden of repayment. Therefore, while participation in credit programs alone may empower women, the existence of pipelining may have a countervailing negative effect.

This paper evaluates the combined effects of pipelining and participation in microcredit programs on the women’s empowerment. Using data from 1,798 households in rural Bangladesh, this analysis first characterizes the capacity for pipelining in measurable terms and then tests whether or not participation in credit programs have a significant positive impact on women’s empowerment in the presence of such capacity. The paper first provides an overview of the current debate in the literature—including the seminal studies by Pitt et al. (2003) and Goetz and Sen Gupta (1998)—and identifies areas in which it improves on existing analysis. The second section of the paper describes the data used and explains theoretical strengths and weaknesses of the relevant empowerment indicators. The following section presents the general empirical approach, which builds on the previous studies by empirically modeling pipelining and its impact on the effect of borrowing on empowerment. A variety of different approaches are taken to test the empirical relationship between borrowing, pipelining, and three measures of empowerment. The ultimate approach is a two-stage least squares fixed effects regression, which accounts for the endogeneity of the decision to borrow. The final section examines the regression results and finds that they confirm the negative effect that pipelining has on girls’ schooling, share of household assets, and share of asset purchases when a woman chooses to participate in a loan program. Four alternate model specifications strengthen the robustness of the results, with each finding that pipelining capacity reduces the empowering effects of micro-credit programs by about half. The conclusion further interprets the significance of the results in the context of female empowerment and discusses implications of the results on micro-credit program designs.

References


I. Introduction
This synopsis assumes familiarity with the pharmaceutical industry in the US and will sketch a brief history of the Indian sector before diving into the case studies representing the meat of the paper. The burning question is how Indian pharmaceutical firms acquired manufacturing and research technologies despite the lack of technology transfer from multi-national firms (MNCs). An answer is sketched by the studies of Biocon India, at time of writing India’s largest biotechnology firm by revenues, and of Ranbaxy Laboratories, India’s largest pharmaceutical manufacturer by revenues, which empirically illustrate certain strategies that Indian firms may have used. Further research is needed to prove that these strategies were indeed the drivers of technical development at these two firms, and in the industry at large.

II. History
The most significant development is the implementation of Trade-Related Aspects of Intellectual Property Rights (TRIPS) in January 2005, which switched India from a process-patent to a product-patent regime. The difference is that generic manufacturers in India are barred from copying and manufacturing a branded drug introduced by an MNC. At the industrial level, the introduction of a process-patent regime in 1970, together with other protectionist policies, had led to learning of basic techniques and increased manufacturing but lower rates of research and development amongst domestic Indian firms, as well as smaller market share of MNCs at the cost of their bringing fewer innovative drugs into the Indian market. At the public health level, the process-patent regime led to self-sufficiency in provision of essential medicines but a simultaneous over-abundance of ‘me-too’ drugs named, marketed, and priced differentially but essentially serving the same therapeutic function.

In recent years, however, Indian pharmaceuticals have come to the fore. Ranbaxy is one of the top ten generic manufacturers in the world, with nearly 40% of its revenues coming from the US market, far higher than the less than 30% coming from the domestic market. Other pharmaceuticals like Dr. Reddy’s Laboratories, have patented certain molecules, the starting point of any synthetic medical drug, in the US. Meanwhile, Biocon seems to be using unique cutting-edge fermentation and other techniques in production of
biological drugs. Another indication to a layperson of the sophistication of Indian firms are the increasingly more equal research partnerships they have affirmed with giant MNC pharmaceuticals, rather than simply serving as manufacturers or distributors.

III. Case Studies

Biocon India
The company started as a beer brewery but was research-focused from the start and diversified into enzyme production, which requires fermentation techniques. From there, it acquired solid-state fermentation technology that enabled it to produce statins, and later, insulin. Biocon developed the production technology and patented it in the US in 2003. However, to conduct early stage research into new pharmaceutical drugs requires a range of skills that Biocon did not possess. To acquire these skills, Biocon used a ‘contract research’ model under its subsidiaries Syngene, to which MNCs outsource certain parts of the drug development process, and Clinigene, which undertakes clinical trials and mines the patient data for information pertinent to drug-design. Later, Biocon also entered partnerships, for example, with the Cuban biotech firm CIMAB, which shared its patented monoclonal antibodies with Biocon in exchange for help in developing, manufacturing and marketing these drugs.

The company has some biological drugs undergoing development but has not patented any drugs in the US. Biocon has patents on production technology, as well as a research pipeline, the main revenue stream is still generic manufacture. Indeed, Biocon aggressively pursues Abbreviated New Drug Applications (ANDA), which allows a company to make and sell off-patent drugs in the US, and otherwise taps lucrative foreign markets.

Ranbaxy Laboratories
Ranbaxy was founded in 1962 and began building a presence outside of India in the late 1970s. However, the period from 2000 to 2005 saw an intense effort to acquire research capabilities and break into the advanced US market.

First, Ranbaxy grew international operations significantly. Key to these efforts was an extremely aggressive intellectual property strategy which saw it apply for and win several ANDAs in the US ahead of American and international firms. It also acquired the right to manufacture and sell generics in the European, Asian, Latin American, and some African markets. Tied to this effort was its ability to rapidly reverse-engineer drugs.

Beyond this, Ranbaxy successfully developed and patented formulations technology, such as single dosage, solid tablet, or liquid forms that allowed it to differentiate its generic product from even the branded original by improving on how the patient took the medicine. Patient compliance may have improved and encouraged more prescription of Ranbaxy products, leading to better performance.

Further, Ranbaxy aggressively expanded manufacturing and distribution capabilities, which requires less cutting edge techniques in basic science but great organizational skill and scaleable production techniques, into foreign markets. It could then leverage its formulations technology, its manufacturing capability, and its marketing reach in partnerships
with MNC biotech and pharmaceutical firms.

At first, these partnerships were such that research institutions or MNCs provided the science, with Ranbaxy responsible for making and selling the drug. Later, Ranbaxy took over some drug development processes, and later formed a research alliance with Glaxo-SmithKline (GSK). As with Biocon, Ranbaxy tried to develop its inhouse research capabilities organically while trying to leverage its other capabilities and exchange services for advanced drug discovery techniques.

However, Ranbaxy is still not an equal partner in the research alliances. With GSK, for example, both GSK and Ranbaxy will provide drug leads, which Ranbaxy will take through early stage development, however, GSK was responsible for late-stage development. GSK then retained the marketing rights worldwide, while Ranbaxy had control of the domestic market. The potential revenue from successful projects is clearly in GSK’s favor. While Ranbaxy invests a high percentage of revenues in R&D relative to other Indian firms, in terms of both proportion and absolute amounts, it lags far behind established MNCs.

**IV. Implications**

Indian firms try to tap foreign pharmaceutical markets for their potential revenue, reinvesting the capital into research capabilities, and building up research skills. They acquire such skills by leveraging existing technical, manufacturing, or marketing capabilities into interactive, technology-based transactions such as contract research.

With respect to policy concerns, it looks as though select Indian firms that have penetrated foreign markets despite their stricter intellectual property environment will not face significant difficulty under India’s new product-patent regime. But the firms seem to have used the domestic market as a testing ground for new products and strategies, and took advantage of lax local conditions to grow domestic revenues; such strategies may no longer work.

TRIPS also affects health policy concerns, addressed briefly in the original paper. Suffice it to say here that Ranbaxy has developed a wide range of anti-infective drugs for the domestic market, and Biocon is similarly active in addressing the need for cheap essential medicines. It is unlikely that the adoption of TRIPS will lead either firm to neglect domestic needs, even if a larger proportion of their revenue growth comes from foreign markets.

The original paper is framed by theories of evolutionary and institutional economics at the industry level, and by dynamic capabilities at the firm level; if the reader is interested I invite him or her to get in touch.
TRADE LIBERALIZATION AND HIGHLY REGULATED ECONOMIES: 
THE MECHANISM THROUGH WHICH GOVERNMENT INTERVENTION 
INFLUENCES GROWTH

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Conventional trade theory emphasizes that greater trade liberalization leads to reallocation of productive resources, where they are used with comparatively greater efficiency. Improved efficiency increases productivity, which increases the growth rate of an economy. Despite that, preliminary empirical evidence suggests that greater trade openness has no impact on GDP growth rates in highly regulated economies. Consequently, the goal of this paper is to investigate the mechanism through which the regulations of business impose a hindrance to absorbing the benefits of trade liberalization, one of which is productivity improvement, and to examine the joint effect of trade liberalization and business entry cost regulation on productivity improvement. A further objective of the paper is to study whether the absolute productivity gap between low and high entry-cost countries increases or decreases as an industry becomes more open.

This research contributes to a growing literature on the importance of government regulations as a hindrance to the benefits of trade liberalization. Its findings suggest that government regulation, in terms of the cost of business entry, creates a significant burden on industrial productivity improvement due to trade liberalization by negatively affecting the cutoff level of productivity. Further, the higher is the entry cost difference between two countries, the smaller will be the decrease in the industrial productivity gap due to trade liberalization.

This study’s adopted approach to analyzing the effect of openness and government regulation on industrial productivity differs from the existing literature in two respects. First, I focus on the mechanism of government intervention and the interaction effect of openness and regulation on productivity. To my knowledge, this question has not yet been well addressed in the literature. Second, in the empirical estimation government regulation is measured with a continuous variable, as opposed to a weighted index. Such a method is advantageous because it makes the interpretation of a change in government regulation meaningful and enables a researcher to talk about relative differences in the level of regulation between countries.

A few major points from the literature on similar issues are worth emphasizing. First, the regulation on business entry plays a major role in slow GDP per capita growth (Bolaky and Freund, 2004; Loayza, Oviedo, and Serven, 2004.); second, it distorts the process of
firm creation and destruction (Fisman and Sarria-Allende, 2004; Klapper, Laeven, and Rajan, 2004); and third, producer turnover is an important determinant of productivity growth (Roberts and Tybout, 1997). Therefore, a potential link between regulation on entry and GDP growth could come through the impact on industrial productivity. This potential link can be well addressed through the new trade theories. By relaxing the assumption of perfect competition and allowing firm heterogeneity, the gains from trade in such models come from intra-sectoral changes in output and productivity due to exposure to foreign competition. Therefore, it is possible to model the mechanism through which government intervention impacts growth as impacting within industry structure and productivity.

I employ a model with imperfect competition and heterogeneous firms developed by Melitz for my analysis (Melitz, 2003). In the model, the average industrial productivity is completely determined by the cutoff level of productivity. Therefore, the regulation of business entry affects average industrial productivity through the effect on the cutoff level of productivity. I find that the derivative of the cutoff level of productivity with respect to the cost of business entry is negative. This finding suggests the following mechanism through which the regulation of business affects average industrial productivity. In equilibrium, the higher entry cost must be offset by a higher average industrial profit, which is negatively related to the cutoff level of productivity. Consequently, the latter would have to decline. Since a lower level of cutoff productivity corresponds to a lower level of average industrial productivity, it has to decline as well. Further, for an industry with a higher entry-cost, the increase in productivity due to a decrease in exporting cost will be smaller, compared with that of a low entry-cost industry (a diminishing marginal improvement in productivity due to openness with respect to the cost of entry). This result is obtained by calculating the second partial derivative of the cutoff level of productivity with respect to tariff rate and then with respect to the cost of entry: the derivative is positive. The finding suggests that an absolute productivity gap between high-regulated and low-regulated industries will increase following trade liberalization.

In the empirical estimation, the following three databases are used: the World Bank Trade and Production Dataset, the regulation of entry database by Djankov et. al. (2002), and Statistics Canada “World Trade Data, 1980 to 2000.” Using the available data, the average productivity is measured as the labor productivity net of capital; the cost of business entry is measured as the official cost that a start-up firm must bear before it can operate legally as a fraction of GDP per capita; the industrial openness is measured as a tariff rate by countries and industries, a trade to GDP ratio by countries and industries, and an average growth in world exports by industries. A sample of 21 countries across 27 manufacturing industries with a total of 561 observations is obtained.

To test the predictions from the model, a country-industry regression analysis is employed. The log-log empirical model specification is further used to estimate whether the cost of business entry negatively impacts industrial productivity and whether there exists a diminishing marginal improvement in productivity due to trade liberalization, with respect to the cost of business entry. An empirical test of the model confirms theoretical predictions: the average manufacturing productivity is negatively related to the cost of
business entry in any specification of the model. In addition, I cannot reject a hypothesis that there exists a diminishing marginal improvement in productivity with respect to openness because of the cost of business entry.

Economists often say that a country does not fully benefit from trade liberalization because of the presence of other rigidities in the economy. This paper looks deeper at the issue of the interaction effect of trade liberalization and government intervention on the economic performance. In particular, the paper investigates the joint effect of trade liberalization and the cost of business entry on the manufacturing productivity. The findings of the paper suggest that government regulation in terms of the cost of business entry creates a significant burden to industrial productivity improvement because of the trade liberalization: in the model with heterogeneous firms and imperfect competition, the cost of business entry reduces average industrial productivity by impinging on the cutoff level of productivity. In addition, an absolute productivity gap between high-regulated and low-regulated industries will increase following trade liberalization. Consequently, if a country wants to benefit from trade liberalization, it has to first loosen its product market regulations; in particular the bureaucrats must reduce the artificially imposed cost of business entry.

References


Hostage taking is a commonly employed terrorist tactic, as illustrated by the numerous hostage situations during Operation Iraqi Freedom. While conventional wisdom suggests that governments should never negotiate with terrorist groups because giving in to demands will only encourage further attacks, governments often do negotiate with kidnappers. This situation consequently raises two interesting puzzles. First, why do some governments choose to negotiate with terrorist groups while others adopt policies of non-negotiation? Second, how does participation in a multinational coalition influence a government’s decision of whether or not to negotiate?

In this paper I present a game theoretic model of the interaction between the targeted government and the multinational coalition when the government must determine whether to negotiate in a transnational hostage situation. Through comparative statics, I derive hypotheses from the model that reveal certain conditions that influence the likelihood of negotiation. Specifically, the model predicts that the role of the government in the multinational coalition largely affects a leader’s decision of whether to negotiate, suggesting that governments that are not vital in securing the long-term success of the coalition are more likely to negotiate. This prediction is underpinned by the intuition that while domestic electoral costs should trump international considerations for leaders of countries that play “supporting” roles in the coalition, this is not necessarily true for leaders of countries that are highly invested in the success of the coalition. The model also posits that domestic political and economic institutions affect the probability that negotiation will occur. That is, a government is more likely to negotiate if it would incur negative electoral consequences for non-negotiation. Furthermore, the model reveals that the level of trust between the targeted government and the hostage takers influence a leader’s decision in policy selection, suggesting that more trusting governments will be more likely to negotiate.

In addition, other factors—such as an upcoming election, the desire to gain admittance to a supranational organization like the European Union, the need for economic aid, or a regional security threat—that are specific to the context in which the hostage incident takes place may also influence a government’s decision of whether or not to negotiate. Although this paper does not empirically test the validity of these predictions, I apply the predictions to case studies of hostage situations during Operation Iraqi Freedom, an exer-
cise that helps illustrate how these hypotheses apply to real-world examples.

The Model
Consider a model of the interaction between a government (G) and a multinational coalition (MC). The government, which is a member of the multinational coalition, must choose whether to negotiate with a terrorist group to secure the release of hostages. The multinational coalition does not want negotiation to occur, so it must select some sort of benefit to offer the government to coerce the government to not negotiate. The two-stage game is played as follows.

In the first stage, hostages are taken and the multinational coalition must choose a level of benefit to offer the government to coerce non-negotiation; in essence, the multinational coalition attempts to buy off the targeted government. The cost to the coalition of offering this benefit is formalized in the model through the variable \(C_u\). Formally, \(C_u\) is a parameter that weighs how onerous the coalition finds paying off the government. Implicit in the game is the assumption that the multinational coalition’s decision to dole out a benefit is a credible one and that at some future date the targeted government will receive this benefit. While in reality the government would have to consider the credibility of the multinational coalition’s promise based on the coalition’s previous actions, this assumption is necessary since the model presented in this paper is a non-repeated game without reputation effects.

The second step of the game represents the government’s decision of whether or not to negotiate with the terrorist group based on the benefit offered by the multinational coalition. In this stage, the government will only receive the proposed incentive if it chooses to not negotiate. If the government chooses to negotiate, I assume that they will make some sort of concession to the terrorist group, and the game ends. For example, negotiation could signal the end of the target country’s participation in the coalition, particularly if the government pulls out its troops. Otherwise, negotiation could entail a lesser status in the coalition. In other words, if a country’s decision-making status in the coalition was 10 before negotiation, its decision-making weight within the coalition could drop to 5 after negotiation.

If the government chooses to not negotiate, it receives the proposed benefit. In this situation, the hostages will be executed with probability equal to 1, but if the government chooses to negotiate, the probability that the hostages will be executed is:

\[
1 - p, \text{ where } 0 \leq p \leq 1
\]

I also assume that the government faces electoral costs if the hostages are killed, regardless of whether it chose negotiation or non-negotiation; this cost is represented by the variable \(C_e\). The model presumes that in a transnational hostage incident, citizens of the targeted country will prefer negotiation (i.e. saving the hostages’ lives) to non-negotiation. Therefore, the electoral costs indicate how the government’s constituents would respond to the hostages being killed. In formal terms, the value of \(p\) makes the values of \(C_e\) different for negotiation and non-negotiation.

In the game, the variables are defined as follows: \(MC =\) Multinational Coalition; \(G =\)
Government; \( N = \text{Negotiation} \); \( nN = \text{Non-negotiation} \); \( B = \) the incentives offered by the multinational coalition to coerce the government to not negotiate; \( C_E = \) the electoral costs the government faces for their decision to negotiate or not negotiate; \( C_M = \) the measure of how onerous the government finds paying off the coalition; \( K = \) the power cost to the coalition if the government chooses to negotiate; \( p = \) the probability that the hostage will not be executed if the government chooses to negotiate; \( \alpha = \) a measure of how much the government’s policy preferences deviate from those of its constituency. In a true democracy \( \alpha = 0 \), whereas in a true dictatorship \( \alpha = 1 \).

Although the model provides a theoretical basis for analyzing hostage negotiation in the context of a multinational coalition, it does not account for all situations, nor have its results been empirically tested. While the qualitative case studies do help to evaluate certain predictions, such studies are merely illustrative and do not constitute conclusive empirical tests. Future research is thus required, as empirical tests of these hypotheses would provide more and stronger evidence as to their validity. Furthermore, the game theoretic model that I present is a single period model that does not account for reputation effects of the multinational coalition. Instead, the model assumes that the coalition is trustworthy and that its pledge to offer the benefit is credible. In reality, however, the government cannot make this assumption. Therefore, multi-period models that account for reputation effects should be designed in order to gain a more solid and realistic understanding of the decision-making dynamics between the government and the multinational coalition in instances of transnational hostage negotiation.
I. Introduction
Why do some poor and undeveloped countries exhibit very low growth and no sign of convergence to richer countries’ income levels? The resource curse theory offers one explanation why a large number of least developed countries have ended up in a poverty trap. Many developing countries are blessed with abundant natural resources. Especially the very poor sub-Saharan African countries have many mineral resources. These countries have therefore specialized in production of primary products—their static comparative advantage. Over time world prices of primary products have, however, had a declining trend and showed great volatility. A volatile and deflationary price environment hampers economic performance. The weak institutions and a high degree of corruption and crony politics of these countries discourage reallocation of production as primary product prices decline and fluctuate. The countries are therefore trapped in poverty.

II. Theory and Findings
This paper focuses on volatility’s effect on economic performance in developing countries. I seek to document and explore how price volatility in developing countries curbs economic development. The impact of volatility on economic performance has been the focus of a large strand of theoretical and empirical research. I will focus on volatility’s effect on investment rates. Using recently published data from the World Bank and IMF on investments and yet unpublished data from the World Bank on terms of trade, I provide evidence of a significant negative correlation between volatility in terms of trade and private investments. Private investments are significantly positively correlated with growth in a Barro regression, therefore they seem important for economic development (as opposed to public investments which are insignificant in a Barro regression). The negative correlation between volatility and private investments is robust for including standard control variables. This volatility-investment correlation could happen through two channels: 1) volatility increases uncertainty and thereby reduces agents’ investments if they are risk averse and credit constrained, and 2) shocks might have persistent effects on investment rates if they are combined with bad macroeconomic stabilization policies. I go on to explore these channels.
The first source has been documented and confirmed by several microeconomic studies. The intuitive reasons are two-fold:

- Volatility under imperfect risk protection makes agents invest less. The basic idea is that uncertainty about the future raises the value of an option to delay investments. Agents will therefore divert their income towards more consumption and savings and less investments. They might also skew their investments away from domestic assets and towards investments in foreign assets.
- When agents experience short-run shocks on income one of the first consumption bundles they cut is health and education investments.

I find support for this source being important. In the face of volatility, private investments in credit-constrained developing countries are reduced more than in less constrained countries.

The second source of volatility’s negative effect on investment rates concerns the governments’ ability to respond to shocks. Rodrik (1999) asserts that bad macroeconomic stabilization policies might drive the correlation. He finds that more divided societies with weaker institutions tend to have difficulties reacting appropriately to shocks. Shocks give rise to a policy decisions concerning distribution of the costs. If the society is divided (has a high degree of latent social conflict) the distributional decision gives rise to social conflicts that delays fiscal policy adjustments and potentially lead to pro-cyclical macroeconomic policies. Therefore, more volatility/shocks can have a persistent negative effect on investment rates. I find evidence that governments in divided societies are less competent at responding properly to shocks.

III. Conclusions

This paper is a contribution to the existing literature in that it (i) uses very recent data and (ii) attempts to figure out the channels linking volatility and economic performance. By analyzing component (ii) the paper provides some policy recommendations on how to cope with volatility in prices: my findings stress the point that countries with volatile terms of trade could attenuate adverse effects on economic performance by developing their capital markets. My findings also suggest that countries with more divided societies might enjoy large gains from building institutions with automatic stabilizers of business cycles, since these countries appear to face difficulties in performing discretionary stabilizing.

A final word of caution regarding my results: robustness checks cast doubt on the robustness of the above mentioned conclusions.
RECENT CURRENCY CRISES IN CONTEXT:
DO PAST INDICATORS STILL APPLY?

Alice Luo
Duke University, Class of 2005
Advisor: Craig Burnside

I would like to thank my advisor, Professor Craig Burnside for his patient guidance and support. I am very lucky to have had such a great advisor and sincerely appreciate his commitment and faith in me.

Over the past fifteen years, the world has been faced with numerous currency crises. In Mexico, the currency crisis led to a serious recession and created huge strains in the banking system. In Turkey, the Turkish Lira was devalued more than 50% causing interest rates to skyrocket and inflation to reach triple digit levels. With the Asian Financial Crisis of 1997, what began as the crash of the Thai baht in Thailand spread currency instability to the Philippines, Malaysia, Indonesia, and South Korea with implications for both Russia and Brazil. Recently in 2001, Argentina first moved from a currency board to a dual exchange rate system, adopting a preferential exchange rate peg for exports. Massive domestic unrest ensued, and months later, the government abandoned the system for a floating regime.

Past studies of currency crises have shown them to be the inevitable conclusion of fundamental imbalances. Governments attempting to keep a fixed exchange rate limit themselves in the use of monetary policy. In the new models of currency crises, the viability of a fixed exchange rate depends pivotally on the attitude of speculators. Because speculators are the actual catalysts that tip the overvalued currency into devaluation, currency crises are strongly subject to market sentiments.

Though exchange controls have been progressively dismantled since the early 1970’s, their removal in emerging economies accelerated significantly in the 1990’s. Development of new technology and financial instruments facilitated capital flow, allowing financial markets to become globally integrated. The trends in the 1990’s have been especially important to developing countries. To take advantage of international capital, developing country governments relinquished some of their historically tight control. As developing countries experienced massive capital inflow that improved infrastructure and fueled real economic growth, the domestic financial systems often found themselves inadequately prepared to handle the accompanying risk. Compounding the lack of transparency and uncertain fiscal policy, developing countries became much more prone to currency pressures. Global integration has been cited many times as the key factor in today’s cur-
rency crises.

Although the crises of the past decade have received much attention and fueled an abundance of second-generation theoretical work, there has been a scarcity of up-to-date empirical work. This paper seeks to empirically study developing countries over a period of over 30 years to determine if modern currency crises can be characterized differently than that of the past. In this paper, the established model of crisis outlined by Frankel and Rose (1996) is extended to determine if the factors that provide the impetus to crisis situations have changed. By extending Frankel and Rose’s study through 2003, the data is expanded to include the recent events of Mexico, Turkey, Southeast Asia, and Argentina. In particular, do the indicators that held for currency crises in the 1970’s and 1980’s still hold for the more recent crisis situations?

Results found that to the extent that the model has been able to fit recent crises offers evidence that traditional indicators can account for modern crises. Out of the significant crises of the past decade, the contemporary model was able to accurately predict, in decreasing probabilities, the crises of Turkey in 2001, Indonesia in 1998, Thailand in 1998, and Mexico in 1995. With the high percentage of accurate predictions, the model seems to have no difficulty accommodating modern crises.

Although many of the basic fundamental trends that Frankel and Rose (1996) found still hold, recent currency crises have several distinctive components. Looking at each regressor individually, we can observe that since Frankel and Rose’s evaluation concessional debt (current account over GDP) and real exchange rate divergence have become significant while foreign direct investment has become insignificant.

The significance of the concessional debt variable is not surprising. Given the literature on stability of debt flows, the more stable the debt flow, the less likely it is to contribute to a crisis. Concessional debt flows include loans from regional development banks, which in a crisis situation, are the least likely to be recalled. The regression results show that for a 1% increase in percent of concessional debt in the overall debt burden lowers the probability of a crisis by 0.13%.

The appearance of the current account balance as a percentage of GDP is significant with a 1% increase indicating a 0.29% increase in the probability of a crisis. In interpretation, this variable may be more of a reaction to a crisis rather than a signal that precedes it. When a currency devalues, one of the immediate impacts is a boost to the current account balance. Exports increase and imports decrease because domestic goods have become cheaper in comparison to the rest of the world.

The significance of real exchange rate divergence should not be surprising but the sign is unexpected. For a 1% increase in real exchange rate divergence, the probability of a crisis decreases by 0.01%. Although small, this trend is counterintuitive. In evaluating this variable, one may want to consider the Balassa-Samuelson hypothesis (Levich, 2001), which states that countries that have experienced high productivity gains, higher real income growth and higher real incomes should have appreciating real exchange rates. For developing countries, this could be a valid hypothesis for which the actual real exchange rate divergence may not have been captured by the current method. The current method measures the real exchange rate minus its country-specific sample mean. A better method
may be to define a variable that subtracts out a linear trend instead of simply subtracting out the mean. This would take into account any time trends that may appear in the real exchange rate data.

The last significant variables: domestic credit growth rate, GDP per capita growth rate, and weighted foreign interest rate all remain consistent with past literature.

In the predictive model, results show significant effects for the percent of total debt that is concessional, the percentage of total debt that is foreign direct investment, the total debt as a percentage of gross national income, reserve as a percentage of monthly imports, the domestic credit growth rate, the real GDP per capita growth rate, and the OECD growth rate.

Surprisingly, there were a good amount of variables that became significant in the predictive regression but were not significant in the contemporaneous one. Foreign direct investment for one, was only significant at 7.4% level in contemporaneous results, just missing the 5% significance threshold. In the predictive regression, it becomes fully significant. FDI would be expected to have similar stabilizing effects on a country’s debt composition as concessional debt discussed earlier.

Total debt is another significant predictive indicator. When total debt as a percentage of gross national income increases by 1%, the probability of a crisis next year falls by 0.01%. This would lead one to believe that since Edwards’ (1984) study, lenders have become more adept at evaluating risk. In order to receive a loan, the country must meet certain standards. Any such external validation usually carries signaling effects. In a developing country, however, those signaling effects may be even more substantive due to the lack of reliable information. The external validation of being granted a loan may signal enough to the market to account for part of the trend. In such a case, the alleviating effect may be self-perpetuating and it does not matter the extent to which original risk was properly gauged.

Another new significant variable is the real OECD growth rate. The real OECD growth rate is the aggregate growth rate of developed countries. When it increases by 1%, the probability of a crash in a developing country decreases by 0.51%. This can be interpreted to mean that changes in the world economy have a significant role in predicting the health of developing economies in the next year. If developed countries show weak growth, crashes are more likely to follow in developing countries. This notion is very intriguing and more studies would have to be done to determine the nature of this effect. If it is correlational, it could be that OECD indicators provide a good signal for overall global economic health. If the trend is causational, however, it could signify that bad trends in developed countries can induce crises in developing countries.

The past eleven years of “modern” crises seem to have changed the significance of several variables but most overall trends remain. Crashes have a higher probability of occurring when concessional debt to total debt is low, reserves to monthly imports are low, current account balance to GDP is high, domestic credit growth rate is high, real GDP per capita growth rate is low, and world interest rates are high. Signs that may precede a crisis include again low levels of concessional debt in relation to other types of debt, low levels of foreign direct investment in relation to other types of debt, low levels of overall debt,
falling reserves as a percentage of imports, rising domestic credit growth rate, falling real GDP per capita growth rate, and falling aggregate world growth rate. As for the indomitable nature of market forces, this broad analysis has revealed some seemingly controllable fundamental factors.

Although the crises of this past decade have been touted as a new generation, they align with crisis models already in place. A majority of the indicators converge with the first and second generation models, as well as support the speculation and contagion literature. The nature of currency crises seemed to have evolved over the past decade but are far from unrecognizable.

References


AN EMPIRIC INVESTIGATION INTO THE RELATIONSHIP BETWEEN CAPITAL CONTROLS AND FOREIGN DIRECT INVESTMENT INFLOWS

Dennis Huggins
Georgetown University, SFS 2005

ABSTRACT

This paper examines the impact of three types of capital controls on Foreign Direct Investment (FDI) inflows into both developed and developing countries: the existence of multiple exchange rate regimes, capital account restrictions, and export proceeds repatriation restrictions. Using three separate models, this study finds that the presence of multiple exchange rate regimes, as well as of capital account restrictions, reduces FDI inflows into developed countries. Among developing countries, the presences of a multiple exchange rate regime, as well as of export proceeds repatriation restrictions, act to reduce flows. With respect to capital account restrictions and export proceeds repatriations restrictions, the relative effects of capital controls on FDI inflows appear to vary over development level. The effects of capital account restrictions are not consistent across the specifications employed in this paper and cannot be fully discerned.

Throughout much of the 1990s, economic wisdom, embodied in what John Williamson has labeled the “Washington Consensus,” posited that capital controls, measures that impede the free flow of capital across international borders, led to suboptimal economic outcomes for countries which maintained such controls. However, this paradigm was challenged by the onset of the Asian Financial Crisis in 1997, which engendered a renewed interest in the effects of capital controls on capital flows. Nonetheless, most of the literature this interest has generated thus far has confined itself to the examination of the effects of those controls on short-term capital flows. In contrast, very few researchers have studied the effects of capital controls on long-term flows, namely, Foreign Direct Investment (FDI).

This oversight is not insignificant: at the end of 1999, over eighty countries maintained some form of capital control restrictions. Moreover, while there is yet no consensus on the relationship between FDI and growth, there is a growing understanding that FDI is posi-
tively correlated with growth and that FDI serves as a conduit for the transfer of advanced
technology across countries, improving productivity (Lim 2001). Accordingly, if capital
controls deter FDI, countries with such controls are limiting their opportunity for econom-
ic growth and development.

Fundamentally, capital controls are measures that impede the free flow of capital
across international borders. The precise manifestations assumed by these controls are
generally country-specific. Nonetheless, the International Monetary Fund (IMF) tracks
three types of capital controls: *capital account restrictions*, *export repatriation proceeds
restrictions*, and *multiple exchange rate regimes*. Capital account restrictions restrict the
movement of funds for investments and loans into and out of a country. Export repatria-
tion proceeds restrictions are a form of capital control that limits a multi-national compa-
y’s ability to transfer profits from its operations in one country to the country in which a
firm is headquartered, where these funds would be dispersed as dividends to the firm’s
stockholders. Multiple exchange rate regimes are government controls applied in conjunc-
tion with a fixed-rate regime that set different exchange rates for different types of goods
or transactions. Information concerning the position of International Monetary Fund
members is collected annually and published in *Exchange Arrangements and Exchange
Restrictions*.

The IMF measures record the existence of capital control restrictions but fail to cap-
ture the intensity of those restrictions, which can vary widely from country to country.
Consequently, only the average effect of the set of restrictions that compose each type of
capital control measured by the IMF can be reported. This is an important limitation, but
an unavoidable constraint: more detailed cross-country capital control reports simply do
not exist while the alternative method of constructing an index that measures capital con-
trol intensity, as pursued by certain authors such as Desai et al (2004), is inherently arbi-
trary.

In light of these issues, data concerning capital controls were collected from the IMF’s
annual report on *Exchange Rate Arrangements and Exchange Restrictions* from 1980 to
1999 for 127 countries. The dependent variable is the log of FDI inflows measured in cur-
rent dollars. These data were obtained for the 127 countries over the twenty-year period
from the UNCTAD Foreign Direct Investment Database. In order to determine the effect
of capital controls on FDI after controlling for other important determinants of FDI, a
number of non-capital control independent variables were selected from the existing liter-
ature concerning the determinants of FDI. These data were drawn from the World Bank’s
*World Development Indicators Online Database*. Five separate regression specifications
were tested on three different samples of the dataset—the aggregate panel and two sub-
samples, one restricted to developing countries, the other restricted to developing coun-
tries. The results of these regressions appear in *Tables 1.0, 1.1 and 1.2*.

The first specification is a naïve estimation of the effect of capital controls. This equa-
tion regresses the log of FDI inflows on each of the capital control dummy variables using
the basic OLS model. The results appear in column one in each figure and serve as a base-
line against which the other specifications can be compared. In light of concerns over
omitted variable bias, a second, adjusted, specification attempts to correct for omitted vari-
able bias by controlling for those country-specific factors identified by current FDI theory that affect the flow of FDI using the basic OLS model. These results appear in column three in each figure.

While these controls should help eliminate omitted variable bias, ultimately the basic OLS model is not the optimal method for analyzing the effects of capital controls on FDI inflows: there will always be some omitted variable bias. In order to address this, the adjusted specification was rerun using the fixed-effects model, the results of which appear in column four in each figure. Finally, a third specification was obtained from a slight modification of the model developed by Asiedu and Lien (2003) as a baseline for comparison. Additionally, the naïve estimation was rerun using a fixed effects approach to provide an improved baseline specification, measuring “within specific country” variation, as opposed to “within total sample” variation, against which the adjusted equations could be analyzed. The results of the naïve estimation using a fixed-effects specification are reported in column two on the tables below.

The results of this analysis generally indicate that capital controls deter FDI, consistent with previous theoretical predictions: on average, the presence of each type of capital control reduces FDI flows in countries by between 1.5% – 0.5%. Given the range of results returned among the fixed-effects specifications and the OLS specifications, it is not possible to pinpoint a specific dollar cost associated with the average set of restrictions which compose a particular type of capital control; a 95% confidence interval estimate based on these ranges is depicted in Chart 1.0 while a numeric interpretation is presented in Table 2.0. These results provide rough estimates of the typical costs incurred in enacting one of the three types of capital control restrictions analyzed here.

These costs are largely consistent with the costs implied by the results reported by Asiedu and Lien (2004). The fact that the results obtained in this paper are smaller than those found in Asiedu and Lien’s (2004) work indicates that capital controls might also lower FDI outflows from countries with such controls. Further, the results of this analysis provide evidence that capital controls affect states differently according to their level of development. Though it is not clear that the effects of multiple exchange rate regimes change as countries become more developed, evidence presented here suggests that as countries become more developed, the effects of capital control restrictions on FDI inflows become more contractionary while the effects of export proceeds repatriations restrictions become slightly less so, perhaps because foreign concerns which invest in developed countries are more likely to intend sustaining these operations through local profits, regardless of the presence of export proceeds repatriation restrictions.

However, the results obtained here suffer from two limitations: a limited sample of capital controls used by developed countries and issues of simultaneity that have not fully been corrected by the models employed here. Setting these limitations aside for the moment, the findings presented here fix a rough approximation of the costs a country can expect to pay in the form of “lost” FDI inflows if it adopts a particular type of capital control regime. As such, the results offer economic policy officials a yard stick against which to assess the decisions to adopt particular capital control restrictions, whether in the face of anticipated speculatory attacks against the country’s currency or due to ideological con-
siderations. In so doing, these findings aid in the transformation of an abstract cost-benefits calculus into a more practical, quantifiable equation, albeit one that may be more precisely estimated by a simultaneous equation model in conjunction with a longer sample period.

References


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<th>(1) Naïve Estimation (OLS)</th>
<th>(2) Naïve Estimation (Fixed Effects)</th>
<th>(3) Adjusted Estimation (OLS)</th>
<th>(4) Adjusted Estimation (Fixed Effects)</th>
<th>(5) Asiedu and Lien Estimation (Fixed Effects)</th>
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<td>S.E.</td>
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<tr>
<td>Intercept</td>
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<td>-31.93a (4.53)</td>
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<td>-0.49a (0.11)</td>
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<td>Capital Account Restrictions</td>
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<td>0.32b (0.15)</td>
<td>-0.16 (0.18)</td>
<td>-0.21 (0.18)</td>
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<td>Export Proceeds Repatriation Restrictions</td>
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<td>-1.09a (0.17)</td>
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<td>Lagged Log of GDP</td>
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<td>Lagged Log of GDP Per Capita</td>
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<td>0.78 (0.23)</td>
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<td></td>
<td></td>
<td></td>
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<td>GDP Per Capita Squared</td>
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<td></td>
<td>0.00 (0.00)</td>
<td></td>
</tr>
<tr>
<td>Fuel And Oil Share of Total Exports</td>
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<tr>
<td>Annual No. of Strikes in a Country</td>
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<td></td>
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<tr>
<td>Observations</td>
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<td>1428</td>
<td>1428</td>
<td>1428</td>
<td>556</td>
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<tr>
<td>R²</td>
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<td>.74</td>
<td>.45</td>
<td>.80</td>
<td>.82</td>
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<tr>
<td>Sum of Squared Residuals</td>
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<td>3009</td>
<td>5709</td>
<td>2082</td>
<td>597</td>
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*a.01 significance level  b.05 significance level  c.10 significance level
### Table 1.3

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<tr>
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<tbody>
<tr>
<td></td>
<td>(Fixed Effects)</td>
<td>(Fixed Effects)</td>
<td>(Fixed Effects)</td>
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<tr>
<td>Intercept</td>
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<td>-6.64 (7.12)</td>
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<td>Multiple Exchange Rate Regime</td>
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<td>Export Proceeds Repatriation Restrictions</td>
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<tr>
<td>Lagged Log of GDP</td>
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<td>Lagged Log of GDP Per Capita</td>
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<td>Lagged Log of the Number of Fixed Line Telephones per 1000 Inhabitants</td>
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<td>1.11a</td>
<td>-</td>
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<td>Lagged Log of Gross Fixed Capital Formation as a Share of GDP</td>
<td>-3.39 (2.69)</td>
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<td>GDP Per Capita Squared</td>
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<td>0.33a</td>
<td>-</td>
</tr>
<tr>
<td>Fuel And Oil Share of Total Exports</td>
<td>-6.64 (7.12)</td>
<td>-0.03a</td>
<td>-</td>
</tr>
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<td>Annual No. of Strikes in a Country</td>
<td>-0.77 (0.78)</td>
<td>-0.15c</td>
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<td>R²</td>
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<td>Sum of Squared Residuals</td>
<td>51296</td>
<td>8567</td>
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* 0.01 significance level, ** 0.05 significance level, *** 0.10 significance level

### Table 2.0

<table>
<thead>
<tr>
<th>Sample</th>
<th>Average FDI Inflows</th>
<th>Average Difference with Multiple Exchange Rate Regime</th>
<th>Average Difference with Capital Account Restrictions</th>
<th>Average Difference with Export Proceeds Repatriation Restrictions</th>
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</thead>
<tbody>
<tr>
<td>Aggregate Sample</td>
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<td>-17.3 / -7.1</td>
<td>-12.4 / -4.5</td>
<td>-22.7 / -5.1</td>
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<td>Developed Countries</td>
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<td>-173.4 / -86.7</td>
<td>-77.1 / -52.1</td>
<td>-67.4 / -</td>
</tr>
<tr>
<td>Developing Countries</td>
<td>541.11</td>
<td>-5.9 / -2.7</td>
<td>1.73 / -</td>
<td>-5.9 / -2.3</td>
</tr>
</tbody>
</table>

*Results are based on the range of statistically significant specifications, **Figures are in millions of USD, ***Not significant at the .01 significance level.
ABSTRACT

This paper aims to test the well-known and controversial hypothesis that foreign direct investment acts as a channel of technology spillover from multinational affiliates to local firms. Using public data from the Czech Statistical Office and the Czech National Bank, this study examines the performance of fourteen branches of Czech manufacturing between 1998 and 2003. We estimate an aggregate Cobb-Douglas production function for the industries with a measure for FDI presence in a given branch as one of the independent variables. Contrary to the original hypothesis, the FDI presence is shown to have a small negative effect on value added growth. Testing for the influence of the technology gap and absorptive capacity, we find no evidence that they facilitate FDI spillovers. In view of the literature, the result can be interpreted as suggesting that productivity improvements experienced by foreign-owned firms are counterbalanced by negative or neutral consequences for domestic enterprises. Present findings concur with the prevalent view that there is no public policy case for subsidizing FDI inflows.

I. Introduction

Foreign direct investment (FDI) flows are an increasingly important part of today’s globalized economy. Over the last 13 years, real FDI growth averaged 17% annually, far outstripping growth in global output and even trade. Countries look to FDI to help balance their current account, but also to gain access to more up-to-date technologies and capital. Since most of the world’s R&D is performed in only a few advanced countries, it is logical for developing countries to wish to get some benefit from research done outside their borders through trade, FDI or licensing. In fact, many countries spend large sums in tax breaks for multinational corporations in the attempt to encourage them to invest. Naturally, the question of whether FDI results in positive spillovers for local domestical-
ly-owned firms in the economy has become the subject of numerous empirical investigations. So far, the results have been inconclusive. Generally, both macro-level studies, exploring the effect of FDI stock on economic or industrial productivity growth, and micro-investigations focusing on individual firm performance have found modest, if any, benefits from FDI presence. Some studies have, however, found that more research-intensive industries and industries with a smaller technology gap vis-à-vis foreign firms do realize positive spillovers. This ambiguous picture as regards horizontal productivity spillovers has shifted the research agenda on foreign direct investment to other areas. Increasingly, economists turn to exploring backward linkages, namely, the benefits investors may bring for their local suppliers in terms of quality control and market access.

This paper aims to return to the question of horizontal productivity spillovers, adopting an intermediate level of analysis between studies exploring effects of FDI stocks on economic growth and micro-productivity firm-level studies. Such intermediate positioning translates into an examination of a panel of fourteen Czech manufacturing industries between 1997 and 2003. The choice of the country is motivated by the belief that the characteristics of its economy (high level of industrial development, high human capital, openness, absence of excessive market distortions, etc.) make the Czech Republic likely to show evidence of FDI spillovers if they indeed occur. Our findings confirm the predominant strain in literature in finding no significant effect of FDI presence on productivity growth in an industry, regardless of industry characteristics. These results should be interpreted with caution due to data limitations, the short time period under consideration, and the fact that productivity fluctuations do not capture the entire welfare impact of FDI flows. The first section reviews the pertinent literature; the second gives a snapshot of FDI in the Czech Republic; the third describes the models used; the fourth summarizes the data; the fifth reports the regression results; and the sixth concludes.

II. Review of Literature

It has long been recognized in the economic literature that foreign direct investment (FDI) can benefit host countries as a result of productivity and other spillovers. Multinational corporations, due to their extensive R&D operations and accumulated managerial know-how, are a rich source of valuable knowledge, much of it tacit (Keller 2001). Since knowledge is a non-rival (non-exclusionary) and semi-public good, it not only spreads without depriving the original possessor of its utility, but its social returns also exceed private ones. Naturally, however, the typical investor and the host country often find themselves at cross-purposes: where the former seeks to maximize private return to its stock of knowledge and prevent spillovers to competitors, the latter has an interest in maximizing such spillovers in the hopes of advancing indigenous industry. This latent contradiction has found expression both in policy measures such as local content requirements or caps on the share of foreign investors, in vogue in the 1970s, and in academic literature, which already in the 1980s recognized that MNCs tend to transfer their best technology to wholly-owned subsidiaries, while joint ventures and especially licensees get access only to older and less valuable knowledge (Javorcik and Spatareanu 2003).

In this section we will outline the various types of FDI spillovers and empirical evi-
REVISITING THE EFFECTS OF FOREIGN INVESTMENT PRESENCE ON PRODUCTIVITY

dence for them. The literature often employs the terms “productivity spillovers” and “technology spillovers” interchangeably, although that is not strictly correct. Given that isolating effects of the transfer of technology is nearly impossible, such spillovers usually refer to the effect the presence of foreign investors, measured as the share of foreign-owned firms in output, assets or employment in a given industrial sector, has on the Solow residual (or total factor productivity) of domestic firms. Productivity spillovers are labeled horizontal when they operate in the same sector as the investor, backward when the effect is on domestic suppliers of foreign-owned firms and forward when they concern downstream firms such as retailers. Scholars have identified a number of potential channels for each type of spillovers. Thus, horizontal spillovers are hypothesized to occur through: 1) demonstration and imitation (domestic firms observe a foreign firm and apply whatever insights they glean from its operations); 2) human capital transfer (employees of a multinational may switch jobs, enriching local industry with their expertise); 3) competition and technical efficiency (domestic firms, formerly operating in protected markets, may have to reduce slack and X-inefficiency to compete with the investor). Some scholars such as Beata S. Javorcik (2004) believe that backward linkages are more important, since the aforementioned conflict of interest between the investor and the host country does not apply in the case of suppliers of a multinational. Channels for backward spillovers include: 1) assistance in setting up and operating production facilities; 2) management assistance; 3) help in diversifying by finding additional customers (presumably because the more diversified and larger a supplier becomes, the cheaper its products are, a benefit internalized by the multinational investor); 4) quality control and certification requirements (Blomström and Kokko 1998 following Lall 1980; Hoekman and Javorcik 2004).

Early empirical studies of the scope of various spillovers were either case analyses or cross-section industry-level econometric snapshots. It is not unreasonable to assume that case studies suffer from a heavy selection bias in favor of ‘successful’ projects. Whatever the case, many of them find significant backward spillovers (Lall 1980, Katz 1969, etc.) while other effects have been more ambiguous. Early cross-section studies uniformly found a positive correlation between industry productivity and foreign presence (Caves 1974 on Australia and Globerman 1979 on Canada are the most cited ones). These studies suffered from a major flaw since they did not account for time-invariant productivity differences among sectors which are not caused by FDI, and the related fact that investors may be drawn to more productive sectors (Görg and Greenaway 2003 and Tybout 2000).

Increasingly, serious work on productivity spillovers has come to be done with panel firm- or plant-level data. Such data allow one to control for time-invariant firm- and industry-specific heterogeneity. Moreover, the latest research has incorporated the insight of Griliches (1995) that each firm’s standard production function input selection is not independent of its past total factor productivity growth, and therefore an appropriate correction must be made. Fruits of such analytical rigor have been sobering: the vaunted benefits of FDI are shown to be modest if not non-existent or negative. Thus, even the hitherto accepted fact that foreign-owned firms are more productive than domestic ones appears to hinge on the investor’s preference for larger and already productive firms or for clustering in attractive industries. The upshot is that the added effect of foreign ownership on produc-
tivity is quite small (Navarette and Venables 2004: ch. 7.3). Evidence for horizontal spillovers is even weaker. If most recent studies on developed economies such as, to name but two, Haskel, Pereira and Slaughter (2002) for the UK and Keller and Yeaple (2003) for the US, show some positive effects, studies on developing and transitional economies run the gamut from non-significant to negative effects of foreign presence (Görg and Greenaway 2003). Thus, an influential study by Aitken and Harrison (1999) examined panel data from Venezuela and found negative and significant effects. Jozef Konings (2001) in his panel study of firms in Bulgaria, Poland and Romania detected no productivity benefit from foreign ownership and negative horizontal spillovers everywhere except Poland where the effect is insignificant. Djankov and Hoekman (2000), using a small sample of Czech firms, find that firms with FDI have higher TFP growth (even with the initial selection bias for larger and more productive firms) but that horizontal spillovers to the rest of the industry are negative. Only Sinani and Meyer (2004) find positive spillovers for Estonia.

Various explanations have been advanced for the failure to find positive horizontal spillovers or finding negative effects. Keller (2004) blames specification error since ‘there is no reason to believe that [FDI spillovers] would be negative’ (p. 770). Other scholars adopt combinations of non-linearity of the underlying relationship, competition effects, time effects and the obvious reason of the success of multinationals in preventing such spillovers from occurring. Thus, Aitken and Harrison (1999) believe that the arrival of multinationals took away market share from local producers and thus, at least in the short run, produced diseconomies of scale by moving them to the left on their downward-sloping average cost curves. It is also believed that spillovers take time to manifest themselves (Djankov and Hoekman 2000) perhaps due to the fact that inefficient domestic firms may be forced to exit in the medium run while others improve productivity (Barrios and Strobl 2002). Along similar lines, Damijan et al. (2003) and Lipsey (2002) hypothesize a non-linear U-shaped relationship between foreign presence and horizontal spillovers. According to their conjecture, the effect of additional foreign presence is initially positive, reflecting learning and other externalities, and then turns negative, as domestic firms can no longer effectively compete. If true, this relation is quite relevant for CEE countries where sectoral clustering of FDI is very pronounced (Damijan et al. 2003a, Hunya 2001b).

Effects of competition on spillovers are another interesting subject for further research. Just as economic theory is ambiguous, incorporating both a Schumpeterian claim for monopolies’ greater propensity to innovate and a more orthodox belief that competition fosters technical efficiency and spurs productivity, empirical evidence is quite contradictory. Kinoshita (2001) finds positive spillovers only in oligopolistic industries in her Czech sample. Barrios and Strobl (2002) find that the coefficient on foreign presence in the sector (the measure of horizontal spillovers) becomes insignificant when the Herfindahl index appears in the regression. If the result generalizes, it might mean that much of what other scholars construed as evidence for horizontal spillovers may reflect a combination of investors’ attraction to sectors with low competition and those sectors’ higher TFP growth. Of course, the TFP growth in itself may be due to the multinational’s entry, and so it would not be entirely incorrect to assign some of the credit to it (Blomström et al. 2000, pp. 105-
It should also be noted that Sjöholm (1999) finds that spillovers actually increase with competition in his panel of Indonesian firms. The largest and most authoritative study of FDI effects in CEE has been done by Joze Damijan et al. (2003a). Exploiting a large data set from ten transition countries and using system Generalized Method of Moments to correct for endogeneity of input choice, the study ends up generating more questions than answers. Thus, in five countries foreign ownership does improve TFP growth (among them regional FDI magnet Hungary and the more restrained Slovenia, seeming opposites as far as FDI penetration is concerned), but in the Czech Republic and Poland the effect is opposite. Of course, this result for the Czech Republic directly contradicts the earlier Djankov and Hoekman (2000) finding. Only to make matters more bizarre, Poland and the Czech Republic are among only four countries out of ten exhibiting positive (although low) horizontal spillovers, again in contradiction with Djankov and Hoekman (2000). Of course, this raises a curious question: how can foreign affiliates, which are not more efficient themselves, have positive spillovers onto their domestic counterparts? Surely, the finding is spurious, in spite of its mild statistical significance. Backward spillovers fare better in terms of magnitude, although they are detected only in the Czech Republic, Poland and Slovenia (Damijan et al. 2003). This result may reflect the greater stability of input-output relationships used as a proxy for backward linkages in these advanced transition countries and poor coverage of some countries (after all, Javorcik 2004 found significant backward spillovers for Lithuania using a larger data set, although her use of Olley-Pakes correction for input endogeneity may account for higher spillover estimates, as Keller and Yeaple 2003 show).

Theoretical work has also blossomed to explain FDI effects. Thus, Markusen and Venables (1999) build a partial equilibrium model in which foreign investment on the one hand competes with domestic production and on the other enables the investor’s suppliers to grow more efficient, which in turn benefits domestic industry. Using anecdotal evidence from Taiwan they believe their model fits the facts in its insistence on the benefits of export-oriented FDI. If foreign firms use domestic intermediate inputs with greater intensity than domestic ones, and do not unduly replace domestic production, prospects for indigenous industrial development are bright. In the opposite extreme case, however, the model permits a complete wipe-out of (presumably inefficient) domestic industry (see Moran 2001, pp. 53-55 for a non-technical exposition and applications).

The biggest factor surmised to influence the incidence of spillovers from FDI is the domestic firms’ absorptive capacity, i.e., ability to absorb and apply new knowledge and techniques. The notion that benefits firms derive from learning new production and managerial techniques have to do with said firms’ human capital endowments and technological savvy is quite intuitive. However, the exact relationships involved are more complicated. One insight is that relative backwardness helps; this view builds on the ideas of Alexander Gerschenkron and Thorstein Veblen and has found formal expression in the paper by Findlay (1978). According to this thesis, the greater the technology gap between the backward and the advanced regions, the greater are the pressures for change and thus productivity growth. Yet, Findlay hastens to add that there must be a minimum threshold of technological knowledge for the convergence to occur, a view still broadly held. He
goes on to claim for multinational corporations the mantle of vagabond academics of early modern Europe in spreading knowledge. Later treatments tended to play down relative backwardness and emphasized the need for the recipient firm’s ‘absorptive capacity’ to be sufficiently high for it to benefit from spillovers. In fact, something of an about-face has occurred in the empirical literature, with technology gap now expected to be inversely related to spillovers. Among more recent conceptualizations, Wang and Blomström’s (1992) stands out for modeling technology transfer as a strategic interaction between the investor and the host country. Insofar as it predicts a faster rate of spillover with greater domestic investments in R&D and a larger technology gap, it builds on Findlay’s insights.

Empirical evidence for the influence of the technology gap and absorptive capacity has been mixed; however, at the risk of overreaching, it can be said that a milder technology gap and the stronger absorptive capacity may be conducive to positive spillovers. Thus, Kokko et al. (1996) find that in a sample of Uruguayan plants those with a moderate technology gap showed positive spillovers while their counterparts facing large technology gaps vis-à-vis foreign-owned competitors did not. Of the more recent studies, Keller and Yeaple (2003) breaks its U.S. sample down into R&D-intensive and non-R&D-intensive sectors and finds positive spillovers for the firms in intensive sectors. However, it would be premature to generalize from this paper, given that it is based on the data from the technological frontier and, besides, it has found a very high overall horizontal spillover magnitude compared to other studies. Sinani and Meyer (2004) employ several measures of absorptive capacity—intangible assets, average wages and investment in new machinery—and find that interaction terms with foreign presence are either negative or insignificant. They interpret their results as indicating that the technology gap may be too large in Estonia for absorptive capacity to matter. Griffith, Redding and Van Reenen (2000) build a model of TFP in a non-frontier country varying positively with the size of the technology gap measured as the productivity distance to the frontier and on R&D expenditures. These expenditures fulfill a dual role: innovative and absorptive. The innovative role of R&D has been the focus of most of the literature until recently. It is the direct channel through which innovation occurs. In contrast, absorptive R&D manifests itself in interaction with foreign technology and permits firms to ‘absorb’ and apply results of foreign research. In the context of this model, the authors find productivity convergence in their panel of OECD industries. Keller (2001) reports, however, that G7 countries benefited more from technology diffusion than developing countries, thus confirming the notion that a certain threshold of technological or other competence must be crossed before convergence can take place. Kinoshita (2001) applies the model of Griffith et al. (2000) to a sample of Czech firms and finds a positive interaction term between R&D expenditure and foreign presence, indicating an important absorptive role for R&D. However, Damijan et al. (2003a) do not confirm this finding either for the Czech Republic or for most other countries in their study. For a few countries the interaction term does appear as significant although low, while the mere foreign presence term is uniformly insignificant.

My work will attempt to add to the growing body of empirical research testing for the existence of horizontal productivity spillovers in manufacturing and exploring the ways in which technology gap and absorptive capacity affect them. It is particularly interesting to
study the Czech Republic for three reasons: 1) it is a country which should be an ideal candidate for both FDI and its spillovers as it offers something to every investor’s taste: cheaper labor than in Western Europe, strong industrial and human capital base, and sufficient absorptive capacity of local firms; 2) studies in the Czech Republic have found contradictory results; 3) the penetration of its manufacturing sector by FDI is extensive but not to the point of complete take-over as in neighboring Hungary.

III. FDI in the Czech Republic

The Czech Republic, along with other countries in Central and Eastern Europe, has emerged as one of the main destinations for FDI since the fall of Communism and the attendant liberalization. Initially, it attracted less FDI than the leader Hungary. However, after the passage of an investment liberalization law in 1998, flows increased markedly. Thus, the ratio of FDI flow to gross fixed capital formation in the country went from 7% in 1997 to 33% in 2000, compared to the 18% average for the CEE region and 22% for the world as a whole. After a decline, the figure stood at 12% in 2003. Similarly, FDI stock as a share of GDP had continuously increased to reach 55% in 2002 and 48% in 2003 from 10% in 1993 (UNCTAD). Thus, in the last years the Czech Republic scores about as highly as Hungary on all the major indicators of FDI presence and flows. It has the most per capita FDI in the region. 80% of inward FDI in the Czech Republic hails from the European Union, with the Netherlands and Germany as the most important investor countries (UNCTAD, “FDI in brief”). Almost half of the FDI is regionally concentrated in Prague (OECD, 2001). In 2003, almost 42% of Czech FDI stocks were in manufacturing (analyzed in this paper), while 47% were in services. Since manufacturing constituted only 26.3% of GDP in 2003, it remains overrepresented in FDI stocks. Just as in other countries of the region, FDI in the Czech Republic has tended to concentrate in several key industries: thus, the biggest single foreign investment was made by the German automobile concern Volkswagen into Škoda works. Consequently, certain industries such as motor vehicles, radio, miscellaneous machinery and equipment and rubber and plastics attract a disproportionate share of FDI (Hunya 2001a).

Foreign direct investment has thus shown itself a potent producer of inequalities, even if it also increases global efficiency. Not only is it divided unequally among industries but it also results in increased inequalities among firms in a given sector. Foreign-owned firms are typically far more productive than their domestic counterparts, and evidence to date shows the gap in performance between domestic- and foreign-owned companies has grown, if anything (UNECE 2001, Zemplinerová 1998). Foreign-owned firms are much more likely to invest, export and to spend on research: thus, if FIEs (foreign investment enterprises) accounted for 27.9% of the equity and 19.6% of the employment of Czech manufacturing in 1998, they furnished 41.6% of total investments and 47% of export sales (Hunya 2001). The most important difference observed between domestic enterprises (DEs) and FIEs both in the Czech Republic and elsewhere in the region is, perhaps unsurprisingly, in capital intensity. In the region in general, it was two to three times higher in FIEs (UNECE 2001, 211), accounting for much of the labor productivity difference. Interestingly, the capital intensity gap widened most in Hungary between 1993 and 1998,
with the ratio of capital intensity in DEs to FIEs passing from 0.56 to 0.31 for total manufacturing (213). This apparently disturbing trend may reflect the fact that with the bulk (70%) of industry sales done by FIEs, DEs assume a subservient position, falling further behind. Since Hungary is the early leader in FDI inflows, the fact that in its economy, domestic firms look to have ceded important ground to foreigners and have not been able to suitably catch up suggests caution in inviting additional FDI flows and lends credence to the hypothesis that past a certain threshold, FIEs may crowd out domestic investment and production. In contrast, the Czech experience has not been as dramatic: the capital intensity gap held steady at 0.7, while the value added per employee gap widened somewhat from 0.66 to 0.54. While these data for total manufacturing mask important differences across branches, it is clear that even if any productivity spillovers occurred to DEs, they failed to match the pace of FIEs’ own productivity growth. Holland et al. (2000) concur in their survey of FDI in the CEE region, writing that most of the net FDI benefit came from intracompany productivity improvements and not from spillovers. A study by a Czech economic think tank speaks of growing duality in Czech manufacturing with the growing productivity gap between foreign- and domestically-owned firms (Newton 2003). They point out that labor productivity is two times higher in FIEs than in DEs, and that gap has grown in 2000-2002 (continuing the aforementioned trend). This finding, if held up, casts doubt on the reality of horizontal spillovers and may spark a reassessment of the extent to which countries ought to encourage FDI inflows.

IV. Models
The literature analyzing FDI spillovers uses variations on the production function theme, either Cobb-Douglas where TFP growth appears as a Solow residual or endogenous where it is modeled more explicitly. Exact characteristics of the model depend on the availability of data (thus, investment per employee has occasionally substituted for missing capital stock information and value added has stood for output when accurate data for materials could not be found) and the researcher’s preferences and goals (controlling for concentration, capital intensity and trade behavior). We will use industry-level models with Value Added in some form as the dependent variable. Due to lack of appropriate data, no attempt is made to differentiate between the performances of foreign- and domestically-owned firms; thus, the question examined is not whether spillovers occur from FDI horizontally, as whether FDI presence encourages productivity growth in an industry as a whole.

The basic model here tests whether lagged FDI stock affects total factor productivity level due to the presence of spillovers. Using the Cobb-Douglas form for the production function and taking the first difference to remove unobserved heterogeneity across industries, as well as dividing value added and capital stock over labor supply (following Bosworth and Collins 2003), we obtain the following form:

\[ \ln\left( \frac{VA_{jt}}{L_{jt}} / \frac{VA_{jt-1}}{L_{jt-1}} \right) = a + b*\ln(\frac{K_{jt}}{L_{jt}} / \frac{K_{jt-1}}{L_{jt-1}}) + c*(FDI_{jt-1} - FDI_{jt-2}) + d*RDDUMMY_{jt} + e*RDDUMMY_{jt}FDI_{jt-1} + f*GAP_{jt} + g*GAP_{jt}FDI_{jt-1}/FDI_{jt-2} + \text{year dummies} \]

where \( j \) is the index for each manufacturing branch, and \( t \) is the indicator for time. \( VA \) is value added, i.e., difference between production and intermediate inputs, \( L \) is employment.
and \( K \) is capital stock. \( \text{FDI}_{i,t} \) is defined as the ratio \( \text{FDI Stock}_{i,t}/K_{i,t} \) and \( \text{RDDUMMY} \) is set at 1 if the industry spends more than 2% of value added on research and development. Thus, model 1 has percentage change in labor productivity as the dependent variable, and percentage change in capital-labor ratio and other parameters as the arguments. The presence of the R&D variable tests for innovative and absorptive roles of R&D spending, although a caveat should be made that the model’s representation of such variables is somewhat crude, in view of the rich literature attempting to specify the correct functional form of the linkage between R&D and productivity (see, for example, Jones (1995) and Jones and Williams (1998)). In the model’s defense, it is not intended to specify the effect of R&D on TFP but rather to test for the significance of R&D as a driver of innovation vs. an aide in absorbing spillovers, following Griffith et al. (2000). This model, along with subsequent ones, imposes common capital coefficients across industries. While that is hardly a realistic assumption, it is justified because we are looking at manufacturing as a whole, and its various branches are interesting only as observations in which various levels of FDI are detected, not for their intrinsic differences in capital intensity (see Griliches and Mairesse (1988) for a technical discussion of production function specification across industries and heterogeneous firms). \( \text{GAP}_j \) is defined as the dummy for whether the ratio of labor productivity in the Czech Republic over its counterpart in Germany in 2002, assumed, yet again, time invariant, is above average. The choice of Germany is motivated by easy availability of data from Eurostat, the fact that its industry is one of the most advanced in the world, and that it is a proximate neighbor and large investor in the Czech Republic. \( \text{GAP}_j \) is set to 1 if the productivity gap is relatively low (below the average for total manufacturing), and zero otherwise. Introducing this variable should help decide whether a low or a high technology gap is conducive to FDI spillovers. It will appear both standing alone and in interaction with FDI. Expected coefficients on both are positive if the Findlay/Griffith thesis holds up. Given that Keller (2001) found 80% of total world R&D in four sectors: chemicals, electrical and non-electrical machinery and transportation, it might be reasonable to follow Keller and Yeaple (2003) and see whether spillovers obtain in those sectors only.

The second model will test whether FDI affects growth and not level of productivity on the assumption that benefits of investment are dispersed in time and cause a spike in growth that is not one-time a year after the initial investment but rather more continuous. Then we obtain:

\[
(2) \ln \left( \frac{VA_{jt}}{L_{jt}} / \frac{VA_{jt-1}}{L_{jt-1}} \right) = a + b \ln \left( \frac{K_{jt}}{L_{jt}} / \frac{K_{jt-1}}{L_{jt-1}} \right) + c \text{FDI}_{jt-1} + d \text{RDDUMMY}_j + e \text{RDDUMMY}_j \times \text{FDI}_{jt-1} + \text{year dummies}
\]

The final model moves away from dividing value added by employment and thus lifts the constant returns to scale assumption. It also uses a rich R&D data set allowing us to test whether lagged R&D spending is significant in a way that a time-invariant propensity to research is not. Additionally, it seeks to include other previously mentioned variables in a comprehensive manner as well as some new ones to obtain:
\[ \ln(\frac{VA_{jt}}{VA_{jt-1}}) = a + b*\ln(\frac{K_{jt}}{K_{jt-1}}) + c*\ln(\frac{L_{jt}}{L_{jt-1}}) + d*(FDI_{jt-1} - FDI_{jt-2}) + e*RD_{jt-1} + f*RDDUMMY_{jt}(FDI_{jt-1} - FDI_{jt-2}) + g*GAP_{jt} + h*GAP_{jt}(FDI_{jt-1} - FDI_{jt-2}) + i*(OPEN_{jt-1} - OPEN_{jt-2}) + j*OPENDUMMY_{jt}(FDI_{jt-1} - FDI_{jt-2}) + k*INTACQDUMMY_{jt}(FDI_{jt-1} - FDI_{jt-2}) \]

where \( RD_{jt} \) is the ratio of R&D spending to Value Added, \( OPEN \) is the imperfect proxy for competitive conditions in an industry expressed as the ratio of exports and imports over value added, and \( INTACQDUMMY = 1 \) if the ratio of intangible fixed assets to total fixed assets in 2002 is above the average for total manufacturing. The latter variable is motivated by the belief that intangible assets may be a better measure of absorptive capacity than R&D spending. The corresponding growth rates specification is:

\[ \ln(\frac{VA_{jt}}{VA_{jt-1}}) = a + b*\ln(\frac{K_{jt}}{K_{jt-1}}) + c*\ln(\frac{L_{jt}}{L_{jt-1}}) + d*FDI_{jt-1} + e*RD_{jt-1} + f*RDDUMMY_{jt}FDI_{jt-1} + g*GAP_{jt} + h*GAP_{jt}FDI_{jt-1} + i*(OPEN_{jt-1} - OPEN_{jt-2}) + j*(OPEN_{jt-1} - OPEN_{jt-2})FDI_{jt-1} + k*INTACQDUMMY_{jt}FDI_{jt-1} \]

V. Data and Empirical Strategy

Data used in this paper come from the following sources: Czech National Bank for FDI, Czech Statistical Office (CSO) for other variables. Some data are taken from Organization for Economic Cooperation and Development (OECD) STAN Industrial Database and Eurostat's New Cronos database for some of them, even though they were originally collected by CSO. Since firm-level data and data distinguishing between DEs and FIEs are not available, we use data disaggregated by branch of manufacturing, with fourteen branches in total. Thus, the central research question is whether FDI presence as measured by the ratio of FDI stock to capital stock has an influence on total factor productivity growth in various industrial sectors.

Different data sources fulfill different functions in the current study. While the main rationale for using them is to verify robustness of whatever findings are obtained on so few years’ worth of observations, they also translate our theoretical variables of interest into empirical terms differently. The first data base, composed of CSO and CNB data, looks at value added divided by employment, that is, labor productivity, as the dependent variable. The second data base, relying on data from the OECD, in contrast breaks it down into capital and labor. Labor is given as employees in full-time equivalents from OECD; capital stock is always represented by total fixed assets from CSO. In both of these data bases, we use FDI stock as percentage of the total fixed assets as the primary independent variable of interest. Because total fixed assets data only extend to 2002, this is effectively the last year of the analysis. Finally, our third database is a combination of Newton data on employment in foreign-owned enterprises as percentage of total employment (a different FDI measure than the ratio of FDI stocks to total fixed assets) and value added deflated data from the Ministry of Industry and Trade (slightly different from values deflated by the author, using CNB sector deflators). Unfortunately, the last database does not include capital stock (leaving us to use the deflated total fixed assets, the mainstay of the study). It also only covers the years 2000-2003.

Fourteen branches of manufacturing, each of which becomes a separate cross-section in the following analysis, are those of the NACE, Rev. 1.1 classification, DA through DN:
**Table 1: Breakdown of Czech Manufacturing**

<table>
<thead>
<tr>
<th>Industry</th>
<th>1998 Foreign Stock % share</th>
<th>2002 Foreign Stock % share</th>
<th>% change in foreign stock share, 1998-2002</th>
<th>% change in share of value added, 1998-2003 (from table 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA</td>
<td>13.6</td>
<td>21.3</td>
<td>56.6</td>
<td>3.18</td>
</tr>
<tr>
<td>DB</td>
<td>10.1</td>
<td>12.8</td>
<td>26.7</td>
<td>-22.92</td>
</tr>
<tr>
<td>DC</td>
<td>1.2</td>
<td>53.1 (9.0 in 2003)</td>
<td>650 (using 2003 data)</td>
<td>-63.39</td>
</tr>
<tr>
<td>DD</td>
<td>6.3</td>
<td>9.3</td>
<td>47.6</td>
<td>18.10</td>
</tr>
<tr>
<td>DE</td>
<td>18.1</td>
<td>28.8</td>
<td>59.1</td>
<td>2.82</td>
</tr>
<tr>
<td>DF</td>
<td>24.5</td>
<td>22.0</td>
<td>-10.2</td>
<td>-51.26</td>
</tr>
<tr>
<td>DG</td>
<td>8.3</td>
<td>21.7</td>
<td>161</td>
<td>-22.10</td>
</tr>
<tr>
<td>DH</td>
<td>18.5</td>
<td>31.5</td>
<td>70.2</td>
<td>11.62</td>
</tr>
<tr>
<td>DI</td>
<td>33.2</td>
<td>36.2</td>
<td>9.0</td>
<td>12.03</td>
</tr>
<tr>
<td>DJ</td>
<td>5.6</td>
<td>14.6</td>
<td>160.7</td>
<td>-12.06</td>
</tr>
<tr>
<td>DK</td>
<td>4.1</td>
<td>15.3</td>
<td>273.1</td>
<td>-8.24</td>
</tr>
<tr>
<td>DL</td>
<td>18.8</td>
<td>31.4</td>
<td>67</td>
<td>19.68</td>
</tr>
<tr>
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<td>20.5</td>
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<td>52.6</td>
<td>40.57</td>
</tr>
<tr>
<td>DN</td>
<td>4.6</td>
<td>13.5</td>
<td>193</td>
<td>1.14</td>
</tr>
</tbody>
</table>

DG – Manufacture of chemicals, chemical products and man-made fiber
DH – Manufacture of rubber and plastic products
DI – Manufacture of other non-metallic mineral products
DJ – Manufacture of basic metals and fabricated metal products
DK – Manufacture of machinery and equipment
DL – Manufacture of electrical and optical equipment
DM – Manufacture of transport equipment
DN – Manufacturing n.e.c. (not otherwise classified)

**Table 2: Shares of Foreign Investment Stock in Total Fixed Assets in Czech Manufacturing**

<table>
<thead>
<tr>
<th>Industry</th>
<th>1998 Foreign Stock % share</th>
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<th>% change in foreign stock share, 1998-2002</th>
<th>% change in share of value added, 1998-2003 (from table 2)</th>
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<td>193</td>
<td>1.14</td>
</tr>
</tbody>
</table>

Source: Czech Statistical Office and author’s calculations
FDI stocks in the Czech Republic are substantial and have progressed in the period under consideration, as Table 3 shows. In 2002 the industry with the smallest FDI presence (9.3% of total fixed assets) was manufacture of wood and wood products, while manufacture of other non-metallic mineral products, rubber and plastics, electrical, optical and transport equipment all attracted sizeable FDI inflows. Thus, the industrial breakdown suggests that the Czech Republic attracted investors not merely by its relatively lower labor costs but also by its developed industries and proximity to the West European markets.

The late 1990s and early 2000s also saw a continuation of the process of industrial restructuring, spurred by the collapse of the old trading relationships within COMECON in the late 1980s. Energy products, chemicals, metals and machinery were on the relative decline, while transport, electrical and optimal equipment as well as wood products progressed (Table 2). Largely, this restructuring went along the trends in evidence earlier in the 1990s (Havlík 2003).

All value added and total fixed assets data are deflated by sector deflators obtained from the Czech National Bank, with July chosen as the reference month. OECD STAN data are only used to run regressions on models (4) and (4’): broadly the same, they have slight differences with regard to value added in different years, perhaps due to application of another computation methodology. The rationale for using the data was to test the robustness of findings to various ways of calculating value added.

### Table 3: Shares of foreign investment stock in total fixed assets in Czech manufacturing

<table>
<thead>
<tr>
<th>Industry</th>
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<td>193</td>
</tr>
</tbody>
</table>

% change in share of value added, 1998-2003 (from table 2)

Source: Czech National Bank, Czech Statistical Office and author’s calculations
VI. Results

A. Czech Statistical Office Data

Descriptive statistics (Table 4) show significant variation in the parameters of interest. Thus, if the mean of DIFFLP (the difference in logs of labor productivity, i.e., the dependent variable) is 0.057075, its minimum is -0.553. Labor productivity in Czech industry grew at the average rate of 5.7% over the period considered, showing a respectable performance. Capital stock average growth was more modest, or 3%. Variation was greater, however, due to the standard deviation equal to that of DIFFLP. The FDI measure’s mean stood at the average of 180 (since it was computed as thousands of Czech crowns of FDI over millions of crowns in capital in that year’s prices, the proper interpretation is that in an average industry at the time considered 18% of the total fixed assets belonged to foreign investors). The standard deviation is almost 106, as we would expect given the differential attractiveness of various industries.

<table>
<thead>
<tr>
<th>Table 4: CSO Sample Descriptive Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>Maximum</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>Std. Dev.</td>
</tr>
<tr>
<td>Observations</td>
</tr>
</tbody>
</table>

In view of the literature and common sense, it is reasonable to ask whether FDI presence is determined by labor productivity and capital intensity. If it is, reverse causality plays an important part in whatever associations of FDI and productivity growth we may discover. However, a Granger causality test returns negative. Thus, the problem does not appear acute. The result accords well with the study by Damijan (2003) finding that investors do not necessarily pick the most productive firms.

Results from regressions 1-3 on the data from CSO show insignificance of FDI in levels and occasional negative significance in growth rates. Interaction variables of FDI with R&D and GAP are insignificant, suggesting that absorptive capacity and technology gap mitigate FDI’s negative impact.

Model 1 does not yield any interesting coefficients: the lagged FDI share does not affect productivity levels. In contrast, the regression run according to model (2) with the White correction for heteroskedasticity of DIFFLP on c, DIFFCAP, FDI(-1) with period fixed effects yields an equation of DIFFLP = 0.079 + 0.42DIFFCAP-0.00002FDI(-1). Thus, lagged FDI ratio may indeed affect productivity growth (Table 5). A 1% increase in the share of foreign assets in total fixed assets then lowers next year’s labor productivity.
growth by .002 percentage points (not percent!) when we control for labor and capital stock changes. R&D and technology gap are not significant in interaction with FDI or independently.

**Graph 1: Mean of LogLabor**

**Table 5: CSO Sample Dependent Variable d(log(Labor Productivity))**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.079862</td>
<td>0.011144</td>
<td>0.0000***</td>
</tr>
<tr>
<td>D(LOG Capital/Labor)</td>
<td>0.417411</td>
<td>0.179803</td>
<td>0.0238**</td>
</tr>
<tr>
<td>FDI(-1)</td>
<td>-0.000222</td>
<td>7.38E-05</td>
<td>0.0039***</td>
</tr>
</tbody>
</table>

Adjusted R-squared is 0.30 and Durbin-Watson (DW) statistic is 2.37 (65 observations)

**B. OECD Data**

Armed with this interesting finding, which lends credence to FDI skeptics, we turn to another data source, OECD’s STAN Industrial Database, to verify the result. Using OECD data, with specific and distinct terms for employment and capital stock (the latter, as well as FDI stocks, come from the CSO because they are not reported by OECD), we relax the formerly implicit assumption of constant returns to scale. Initially, capital and labor do not always appear significant but after addressing autocorrelation by putting in a first autoregressive term, we obtain results remarkably similar to those from the CSO data (Table 6). Including AR(2) raises the adjusted R-squared but reduces the number of observations from an already small number 52 to 38. Nonetheless, the coefficient on FDI(-1) remains slightly negative and becomes significant at the 1% level. When we interact FDI(-1) with dummies supposed to proxy absorptive capacity and technology gap, the result is insignificant. In other words, FDI does not hurt the growth of industries with stronger absorptive capacity measured by acquisition of intangible assets or R&D spending, and with a smaller technology gap. Thus, we find confirmation at the aggregate industrial level of the significance of absorptive capacity and technology gap. However, we still do not see positive coefficients (with the exception of the interaction with GAP, which is significant at the
11% level). Interestingly, however, OPEN should not be used as a measure of absorptive capacity. When we interact FDI variable with the dummy for whether the sum of an industry’s exports and imports over value added exceeds the average for total manufacturing, the coefficient remains negative and significant.

TABLE 6: OECD SAMPLE DEPENDENT VARIABLE d(LOG(VALUE ADDED))

<table>
<thead>
<tr>
<th>OLS AND WHITE CORRECTION FOR HETEROSKEDASTICITY; AR(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>D(LOG(CAPITAL))</td>
</tr>
<tr>
<td>D(LOG(EMPL))</td>
</tr>
<tr>
<td>FDI(-1)</td>
</tr>
<tr>
<td>AR(1)</td>
</tr>
</tbody>
</table>

Adjusted R-squared is 0.44 and DW statistic is 2.44 (52 observations)

Technology gap and first difference in lagged openness to trade are significant and positive determinants of TFP growth. Interestingly, it is these variables, along with FDI, that enable us to get positive and significant coefficients on labor and capital, which are insignificant when they are sole regressors! The fact that technology gap dummy is significant and positive with a value of 0.15 means that already relatively advanced industries progress faster, thus contributing to the duality of the Czech economy. However, in interaction with FDI these variables prove insignificant.

Perhaps, our failure to find clear positive effects of the technology gap on benefits from FDI is due to the dilution of the interaction effects by industries for which the dummies equal 0. After all, we found a positive coefficient on the interaction term with technology gap, suggesting that perhaps more advanced industries indeed benefit from FDI. To test this hypothesis, we estimate the equation dlnVAjt=a + b*dlnKjt + c*dlnLjt + FDIjt (-1) on a sample of eight industries which have below average technology gap (that is, the more advanced manufacturing industries). Unfortunately, the procedure pins down no significant coefficients. The reason for such a conundrum is not immediately clear. One explanation may be that Czech industries are not very widely dispersed in terms of relative productivity. The least productive is manufacture of chemicals, where labor productivity in 2002 stood at 13% of the German level, and the most productive was manufacture of food and tobacco, for which the statistic equals 37%


Finally, we examine the period of 2000-2003, when the Czech economy was out of its 1997-98 recession and FDI stocks reached their highs. The Ministry of Industry and Trade has data in constant prices for value added in 2000-2003 that diverges for some sectors from the data we obtained by deflating the current price data by the sector-specific July deflators. We also use the data on FDI as a share of employment from Newton (2003), a more standard measure of FDI penetration than FDI stock over total fixed assets, but which we have only for 2000-2003. Thus, for a number of reasons, running a regression
with new data seems the best way to confirm once again the robustness of findings that FDI presence does not affect value added levels or growth. For lack of a better statistic, we continue to use deflated total fixed assets from the Czech Statistical Office’s National Accounts as a measure of capital stock. It is obvious that its reliability is questionable due to measurement error and difficulty of estimating capital stock. Moreover, the production function includes a flow of capital (capital utilization), which is only imperfectly represented by the capital stock. Our doubts are only confirmed when we regress the difference in the log of constant-price value added for the 2000-2003 sample on a constant, differences in the logarithms of fixed assets and employment in full time equivalents from OECD, and the coefficient on fixed assets is negative and significant. It is highly unlikely that in the period under consideration more capital utilization reduces value added, so the result is surely spurious. Dropping the fixed assets variable, we regress difference in log of value added on difference in log of employment and the lagged FDI share of employment. In this case, without fixed or random effects, FDI variable is scarcely positive and significant at 10% level (Table 7). It is important to remember that FDI variable here is different from the two previous data bases, rendering coefficients not comparable across data bases. The correct interpretation of the present result is that a 1% increase in share of employment accounted for by foreign-owned firms leads to a 0.002 percentage point increase in subsequent value added growth. The finding probably reflects the fact that foreign investors make their targets more capital-intensive, and thus does not imply any consequences for TFP. More optimistically, it could be interpreted as suggesting a turnaround in FDI influence, consistent with the emphasis some place on temporal effects of FDI. According to this view, initially FDI presence drives out inefficient performers and may have negative net effects on the industry’s productivity due to its competitive pressure. In the medium term, however, it is a positive driver of growth.

**Table 7: 2000-2003 Sample Dependent Variable d(log(value added))**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.036575</td>
<td>0.036385</td>
<td>0.3219</td>
</tr>
<tr>
<td>D(LOG(EMPL))</td>
<td>0.727960</td>
<td>0.272579</td>
<td>0.0115**</td>
</tr>
<tr>
<td>FDI(-1)</td>
<td>0.002078</td>
<td>0.001077</td>
<td>0.0621*</td>
</tr>
</tbody>
</table>

Adjusted R-squared is 0.34 and DW=1.91 (39 observations)

To summarize, the present examination of value added growth in fourteen Czech manufacturing industries between 1997 and 2003 does not support the hypothesis that increased FDI presence at the aggregate level of a certain industry increases either the level or growth rate of the industry’s total factor productivity. This result is robust to the inclusion of multiple measures of absorptive capacity (R&D spending, acquisition of intangible assets in proportion to total fixed assets, and openness) as well as the measure of technology gap (ratio of labor productivity). Considering that past studies for Czech Republic and other countries alike typically find that foreign-owned enterprises are more capital-intensive and more productive, the conclusion from this study suggests that bene-
fits they derive are insufficient to influence the aggregate productivity or outweigh whatever negative consequences may fall on the domestically-owned firms.

VI. Conclusions

FDI has traditionally received attention from economic researchers as one of the potential channels for technology spillovers from advanced countries to developing and transition economies, along with trade and licensing. Theory predicts that a multinational corporation is more likely to share its cutting-edge know-how and technology with its affiliate than license it to a possible competitor. However, the affiliate’s profits are ultimately repatriated to the home country, which limits the utility of the investment to its host country, unless it can expect spillovers to domestic industry. Given the prominent place FDI promotion and openness in general claim in the recommendations of international financial institutions, it is natural that the question of spillovers from FDI interests economists. Results have been modest, so far, and this paper is no exception.

After analyzing value added growth with the use of three somewhat different databases on value added, it is clear that at least in the short period FDI share in an industry’s capital stock does not have a significant effect on the level of either value added or labor productivity. In contrast, lagged share of FDI stock to total fixed assets does have a small but statistically significant negative effect on growth of total factor productivity. Thus, industries with greater stocks of FDI tend to grow slower, controlling for other factors. This finding may not be robust to a different way of measuring FDI, as we saw with the third database; however, capital’s insignificance in that regression makes its results incomparable with others.

Keeping the paper’s results in mind, it is important to remember the nature of data on which this paper bases its analysis. Unlike some similar works, we do not use a database breaking down industries into firms with foreign and domestic ownership. Thus, we examine aggregate evolutions and not the separate paths taken by FIEs and DEs. The result obtained, therefore, may mean that FIEs progress, while DEs regress, or any other combination of outcomes. In this sense, the result is not an exhaustive analysis of the FDI impacts, which is impossible in such a short time frame. However, we found limited support for the hypothesis that a low technology gap and absorptive capacity cushion industries against negative fallout from FDI, and may indeed foster spillovers. More micro-level studies need to further clarify this point, for it is at the level of the firm that most technological learning actually takes place.

Nonetheless, the findings of this paper and others before it leave ample food for thought. An advanced transition economy such as the Czech Republic should theoretically be the ideal case for spillovers. Boasting an advanced industrial infrastructure and a well-educated workforce, while being away from the productivity frontier, the Czech industry should be able to benefit from FDI inflows. Yet, in the aggregate the results so far have been sobering: there is no evidence that FDI benefits the industry as a whole. In fact, other studies (UNECE 2001, Hunya 2001b, Damijan et al. 2001) find evidence for the gradual emergence of a two-track economy in which foreign-owned enterprises benefit while domestic enterprises languish. Indeed, productivity gap between foreign-owned and
domestic firms has not diminished in any CEE country, except Slovenia, which, incidentally, is very cautious about accepting FDI flows. Perhaps, FDI provides other benefits through backward linkages, as Beata S. Javorcik believes, but evidence so far has been modest. It is important to continue research to see whether such benefits are indeed substantial, but that will require further development of micro-data sets and improved accounting on the part of firms as well as fuller records of firm-level input-output relationships. Other promising avenues of research suggested by this paper’s findings are the time path of how FDI presence influences both FIEs and DEs, as well as the question of whether FDI affects total factor productivity or only capital intensity.

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EQUILIBRIA IN GAMES WITH “AUCTION-LIKE” DISCONTINUITIES

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ABSTRACT

A measure-theoretic proof establishes the existence of monotone pure strategy Nash equilibria in first-price auctions with interdependent, multidimensional types when there is uncertainty in bid valuations or the bid valuations depend on either private information of the bidder or seller. This existence result holds in the important case where types are affiliated and the seller’s value of each bid is increasing in some signal of the relevant bidder or some signal of his own; the result is robust to an arbitrary choice of tie-breaking rule, and has particular application outside of standard auction formats to political and legal scenarios, as well as scoring auctions. Other results herein include a limit theorem applying this result to cases where there is no uncertainty in the seller’s bid valuations and a basic structure for multidimensional type testing.

1. Introduction

The literature on first-price auctions, particularly pertaining to the existence of equilibria, is quickly growing. Certainly, the pioneering work of Reny and Zamir (2004), McAdams (2003), and Athey (2001) have shown that under some very weak assumptions, the standard first-price auction possesses a pure strategy Nash equilibrium that is nondecreasing in bidders’ types; that is, it is a monotone equilibrium. However, attention has not been given to situations where there is incomplete information about the assignment rule, that is, the rule that a utility-maximizing seller may use to assign an object to bidders. This is of particular importance in scenarios where the seller might want to construct an optimal mechanism to favor a particular bidder based upon certain desirable properties, for example in the classical mineral rights model where the seller might want to systematically favor more productive bidders. Other cases where this might come into play would be a scenario like a political alliance, where competing interests for a state’s alliance might be weighed differently depending upon various political signals, even in spite of the raw expected value of offers.

One can clearly construct many other examples where understanding the question of
existence of monotone pure strategy Nash equilibria in first-price auctions with uncertainty about bid valuations is important. The result in the following section establishes that under affiliated signals (i.e., signals of both the seller and bidders) and other very general assumptions, first-price auctions with uncertain bid valuations possess monotone pure strategy Nash equilibria; and, though the method of proof first involves proving a familiar single-crossing condition for best-response sets on finite subsets of the bid space, the appropriate choice of finer finite subsets of the bid space yields a sequence of monotone pure strategy Nash equilibria on these finite subsets whose limit is a monotone pure strategy Nash equilibrium of the original auction by a new measure theoretic method which might serve as a useful tool in other problems where uniform tie-breaking rules are used to determine outcomes, though the proof below does not rely upon the fact that the constructed auction has a tie-breaking rule that is uniform.

The following section contains the main proof. As was the case in the examples above, this result was motivated by an interest in modeling alliances. As an aside, notice that use of an analogue to Reny and Zamir’s *individually rational tieless single crossing condition* means that this proof will go through particularly where Athey’s proof breaks down: in cases where bids are not individually rational or ties occur at winning bids. Section 3 gives extensions that apply to cases with no uncertainty in the seller’s valuation of bids and proves a more general monotone existence result for games with ”auction-like” discontinuities. Additionally, it establishes genericity of strictly monotone equilibria among this class of auctions under study and develops a basic theory for multidimensional type hypothesis testing. Section 4 concludes.

2. The Main Result
The structure of the first-price auction with uncertainty in the assignment rule follows. Each bidder \( i = 1, ..., I \) has a signal \( t_i \), and the seller has a signal \( s_D = (s_{1,D}, ..., s_{I,D}) \). Bidders submit bids \( b_i \in \{l \cup [r_i, \infty)\} \) where \( l \) is a common losing bid, and the seller has utility \( u_i(b_i, t) \) which he wishes to maximize in expectation. Hence the winning bid in this auction is defined as

\[
\max_{b_i} h_i(b_i, s_D)
\]

where ties are, for now, broken uniformly among winning bids. Let \( t_{-i} \) denote the types of all bidders not equal to player \( i \), and let the joint type space of bidders be denoted by \( T = \times_{i} T_i \) (with representative element \( t \in T \)), where each \( T_i \) is a compact and convex subset of \( R^n \); also, let \( S_D \), the dictator’s type space, be a compact and convex subset of \( R^{n_0} \). Suppose also that the following assumptions are satisfied for each bidder \( i \in I \):

**Assumption 2.1.**

(i) \( u_i: [r_i, \infty) \times T \to R \) is measurable, \( u_i(b_i, t) \) is bounded in \( t \) for each \( b_i \geq r_i \) and continuous in \( b_i \) for each \( t \).

(ii) There exists \( \bar{b} \geq r_i \) such that \( u_i(b_i, t) < 0 \) for all \( b_i > \bar{b} \) and all \( t \in T \).
(iii) For every $b_i \geq r_i$, $u_i(b_i, t)$ is nondecreasing in $t_{-i}$ and strictly increasing in $t_i$.

(iv) $u_i(\overline{b}_i, t) - u_i(b_i, t)$ is nondecreasing in $t$ whenever $\overline{b}_i \geq b_i \geq r_i$.

**Assumption 2.2.**

(i) The joint density $f_{I,D}(t, s_D)$ is measurable, strictly positive, and continuous on $\{T, S_D\}$.

(ii) $f(t, s_D \land t', s_D') \geq f(t, s_D) f(t', s_D')$ for all $(t, s_D), (t', s_D') \in \{T, S_D\}$

(iii) $h_i(b_i, s_D)$ is strictly increasing in $s_{i,D}$, nonincreasing in $s_{-i,D}$, strictly increasing in $b_i$, and continuous in both variables.

Payoffs for each bidder $i$ will be defined as

$$V_i(b_i, b_{-i} | t_i) = E_{f_{-i,D}}[v_i(a_i, t_i; b_{-i}(T_{-i}), S_D) | T_i = t_i],$$

where $v_i(\cdot)$ is the function that gives bidder $i$ utility $u_i(b_i, t)$ if $i$ wins the auction, and 0 if he loses, where ties are broken uniformly. We now establish the existence of a monotone pure strategy Nash equilibrium in this incomplete information game. The proof is fairly simple and relies upon some of the intuition in Reny and Zamir (2004), henceforth RZ; a key fact is that $u_D(\cdot)$ is increasing in its first variable. We first establish that the multidimensional version of the individually rational tieless-single crossing condition of RZ is satisfied for this game, and begin by defining it.

**Definition 2.1. IRT-ESCC.** A first-price auction satisfies IRT-ESCC if for each bidder $i$ and all pairs of bids $b_i, b'_i \in \mathbb{R}_+$, the following condition is satisfied for all nondecreasing bid functions $b_j$ such that $Pr[l < \max_{j \neq i} h_i(b_j(T_j), S_D) = h_i(b_i, S_D) \text{ or } h_i(b'_i, S_D)] = 0$:

Suppose $V_i(b_i, b_j | t_i) \geq 0$. If $V_i(b'_i, b_{-i} | t_i) \geq V_i(b_i, b_{-i} | t_i)$, then this inequality is maintained when $t_i$ rises if $b'_i > b_i$, while it is maintained when $t_i$ falls if $b'_i < b_i$.

Now we prove that the seller’s auction so defined satisfies IRT-ESCC, a fact which will prove useful in establishing existence of a monotone pure strategy Nash equilibrium.

**Lemma 2.1.** Given the seller’s auction satisfying Assumptions 2.1 and 2.2, IRT-ESCC is satisfied.

**Proof.** To establish IRT-ESCC, fix $\underline{b}_i$ and $\overline{b}_i$, and also fix nondecreasing bid functions $b_j$ for $j \neq i$ such that $Pr[l < \max_{j \neq i} h_i(b_j(T_j), S_D) = h_i(\underline{b}_i, S_D) \text{ or } h_i(\overline{b}_i, S_D)] = 0$.

If $b_i = \underline{b}_i$ or $\overline{b}_i$, then the probability that $b_i$ is among the highest serious bids is equal to the probability that $\underline{b}_i$ is the unique highest bid, and thus serious. Since $f_{T,D} > 0$ and the event that $b_i$ is the unique highest bid depends only upon the others’ signals and $s_D$, this event has positive probability if and only if it has positive probability conditional on every
Let $A$ denote the event that $\overline{b}_i$ is a winning bid. That is,

$$A = \{(t_i, s_D) : \max_{j \neq i} h_j(b_j(t_j), s_D) < h_i(\overline{b}_i, s_D)\}.$$ 

If $b_i$ wins with probability zero, then $V_i(\overline{b}_i, b_i | t_i) = 0$ for every $t_i$. Consequently, IRT-ESCC holds because, by MW Theorem 5, $E(u_i(\overline{b}_i | T) | t_i, A)$ is nondecreasing in $t_i$ whenever $A$ has positive probability. So we can assume that $b_i$ wins with positive probability. Hence $\overline{b}_i$ wins with positive probability and so $A$ has positive probability. Then define

$$A(J) = A \cap \{(t_i, s_D) : \forall j \neq i, h_j(b_j(t_j), s_D) \geq b_i \text{ iff } j \in J\};$$

that is, $A(J)$ is the event that $\overline{b}_i$ loses against precisely those bidders in $J$. Because $A(J) \subseteq A$, $\overline{b}_i$ wins against every $j \neq i$ in each $A(J)$. Note that $A(\emptyset)$, the event that $b_i$ loses to no one, is the event that $\overline{b}_i$ wins the auction and so has positive probability.

Since both $\overline{b}_i$ and $b_i$ win with positive probability and tie maximum of others’ bids with probability zero, IRT-ESCC reduces to the following.

(A.1) $E[u_i(\overline{b}_i, T) - u_i(b_i, T) I_{A(\emptyset)} | A, t_i] \geq 0 \Rightarrow E[u_i(\overline{b}_i, T) - u_i(b_i, T) I_{A(\emptyset)} | A, \overline{t}_i] \geq 0$

when $E[u_i(\overline{b}_i, T) | A, t_i] \geq 0$, and

(A.2) $E[u_i(\overline{b}_i, T) - u_i(b_i, T) I_{A(\emptyset)} | A, \overline{t}_i] \leq 0 \Rightarrow E[u_i(\overline{b}_i, T) - u_i(b_i, T) I_{A(\emptyset)} | A, t_i] \leq 0$

when $E[u_i(b_i, T) | A(\emptyset), \overline{t}_i] \geq 0$.

Now, by MW Theorem 5, $E[u_i(\overline{b}_i, T) | A, t_i] \geq 0$ implies $E[u_i(\overline{b}_i, T) | A, \overline{t}_i] \geq 0$. So if it is also true that $E[u_i(\overline{b}_i, T) I_{A(\emptyset)} | A, \overline{t}_i] < 0$, then (A.1) because the second difference is positive. Hence we only have to show that (A.1) and (A.2) hold when $E[u_i(b_i, T) I_{A(\emptyset)} | A, \overline{t}_i] \geq 0$, or equivalently when $E[u_i(b_i, T) | A(\emptyset), \overline{t}_i] \geq 0$. The following in fact shows that when

$$E[u_i(b_i, T) | A(\emptyset), \overline{t}_i] \geq 0,$$

then

(A.3) $E[u_i(\overline{b}_i, T) - u_i(b_i, T) I_{A(\emptyset)} | A, t_i] \leq E[u_i(\overline{b}_i, T) - u_i(b_i, T) I_{A(\emptyset)} | A, \overline{t}_i]$. 


To show that this is true, we let $\Delta_i(t) = u_i(\bar{b}_i, t) - u_i(\bar{b}_i, t)I_{A(\emptyset)}$, and notice that $\Delta_i(t, t_{-i})$ is nondecreasing in $t_i$. Hence by Lemma A.1 of RZ, it suffices to show that $\Delta_i(\bar{t}_i, \cdot): A \rightarrow \mathbb{R}$ is cellwise nondecreasing with respect to $f(t_{-i} | A, \bar{t}_i)$. Consider the sets \{$A(J)$\} constructed above, and now consider only those $J$ such that $A(J)$ is nonempty.

If $A(J') \geq A(J)$, where the ordering is constructed so that $A(J') \geq A(J)$ if the lower (upper) endpoint of each interval in the product defining $A(J)$ is no greater than the lower (upper) endpoint of the corresponding interval in the product defining $A(J')$, then

$$E[u_i(\bar{b}_i, T) | A(J'), \bar{t}_i] \geq E[u_i(\bar{b}_i, T) | A(J), \bar{t}_i]$$

follows from MW Theorem 5. Furthermore, because every $A(J) \geq A(\emptyset)$,

$$E[u_i(\bar{b}_i, T) | A(J), \bar{t}_i] \geq E[u_i(\bar{b}_i, T) | A(\emptyset), \bar{t}_i] \geq E[u_i(\bar{b}_i, T) - u_i(\bar{b}_i, T) | A(\emptyset), \bar{t}_i],$$

where the first inequality follows from MW Theorem 5 and the second follows because $E[u_i(\bar{b}_i, T) | A(\emptyset), \bar{t}_i] \geq 0$. Hence, $\Delta_i(\bar{t}_i, \cdot)$ is cellwise nondecreasing, and IRT-ESCC is established.

The following definition is necessary before the existence proof.

**Definition 2.2. BR-ESCC.** If $b'_i$ is a best reply for $t_i$ against $b_{-i}$ and $b_i$ is feasible for $t_i$, then the inequality $V_i(b'_i, b_{-i} | t'_i) \geq V_i(b_i, b_{-i} | t'_i)$ holds for all $t'_i > t_i$ if $b'_i > b_i$, while it holds for all $t'_i > t_i$ if $b'_i > b_i$.

If this is satisfied in the case of a finite strategy space, then a multidimensional-type extension of Athey (2001, see Appendix) may be used to establish the existence of a PSNE under the assumption of atomless types (which we have assumed since the joint density $f_{i, D}$ was continuous). The main proof proceeds.

**Theorem 2.1.** There exists a monotone pure strategy Nash equilibrium of the seller’s auction under assumptions 2.1 and 2.2.

**Proof.** Observe that we satisfy IRT-ESCC for this auction by the previous Lemma. Then take a finite set of $M$ bids for each player in the set $B_i$, where each contains the common losing bid $l$. Denote them by $B_i^M$. We assume that $G^M = G^{\frac{1}{2}}$ where we require each bidder to bid $l$ when his signal is in a $\delta$-neighborhood of 0, so that any serious bid submitted by a bidder wins with strictly positive probability. We see that

$$Pr[l < \max_{j \neq i} h_j(b_j(T_j), S_D) = h_i(b_i, S_D)] = 0 \quad (2.1)$$
for all nondecreasing \( b_j \) and \( b_i \) for all players \( i \), after arbitrarily small perturbations of the sets \( B_i^M \) to some new sets \( B_i^{M'} \) which again each contain the common losing bid \( l \). One way to see this is the following.

Consider the function \( h_i(b_j) \) with \( b_j \in B_i^M \), and consider some \( h_j(b_j) \) with \( b_j \in B_j^M \). Observe that \( h_i(b_j) \) is increasing in its first variable. Hence consider some \( \varepsilon > 0 \) and the neighborhood \( B(b_j, \varepsilon) \). Since \( S_D \) is compact and \( h_i(b_j) \) is increasing in its first variable, there are only countably many elements in the set

\[
m_v(b_j, B(b_j, \varepsilon)) = \{ y \in B(b_i, \varepsilon) : m(z \in S_D) \in h_i(y, z) \cap h_j(y, z) > 0 \}.
\]

Hence there is a set \( Y(b_j, b_i, \varepsilon) = B(b_i, \varepsilon) \setminus m_v(b_j, B(b_j, \varepsilon)) \) of full measure in \( B(b_j, \varepsilon) \) such that \( m(z \in S_D) \in h_i(y, z) \cap h_j(y, z) = 0 \), for all \( y \in Y(b_j, b_i, \varepsilon) \). By taking \( B_i^{M'} = B_i^M \), and taking

\[
b'_2 \in \bigcap_{h \in B_i^{M'} \setminus j} Y(b_1, b_2, \varepsilon)
\]

\[
b'_3 \in \bigcap_{i \in \{1, 2\}} \bigcap_{h \in B_i^{M'} \setminus j} Y(b_1, b_3, \varepsilon)
\]

\[
... 
\]

\[
b'_k \in \bigcap_{i \in \{1, 2, \ldots, k-1\}} \bigcap_{h \in B_i^{M'} \setminus j} Y(b_1, b_k, \varepsilon),
\]

we obtain the desired perturbed sets \( B_i^{M'} \) inductively for every bidder \( i \), where \( b'_k \in B_k^{M'} \) is the representative perturbation for \( b_k \in B_k^M \). Notice that we are guaranteed that all of these intersections are nonempty because \( m_v(b_j, B(b_j, \varepsilon)) \) is countable for every \( b_j, b_i \) and \( \varepsilon > 0 \). Additionally, we as mentioned require \( l \in B_i^{M'} \) for every bidder \( i \).

This helps us establish BR-ESCC for this restricted game, and in the following way. Let \( b_i \) denote a feasible bid. Suppose that \( b'_i \) is a best reply for \( t_i \) against the others’ monotone strategy \( b_{-i} \). Then because the bids \( l \) and \( b_i \) are feasible, it must be that

\[
V_i(b_i, b_{-i} \| t_i) \geq \max \{V_i(b'_i, b_{-i} \| t_i), V_i(b_i, b_{-i} \| t_i)\} 
\]

Hence \( b'_i \) is individually rational and (2.1) holds, so that

\[
V_i(b'_i, b_{-i} \| t'_i) \geq V_i(b_i, b_{-i} \| t'_i)
\]
holds for all $s'_i > s_i$ if $b'_i > b_i$, while holding for all $s'_i < s_i$ if $b'_i < b_i$. So BR-ESCC is satisfied for the perturbed game $G^M$ and it possesses a monotone pure strategy Nash equilibrium $b^M$. Letting $M \to \infty$, we can let the appropriately constructed sets $B_i^{M'}$ become dense in the space of all bids for each bidder $i$ because for each $M$, the original sets $B_i^M$ were arbitrary and the sets $B_i^{M'}$, were arbitrarily small $\varepsilon$-perturbations of the sets $B_i^M$.

Because $h_i(\cdot, \cdot)$ is continuous in its first and second variables, we may place the supremum norm on the function space $\{h_i(b_i, \cdot)\}_{b_i \in B_i, i = 1, \ldots, l}$; that is, we may construct the metric

$$\sigma(h_i(b_i, \cdot), h_j(b_j, \cdot)) = \sup_{s_D \in S_D} \left\| h_i(b_j, s_D) - h_i(b_j, s_D) \right\|.$$  

Since all serious bids win with positive probability, and because $l$ is a possible strategy in each $G^M$, each $b_i^M$ is bounded above by $\bar{b}$ in assumption 2.2(ii) and bounded below by $l$. So by Helley’s Selection Theorem we may assume without loss of generality that for every $i$, $b_i^M(t_i) \to b_i'(t_i)$ for a.e. $t_i$, where each $b_i'$ is nondecreasing in $t_i$ and has a countable set of mass points in the compact set $\{h_i(b_i, \cdot)\}_{b_i \in B_i}$ with the above $\sigma$-metric. It will be argued that $b^*$ is a monotone equilibrium of the original game.

Now, we let $\lambda_i(b, b_i, s_D)$ be the probability that $i$ wins when the vector of bids is $(b, b_i)$ and the dictator’s signal is $s_D$. Define

$$H^*_i = \{(t_i, s_D) : \max_{j \neq i} h_j(b^*_i(t_j), s_D) \leq h_i(b^*_i(t_i), s_D)\}$$

and suppose that $Pr(H^*_i \mid t_i) > 0$. Because $h_i(\cdot, \cdot)$ is increasing in $s_i, D$, it follows that $\lambda_i(b, b^*_i(t_i), s_D) = 1$ for a.e. $(t_i, s_D) \in \{H^*_i \mid t_i\}$. Since $\lambda_i(b_i, b^*_i, s_D)$ is nondecreasing in $b_i$ and nonincreasing in $b_i$,

$$\lambda_i(b^M(t), s_D)$$

is a sequence of functions which is monotone in the arguments $t_1, \ldots, t_l$, since it is nondecreasing in $t_i$ and nonincreasing in $t_{-i}$. It is also monotone in $s_D$ because it is nondecreasing in $s_i, D$ and nonincreasing in $s_{-i, D}$; so we may apply Helley’s theorem again so that there exists a function $\alpha_i : T \times S_D \to [0, 1]$ that is nondecreasing in $(t_i, s_i, D)$ and nonincreasing in $(t_{-i}, s_{-i, D})$ where without loss of generality, $\lambda_i(b^M(t), s_D) \to \alpha_i(t, s_D)$ for a.e. $t \in T$ and $s_D \in S_D$. Hence, $\sum_{i \in I} \alpha_i(t, s_D) \leq 1$ for a.e. $t \in T$ and $s_D \in S_D$. The function $\alpha_i(\cdot)$ is the function that RZ call a surrogate tie-breaking rule that would yield continuity of payoffs if it were used at the limit. Now, let
\[ H_i^M = \{ (t_{-i}, s_D) : \max_{j \neq i} h_j(b_j^M(t_j), s_D) \leq h_i(b_j^M(t_i), s_D) \} , \]

and consider some \( t_i \) such that \( Pr(H_i^* \mid t_i) > 0 \). We see that \( H_i^M \) eventually occurs with positive probability for sufficiently large \( M \) given \( t_i \) by continuity of \( h_i(\cdot, \cdot) \) for all \( i = 1, \ldots, I \), and hence for such large enough \( M \),

\[ \lambda_i(b_i^M(t), s_D) = 1 \]

for a.e. \( (t_{-i}, s_D) \in H_i^M \) because \( h_i(\cdot, \cdot) \) is strictly increasing in \( s_{i,D} \). Also, notice that

\[ \lim_M m(H_i^M \Delta H_i^*) = 0 \]

where \( \Delta \) denotes symmetric difference, so that in particular

\[ \lim_M m(H_i^* \setminus H_i^M) = 0 \]

by subadditivity and nonnegativity of measure. Hence for sufficiently large \( M \) there is some subset of arbitrarily small measure in \( H_i^* \) such that \( \lambda_i(b_i^M(t), s_D) \neq 1 \). So define

\[ \Lambda_i^M = \{ (t_{-i}, s_D) \in H_i^* : \lambda_i(b_i^M(t), s_D) = 1 \} , \]

and for for \( \mu > 0 \), choose \( M \) large enough to satisfy

\[ m(H_i^* \setminus \Lambda_i^M) < \mu . \]

Without loss of generality, \( \lambda_i(b_i^m(t), s_D) = 1 \) for all \( m \geq M \) and all \( (t_{-i}, s_D) \in \Lambda_i^M \). Since \( \lambda_i(b_i^m(t), s_D) \rightarrow \alpha_i(t, s_D) \) for a.e. \( t \in T \) and \( s_D \in S_D \), it must then be true that \( \alpha_i(t, S_D) = 1 \) for a.e. \( (t_{-i}, s_D) \in \Lambda_i^M \), for a.e. \( t_i \) such that \( Pr(H_i^* \mid t_i) > 0 \). Assuming that this is some such \( t_i \) where \( \alpha_i(t, S_D) = 1 \) for a.e. \( (t_{-i}, s_D) \in \Lambda_i^M \), letting \( M \rightarrow \infty \) yields

\[ m((t_{-i}, s_D) \in H_i^* : \alpha_i(t, s_D) \neq 1) = 0 , \]

since

\[ \lambda_i(b_i^m(t), s_D) \rightarrow \alpha_i(t, s_D) \] for a.e. \( t_{-i} \in T_{-i} \) and \( s_D \in S_D \) given this \( t_i \).

So \( E[\alpha_i(T, s_D) \mid t_i, H_i^*] = 1 \) for such \( t_i \), hence for a.e. \( t_i \) such that \( Pr(H_i^* \mid t_i) > 0 \). Hence,
given $\emptyset \neq I \subseteq \{1, \ldots, N\}$ and defining
\[
T_i = \{ (t, s_D) : h_i(b_i^*(t), s_D) = \max_j h_j(b_j^*(t), s_D) > l, \forall i \in I \},
\]
we see that if $Pr(T_i) > 0$, then for every $i \in I, \alpha_i(t, s_D) = 1$ for a.e. $(t, s_D) \in T_i$.

But $\sum_{i=1}^{\infty} \alpha_i(t, s_D) \leq 1$ for a.e. $(t, s_D) \in \{T, S_D\}$, so that there must be only one bidder in the set $I$. Hence, the probability that two or more bidders simultaneously submit the highest bid above $l$ when playing $b^*$ is zero. This implies that for every $i$ and a.e. $t_i, V_i(\cdot | t_i)$ is continuous at $(b_i^*(t_i), b_i^*)$, since it is continuous there whenever $b_i^*(t_i) = l$ because $l$ is isolated.

Therefore, $\lim_{n} V_i(b_i^M(t_i), b_i^M | t_i) = V_i(b_i^*(t_i), b_i^* | t_i)$ for a.e. $t_i$. Now, because each $b_j(T_j)$ has at most countably many mass points in the set $\{h_i(b_i, \cdot)\}_{b_i \in B_i}$ endowed with the $\sigma$-metric, it must be true that for every $b \in B_i$, every $\varepsilon > 0$, and a.e. $t_i$, there exists $m \geq 1$ and $\overline{b} \in B_i^{\varepsilon'}$ such that
\[
\lim_{b \downarrow \overline{b}} V_i(b', b_i^* | t_i) \leq V_i(\overline{b}, b_i^* | t_i) + \varepsilon
\]
\[
\leq V_i(\overline{b}, b_i^M | t_i) + 2\varepsilon \text{ for } M \geq m,
\]
\[
\leq V_i(b_i^M(t_i), b_i^M | t_i) + 2\varepsilon \text{ for } M \geq m,
\]
where the first line follows because $\overline{b}$ can be chosen using the argument with the $m_\varepsilon$-sets above so that
\[
Pr[h_j(b_j^*(T_j), S_D) = h_i(\overline{b}, S_D)]
\]
is arbitrarily small and the second line follows because $\overline{b}$ may also be simultaneously chosen by the same argument to make
\[
Pr[h_j(b_j^M(T_j), S_D) = h_i(\overline{b}, S_D)]
\]
arbitrarily small, for every $M$ and $j \neq i$, because a countable union of countably many mass points (here, in the sets $\{h_j(b_j, \cdot)\}_{b_j \in B_j}$ for $j \neq i$) must also be countable. The third
line follows because \( \mathbf{b}^M \) is an equilibrium of \( G^M \) and \( \mathbf{b} \in B_{i'} \) is feasible in \( G^M \) for every \( M \geq m \) because without loss of generality we may assume \( B_{i'} \subset B_{i''} \) if \( M \leq N \) by competing an inductive construction of the eventually dense sets using the \( m_+ \) construction above, so that for example \( B_{i'} \) is constructed to satisfy (2.1) for all elements in the sets \( B_{i'} \), \( j = 2, \ldots, I \), so that \( B_{i'} \subset B_{i''} \) is constructed to satisfy (2.1) for (1) all elements in the sets \( B_{i'} \), for \( j = 3, \ldots, I \) and (2) the set \( B_{i''} \), so that \( B_{i'} \subset B_{i''} \), and so on.

Because \( \varepsilon > 0 \) is arbitrary, as is \( b \) in the above, we obtain the following for every \( i \) and a.e. \( t_i \):

\[
\sup_{b \in B_i} V_i(b, b^*_i \mid t_i) \leq \lim_{M \to \infty} V_i(b^*_i(t_i), b^*_i \mid t_i);
\]

hence

\[
\sup_{b \in B_i} V_i(b, b^*_i \mid t_i) \leq \lim_{M \to \infty} V_i(b^*_i(t_i), b^*_i \mid t_i) = V_i(b^*_i(t_i), b^*_i \mid t_i),
\]

for all \( b \in B_i \), a.e. \( t_i \), and all bidders \( i \). Hence \( \mathbf{b}^* = (b_1^*, \ldots, b_I^*) \) is an equilibrium; this concludes the proof. 

Of course, one can remove uncertainty from the assignment rule (excepting the case of ties) if each \( h_i(b_j, s_D) = h_i(b_j, s_{i,D}) \), for example, where \( h_i(\cdot, \cdot) \) is strictly increasing in \( s_{i,D} \) where we let \( s_{i,D} = t_i \) and \( t_i \) is known to the seller, because the proof still goes through in this setting. But this is truly only evidence of a more general and crucial point: the proof above goes through if we consider many different generalizations of the setup. For example, one might also consider the case where \( h_i \) is defined as

\[
h_i(b_j, s_D, t),
\]

i.e., a scenario where the seller’s assignment rule depends upon the known private information of the bidders, and in fact as long as \( h_i(\cdot, \cdot, \cdot) \) is continuous and strictly increasing in \( s_{i,D} \) as before, the existence result is again clearly not affected because the proof still goes through. Hence, if one looks at this first-price auction as a scoring auction, one can see that this proof also establishes existence of monotone pure strategy Nash equilibria in scoring auctions in the challenging case of multidimensional signals mentioned by Cantillon and Asker without simplification of signal spaces.

A simple example is now provided that demonstrates how the sort of first-price auction constructed for the Theorem above might be strictly optimal for the seller when compared to the standard first-price auction.

**Example 2.1.** We consider a simple case of independent private values where the seller
has an interest in social welfare. Particularly, suppose for simplicity that each bidder has quasilinear utility, and that values are simply equal to types; suppose also that the type space for each $t_i$ is the unit interval $[0, 1]$ and that types are distributed uniformly; but thirdly, suppose that bidder 2 has some multiplier $\alpha$ such that if bidder 2 wins the auction, the social welfare gain associated with that win will be $\alpha t_2$. Also, suppose that an analogous multiplier for bidder 1 is $\alpha_1 = 0$, for simplicity. Suppose then that the seller chooses to enact a uniform tie-breaking assignment rule, which in this simple case is free of uncertainty for bidders, corresponding to her utility where

$$h_i(b_i, t_i) = u_i(b_i, t_i) = b_i + \alpha i t_i;$$

the equilibrium of this auction yields expected utility that is strictly higher for the seller than the equilibrium of the standard first-price auction.

One can see this in the following way. If there are $N = 2$ bidders, then the optimal bid in the standard first-price auction is $\frac{N-1}{N} t_i$, when individual $i$’s type is $t_i$. Hence in this situation expected revenue will be $N$ times the ex ante expected payment of each bidder, which is simply $\frac{N-1}{N^2}$ so that $ER_{fpa} = \frac{N-1}{N}$. Since each bidder wins with probability $\frac{1}{N}$, this means that

$$EU_{fpa} = \frac{N - 1}{N} + \frac{1}{2N} \sum_{i=1}^{N} \alpha_i = 1 + \frac{1}{4} \alpha.$$

Suppose now that the new, modified auction is used. Assuming a strictly increasing and differentiable bid function, one observes without great difficulty that the equilibrium bid functions are

$$b^*_i(x) = \frac{1}{(2\alpha + \alpha^2)x}[1 - \sqrt{(1 - (2\alpha + \alpha^2)x^2}$$

and

$$b^*_2(x) = \left(\frac{x\alpha}{1 + \alpha\frac{1}{2\alpha + \alpha^2}}\right)^\frac{1}{2+\alpha},$$

hence if we consider, for example, the case where $\alpha = .4$, we see that

$$EU_{mfpa} \approx .60245 > .6 = EU_{fpa}.$$
can easily verify, the equilibria in both the first-price auction and the modified first-price auction above are unique.

It makes sense, then, that sellers often appeal to these modified first-price auctions in practice. Certainly, scoring auctions apply here: in particular, consider Cantillon and Asker’s example of $A + B$ comparisons of highway projects, where $A$ might be the cost that a certain company has for completing construction work and $B$ might be the time that it would take the company to finish the project. A recent example that appeared in the article “Bidding War” by James B. Stewart (New Yorker, 2003) is a scenario where a judge auctioned the right to represent Sotheby’s and Christie’s in a civil price-fixing suit and considered “the amount bid...and the reputation of the lawyers.” Another scenario where particularly many examples in human history can be drawn upon would be a situation where a political leader auctions off the right to a political alliance.

One important conclusion that we can draw from looking at this result is that there are three main results at work. The first is the establishment of IRT-ESCC, which relies on affiliation properties and the fact that the highest bid wins. The second is the appropriate creation of the finite bid sets so that the probability of ties is zero for any bids; this depends upon the fact that $h_i(\cdot, \cdot)$ is increasing in its first variable. The third is the measure-theoretic portion of the proof; this relies upon the fact that $h_i(\cdot, \cdot)$ is increasing in $s_{i,D}$ and nonincreasing in $s_{-i,D}$. The properties needed to establish each of these three results are essential to the fundamentals of the argument, and cannot be easily relaxed in these settings.

Perhaps the most convenient part of this analysis is the fact that this form of approximation proof has disjoint pieces that lend so much flexibility to the construction of sufficient assumptions for a particular result. This is of utmost importance in these kinds of games because once a condition like IRT-ESCC is established, it suffices to find the appropriate approximation method with finite sets so that the required continuities emerge at the limit. And in this case, we were dealing with the problem of establishing measure zero intersection of functions $h_i(b_i, \cdot)$ where $b_i$ was drawn from a finite, but eventually dense space of bids. The fundamental point on the approximation method is then that these sorts of functional approximation solutions, devoid of discussion about affiliation properties, are important in incomplete information settings because they are telling us that ties do not matter when uncertainties are smooth. The next section extends this fact to some cases where uncertainties in the functions $h_i$ do not exist.

**III. Extensions**

First, notice that by letting the functions $h_i(\cdot, \cdot)$ converge to $b_i$ in an $L^1$ sense immediately yields the existence result of Reny and Zamir (2004), and in fact, a greater result.

**Theorem 3.1.** Consider a sequence of auctions $\{A_n\}$ as above with identical payoff functions, where value assignments $\{h_i^a(b_i, s_i)\}_{i=1}^n$ satisfy, for all $i \in I$ and all $n$,

$$h_i^a(b_i, s_i) \to h_i^a(b_i), \text{ a.e.}$$
Then without loss of generality, the limiting auction $A^*$ has a monotone pure strategy equilibrium $b^*$ which also does not depend upon the choice of tie-breaking rule.

Proof. Let $b^*_n$ be the equilibrium of $A_n$, and without loss of generality let $b^*_n \rightarrow b^*$ a.e., which can exist by the arguments above because the bid space is without loss of generality compact. Notice, then, that for each $i \in I$ and a.e. $t_i \in T_i$,

$$Pr_{win}(b_n^*(\cdot),\{h_i^n(b_i,s_D)\}_{i \in I} | t_i) \rightarrow Pr_{win}(b^*(\cdot),\{h_i^n(b_i,s_D)\}_{i \in I} | t_i)$$

Hence suppose that there is some set of positive measure $K \subset T_i$ for some $i$ where

$$Pr_{tie}(b^*(\cdot),\{h_i^n(b_i)\}_{i \in I} | t_i) > 0, \forall t_i \in K.$$ 

Then since $h_i^n(b_i,s_D) \rightarrow h_i^*(b_i)$, a.e., we have that for some $N_1$ large enough, there exists some $K_n \subset T_i$, for all $n \geq N_1$, such that

$$Pr_{tie}(b^*(\cdot),\{h_i^n(b_i,s_D)\}_{i \in I} | t_i) > 0, \forall t_i \in K_n.$$ 

Letting each $\{h_i^n(b_i,s_D)\}_{i \in I}$ generate a continuous outcome function

$$Pr_{win}(b(\cdot),\{h_i^n(b_i,s_D)\}_{i \in I} | t_i)$$

in $b(\cdot)$ for each $t_i \in T_i$, we also see that since $b^*_n \rightarrow b^*$ a.e., it must be true that for all $\varepsilon > 0$ there exists an $N_2$ such that, for all $n \geq N_2$,

$$Pr_{win}(b_n^*(\cdot),\{h_i^n(b_i,s_D)\}_{i \in I} | t_i) - Pr_{win}(b^*(\cdot),\{h_i^n(b_i,s_D)\}_{i \in I} | t_i) < \varepsilon,$$

for a.e. $t_i$. Hence choosing $\varepsilon$ to be small enough and letting $\bar{N} = \max\{N_1,N_2\}$, it will be true that, for $n \geq \bar{N}$, there exists some $K'_n \subset K_n$ of positive measure such that

$$Pr_{tie}(b_n^*(\cdot),\{h_i^n(b_i,s_D)\}_{i \in I} | t_i) > 0, \forall t_i \in K'_n.$$ 

Hence this establishes that if $b_n^*$ is an equilibrium where

$$Pr_{tie}(b_n^*(\cdot),\{h_i^n(b_i,s_D)\}_{i \in I} | t_i) = 0, \text{ a.e. } t_i \in T_i, \forall i \in I,$$

then

$$Pr_{tie}(b^*(\cdot),\{h_i^*(b_i)\}_{i \in I} | t_i) = 0, \text{ a.e. } t_i \in T_i, \forall i \in I.$$
Hence the strategy $b^*$ is an equilibrium and has ties occurring with zero probability according to the valuations $\{h_i'(b_i)\}_{i \in I}$, for a.e. $t_i \in T_i, \forall i \in I$. Hence alteration of tie-breaking rules do not affect the fact that $b^*$ is an equilibrium of $A^*$, and the result is proven.

Observe also that we easily have the following simple and broad extension, which was briefly hinted at in the previous section. We first define local variation.

**Definition 3.1.** A map $f : A \times B \rightarrow \mathbb{R}$ satisfies local variation on $A$ if for every $(a, b) \in A \times B$ and $\varepsilon > 0$, there exists some $a' \in A \cap B(a, \varepsilon)$ such that $m(\text{Im}_b f(a', b) \cap \text{Im}_b f(a, b)) = 0$.

We will want the maps $h_i(b, s_D)$ to satisfy local variation on $A = \{[r_i, \infty)\}_{i \in I}$, the set of joint bids, for each $i \in I$. This is stated as an assumption; note that we specify these as maps to admit multi-unit auctions. The relevant assumption follows.

**Assumption 3.1.** $|h_i(b, s_D)| = K$, for all $(b, s_D)$, for each $i \in I$, where $K \in \mathbb{N}$.

This is the assumption that invites multi-unit auctions and multi-dimensional bids. In fact, notice that this finite-dimensional quality of the image of $h_i(\cdot, \cdot)$ is quite important, because it allows us to use continuity of $h_i(\cdot, \cdot)$ in both variables to employ the measure-theoretic portion of the proof. We also make the local variation assumption, now stated.

**Assumption 3.2.** The maps $h_i(b, s_D)$ satisfy local variation, for each $i \in I$.

Two other relevant, albeit slightly repetitive assumptions, now follow before the statement of the theorem.

**Assumption 3.3.**
(i) $u_i : \{x_{i_1}[r_i, \infty)\} \times T \rightarrow \mathbb{R}$ is measurable, $u_i(b, t)$ is bounded in $t$ for each $b \geq (r_i, \ldots, r_i)$ and continuous in $b$ for each $t$.
(ii) There exists $\tilde{b} \geq (r_i, \ldots, r_i)$ such that $u_i(b, t) < 0$ for all $b > \tilde{b}$ and all $t \in T$.
(iii) For every $b \geq (r_i, \ldots, r_i)$, $u_i(b, t)$ is nondecreasing in $t_i$ and strictly increasing in $t_i$.
(iv) $u_i(\tilde{b}, t) - u_i(b, t)$ is nondecreasing in $t$ whenever $\tilde{b} > b \geq (r_i, \ldots, r_i)$.

**Assumption 3.4.**
(i) The joint density $f_{1D}(t, s_D)$ is measurable, strictly positive, and continuous on $(T, S_D)$.
(ii) $f(t, s_D \vee t', s_D') f(t, s_D \wedge t', s_D') \geq f(t, s_D) f(t', s_D')$ for all $(t, s_D), (t', s_D') \in (T, S_D)$. 

(iii) $h_i(b, s_D)$ is strictly increasing in $s_{i,D}$ and continuous in both $b$ and $s_D$.

Notice that the tie-breaking rule is not specified here. The following theorem immediately results, observing that the proof still goes through in this setting.

**Theorem 3.2.** Under the above assumptions, such a “K-auction” has a monotone pure strategy Nash equilibrium.

Notice that under the defined utility functions and assignment rule, it is not necessary that an individual pay her bid, or even win if her bid is highest. Another result is quite immediate, stated as a corollary.

**Corollary 3.1.** Under the assumptions set forth in this section, the equilibrium $b$ of the above auction is generically strictly monotone.

**Proof.** This follows from two basic facts. Let $\mathcal{A}$ denote the set of auctions satisfying the assumptions above. Also, denote

$$\Omega = \{ \mathcal{A} : b^*(\cdot) \text{ is strictly increasing, } \forall i \in I \}.$$ 

Now, define

$$\Lambda = \{ A : u_i(\bar{b}, t) - u_i(b, t) \text{ is strictly increasing in } t, \forall i \in I, \bar{b} > b > (r_1, \ldots, r_j) \}.$$ 

Observe that $\Lambda$ an open set and is obviously dense in the space $\mathcal{A}$, viewed as a metric space when endowed with the norm

$$\|A_1 - A_2\| = \max_{i \in I} \{ \sup_{b_j, t_j} [u_i(b, t) - u_{2i}(b, t)] \}.$$ 

As a result, $\Lambda$ must have full measure. Notice then that for each player $i \in I$, the following is satisfied for every auction in $\Lambda$:

**IRT-SESCC.** A first-price auction satisfies IRT-SESCC if for each bidder $i$ and all pairs of bids $b_i, b'_i \in \mathbb{R}_+$, the following condition is satisfied for all nondecreasing bid functions $b_j$ such that $Pr[l < \max_{j \neq i} h_j(b(T_j), S_D) = h_i(b, S_D) \text{ or } h_i(b', S_D)] = 0$:

Suppose $V_i(b_i, b_j | t_i) \geq 0$. If $V_i(b'_i, b_j | t_i) \geq V_i(b_i, b_j | t_i)$, then this inequality is maintained and becomes strict when $t_i$ rises if $b'_i > b_i$, while it is maintained and becomes strict when $t_i$ falls if $b'_i < b_i$.

This strictness is satisfied for all $b_i$ and $t_i$, in fact, because $f(\cdot) : T \to \mathbb{R}$ has positive
support (notice that the definition of IRT-SESCC differs from the definition of IRT-ESCC by only one strict inequality). Hence, best response sets are not only nondecreasing in the strong set order: in fact, they are now strictly increasing in the strong set order. Hence any monotone pure strategy Nash equilibrium must be strictly increasing. By the theorem, equilibria of this type must exist in this class of games, and hence, the result is established, since $\Lambda \subset \Omega$. 

One can also consider allowing strategic play among the seller(s). Suppose that the seller’s utility is nondecreasing in his type $t_D$ and the payment for the auctioned good(s), where the seller’s price provides a floor for the minimum selling price and there is yet the additional component of uncertainty $s_D$ in the chosen $h_i(\cdot, \cdot)$ (each seller observes his own $s_D$), where again the tie-breaking rule is arbitrary. Under such assumptions, the seller’s strategy is a function $h(\cdot, \cdot) = (t_D)$, and we see that the proof above again goes through, yielding the following result.

When sellers are strategic, there will be a monotone pure strategy Nash equilibrium of the "strategic K-auction".

Notice that with this form of auction, we are effectively dealing with a general market that has a finite number of sellers and buyers. And, using this logic, one can construct the set of K-auction decomposable games, and then use this to establish equilibria for “$\mathcal{X}$-decomposable games.”

There is a greater empirical problem here that deserves study as well. To develop some machinery for such a problem, the following results must be stated at the outset.

**Proposition 3.1.** Any strictly increasing, isotone equilibrium $b^{*}_{i,>}$ of an auction has an inverse $b^{*-1}_{i,>}(b)$ that represents, for each $b$, a continuous path homeomorphic to a subset of dimension $\mathbb{R}^{n_i-1}$, where $\dim(T_i) = n_i$.

**Proof.** See Appendix (Lemma 4.1); any strict isotone equilibrium cannot jump discontinuously, by the arguments therein. 

The following result explains that we may approximate any transitioning distribution over a type set $b^{*-1}_{i,>}(b)$ for some bid $b$ with finite distributions, so that this notion is well-defined, even if the set points in this inverse image is homeomorphic to a set of dimension $\mathbb{R}^{n_i-1}$.

**Proposition 3.2.** Let $r(\cdot): b^{*-1}_{i,>}(b) \to T_i$ be an arbitrary transitioning distribution that is smooth and continuous in $b^{*-1}_{i,>}(b)$ for every bid $b$. Suppose also that $f(\cdot)$, the joint distribution of types, is continuous. Then, given $b^{*-1}_{i,>}(b)$ for some bid $b$, the distribution
exists and is proportional to

$$\lim_n \sum_{i=1}^n r(t_i)$$

where \{t_i\}_{i=1}^\infty is a countable, dense subset of \(b_i^{-1}(b)\).

**Proof.** The result follows in the limit from the continuity properties of \(r(\cdot)\) and \(f(\cdot)\). Hence it is well-defined, and thereby must exist. \(\square\)

Now, an empirical theory for this problem must compensate for the inherent dimensionality difference between the set \(b_i^{-1}(b)\) and the set \(T_i\) (i.e., the image of \(r(\cdot)\)); such an empirical theory is now constructed. Suppose that a sequence of equivalent auctions \(\{A_n\}_{n=0}^\infty\) were observed with certain strictly isotone equilibrium bids \(b_n^*\) being played. Let \(\gamma_{i,n} = b_{n,i,>}(b)\) be the set of potential types for player \(i\) given bid \(b\) in auction \(A_n\), for shorthand. Let

\[
B(\gamma_{i,n}, \delta_n) = \{t' \in T_i \mid \|t - t'\| < \delta_n, \text{ for some } t \in \gamma_{i,n}\}.
\]

Also, taking \(t \in \gamma_{i,0}\), for \(\varepsilon > 0\) let

\[
B_0(t, \varepsilon) = \{t' \in B(\gamma_{i,0}, \delta_0) \mid \|t - t'\| < \varepsilon\}.
\]

Then, notice that by Bayes’ rule, letting the statement “\(\gamma_{i,n} \in B(\gamma_{i,n}, \delta_n)\)” be denoted by \(\gamma_n'\) for shorthand,

\[
P[t \in B_0(t, \varepsilon) \mid \gamma_0', \gamma_1', \gamma_2', ..., \gamma_n'] = \frac{P[t \in B_0(t, \varepsilon)] \prod_{k=0}^{n} P[\gamma_k' \mid \gamma_0', \gamma_1', \gamma_2', ..., \gamma_{k-1}, t \in B_0(t, \varepsilon)]}{P[\gamma_1', \gamma_2', ..., \gamma_n']}.
\]

We clearly need to specify \(B(\gamma_{i,n}, \delta_n)\), particularly for the case where \(r(\cdot)\) is a smooth distribution. This probability gives us a sequence of test statistics \(\{c_0, c_1, ..., \}\) by letting \(\sup_n \delta_n \rightarrow 0\), and when accompanied by such an \(r(\cdot)\) yields a formal hypothesis testing theory.
IV. Conclusions
So we have seen that these methods give rise to an existence theory, a characterization theory, and an estimation theory. Furthermore, the results apply to a broad range of auctions which do not restrict attention to simply the class of first-price auctions with uniform tie-breaking rules. The fact that this theory is robust to making the seller(s) strategic also tells us that this gives a useful theory on equilibria in general markets with uncertainty in the assignment rule, and in the limit, without it. Further research would seemingly constitute a core theory on this topic, an area not well understood.

V. Appendix
This Appendix provides the multidimensional analogue to Athey (2001) necessary to establish existence of monotone pure strategy Nash equilibria on the finite bid sets constructed in the proof of the main result. Consider a game of incomplete information where each player \( i \)'s type distribution is a compact, convex set \( T_i \subset \mathbb{R}^n \). Suppose that the set of actions is a finite set \( A_i = \{A_i, \ldots, A_m \} \subset \mathbb{R} \) for each player \( i \). A few definitions are first presented.

**Definition 5.1.** Consider elements \( x \in \mathbb{R} \) and \( \theta \in \mathbb{R}^n \). The function \( h: \mathbb{R}^{n+1} \rightarrow \mathbb{R} \) satisfies the extended single crossing property of incremental returns (ESCP-IR) if, for all \( x_H > x_L \) and \( \theta_H > \theta_L \), \( h(x_H, \theta_L) - h(x_L, \theta_L) \geq (>)0 \) implies that \( h(x_H, \theta_H) - h(x_L, \theta_H) \geq (>)0 \).

Also, we present the definition of the strong set order, which will become important later when we consider the structure of best-response sets in these games.

**Definition 5.2.** A set \( A \subset \mathbb{R} \) is greater than a set \( B \subset \mathbb{R} \) in the strong set order, written \( A \succeq_s B \), if, for any \( a \in A \) and any \( b \in B \), \( \max(a,b) \in A \) and \( \min(a,b) \in B \). If \( K \) is a partially ordered set, a set-valued function \( A: K \rightarrow 2^\mathbb{R} \) is nondecreasing in the strong set order if for any \( \kappa_H > \kappa_L \), \( A(\kappa_H) \succeq_s A(\kappa_L) \).

The set-valued function we will analyze will be, as you might guess, best-response sets. Suppose for these games that the multidimensional analogue to the SCC of Susan Athey holds. This is defined as:

**Definition 5.3.** The Extended Single Crossing Condition for games of incomplete information (ESCC) is satisfied if for each \( i = 1, \ldots, I \), whenever every opponent \( j \neq i \) uses a strategy \( \alpha_j: T_i \rightarrow A_i \) that is nondecreasing, player \( i \)'s objective function, \( v_i(a_i, t_i; \alpha_{-i}(\cdot)) \), satisfies extended single crossing of incremental returns (ESCP-IR) in \( (a_i; t_i) \).

The ESCC implies that in response to nondecreasing strategies by all opponents, each player’s best-response correspondence is nondecreasing in the strong set order, which implies that there exists some nondecreasing best-response strategy, though it clearly does not imply that all best-response strategies need to be nondecreasing. For the remainder of the paper, let
\[ V_i(a_i, \alpha_{-i} | t_i) = E[v_i(a_i, t_i; \alpha_{-i}(\cdot)) | T_i = t_i] \]

denote player i's ex-ante expected payoff at ai given the signal ti. In particular, notice that the ESCC implies that \( V_i(a_i, \alpha_{-i} | t_i) \) satisfies the ESCP-IR in \((a_i; t_i)\). We make one distributional assumption before proceeding with establishing the main result of the paper.

**Assumption 5.1.** The joint distribution of types, denote it \( f : T = \times_{i=1}^I T_i :\to \mathbb{R} \), is atomless.

Let the set of nondecreasing (also called monotone) strategies for player i in this game be denoted by \( X_i \), where payoffs will be determined by \( V_i(a_i, \alpha_{-i} | t_i) \). To establish that there is a pure strategy Nash equilibrium (PSNE) where all strategies are nondecreasing, it suffices by ESCC to show that there exists a PSNE if players restrict attention to \( X = \times_{i=1}^I X_i \), the set of nondecreasing pure strategies, because ESCC guarantees that in response to nondecreasing strategies by all opponents, there exists some nondecreasing best-response strategy if payoffs are determined by \( V_i(a_i, \alpha_{-i} | t_i) \). It must be noted here that to prove this result about equilibria, we assume that players are maximizing ex ante expected utility.

We will prove this result using the Glicksberg-Fan Fixed Point Theorem, but in a particular way. It is important to decide how we should do this because proving the theorem depends first upon the topology given to the space \( X \) and second upon the operation used to determine convex combinations of strategies. A more delicate construction of this space is required than in previous results because type spaces are multidimensional. First, we present a basic fact about the elements of \( X_i \). Let \( \bar{t}_i \in T_i \) be the unique least upperbound in the set \( T_i \). Since \( T_i \) is a compact and convex subset of \( \mathbb{R}^{n_i} \), it can be written as a union of vectors beginning at \( \bar{t}_i \) and ending at another boundary point of \( T_i \). Another special property of monotone strategies can now be established, after letting \( \beta_i(\bar{t}_i) \) be this set of vectors.

**Lemma 5.1.** Any strategy \( \alpha_i \in X_i \) can be represented by a set \( x_i \) of \( n_i - 1 \) continuous “jump surfaces” in the space \( T_i \subset \mathbb{R}^{n_i} \).

**Proof.** Consider a strategy \( \alpha_i \in X_i \) and an element \( b \in \beta_i(\bar{t}_i) \). We see that along this vector \( b \) there must be \( n_i - 1 \) jump points for \( \alpha_i \) which can fully represent \( \alpha_i \) when attention is restricted to this vector \( b \) because the elements of \( b \) are totally ordered and \( \alpha_i \) is nondecreasing. Now, consider the \( m \)th jump point (between strategies \( A_m \) and \( A_{m+1} \)) for a sequence of vectors \( b_n \) with limit \( b^* \) (where vector convergence is determined by convergence in angular distance between vectors), and call these jump points \( z_{mn} \) for each \( b_n \). Suppose that \( z_{mn} \to z_m^* \), where we consider convergence in the usual Euclidean norm for...
the sequence \( \{z_{mn}\} \). Then since the elements of \( b^* \) are totally ordered, we can assume without loss of generality that there is some \( z \) such that \( z_m^* < z = \liminf z_{mn} \). But then this implies that for \( n \) large enough, \( z_{mn} > z_m^* + 2\tilde{e} \) for some vector \( \tilde{e} > 0 \), which in turn implies that there is some \( t \) along \( b_n \) for such \( n \) with \( \|t - z_{mn}\| < \epsilon \) and \( t < z_{mn} \) so that \( A_k \) is played for some \( k \leq m \) at \( t \). But by definition \( t > z_m^* + \tilde{e} \), and hence there exists some \( t' \) along \( b^* \) such that \( t > t' > z_m^* \) so that \( A_{m+1} \) is played at \( t' \). Hence \( \alpha_i \) is decreasing in the set \( \{t \cup t'\} \); this is an immediate contradiction because \( \alpha_i \) was assumed to be a nondecreasing strategy.

Observe also that on \( b \in \beta_i(\vec{t}) \) there is one and only one jump point for \( \alpha_i \) from \( A_m \) to \( A_{m+1} \), for each \( m = 1, \ldots, n_i - 1 \). Denote this jump point for each \( m = 1, \ldots, n_i - 1 \) by \( f_{\alpha_{im}}(b). \)

Hence for each \( m \) the function \( f_{\alpha_{im}}(b) : \beta_i(\vec{t}) \to \mathbb{R}^{n_i} \) is a continuous function mapping each vector \( b \in \beta_i(\vec{t}) \) to exactly one point on \( b \). Therefore, this continuous function forms a surface in \( \mathbb{R}^{n_i} \), which was what we wanted. \( \square \)

We assume the path representation of elements in \( X_i \) from this point onward, and denote an arbitrary element in \( X_i \) by \( x_i \).

**Lemma 5.2.** Consider a strategy \( x_i \in X_i \); let the jump surface between actions \( A_m \) and \( A_{m+1} \) be denoted by \( x_{im} \), and consider some \( b \in \beta_i(\vec{t}) \). Then there exists a unique point \( t(x_{im}, b) = x_{im} \cap b \).

This follows directly from the fact that the elements on such a \( b \in \beta_i(\vec{t}) \) are totally ordered. The elements of \( \beta_i(\vec{t}) \) give us a useful way of taking convex combinations of strategies in \( X_i \).

**Definition 5.4.** Consider \( x_i, y_i \in X_i \), and let \( \lambda \in (0,1) \). Define, for each \( m = 1, \ldots, n_i - 1 \),

\[
\lambda \circ x_{im} \oplus (1-\lambda) \circ y_{im} = \bigcup_{b \in \beta_i(\vec{t})} (\lambda \cdot t(x_{im}, b) + (1-\lambda) \cdot t(y_{im}, b))
\]

where \( \cdot \) denotes the usual scalar multiplication in \( \mathbb{R}^{n_i} \).

It is easy to verify that, when so defined, \( x_i = \lambda \circ x_i \oplus (1-\lambda) \circ y_i = (\lambda \circ x_i \oplus (1-\lambda) \circ y_i, \ldots, \lambda \circ x_{i(n-1)} \oplus (1-\lambda) \circ y_{i(n-1)}) \in X_i \), so that \( X_i \) is convex under this operation. One can show (see the Appendix) that this operation is simply scalar multiplication and addition in a vector space \( \mathcal{V}_i(\vec{t}) \) where \( X_i \subset \mathcal{V}(\vec{t}) \); the elements of \( \mathcal{V}_i(\vec{t}) \) are basically cross-products of appropriately ordered \( n_i - 1 \) tuples of continuous surfaces.
We now define the metric that will determine the appropriate topology for the space $\mathcal{V}(\mathbf{t})$.

**Definition 5.5.** Consider $\mathbf{x}, \mathbf{y}, \in \mathbf{X}$. Define $\rho : \mathbf{X} \times \mathbf{X} \to \mathbb{R}$ by

$$\rho(\mathbf{x}, \mathbf{y}) = \max_{m \in 1, \ldots, n_i - 1} \{ \sup_{b \in \beta_i(\mathbf{t})} | t(\mathbf{x}_m, b) - t(\mathbf{y}_m, b) | \}.$$ 

One can easily verify that this is a metric, and that in fact $\mathbf{X}$ is compact under this metric. This metric, combined with the convexity operation above, can be used to make the vector space $\mathcal{V}(\mathbf{t})$ a *convex Hausdorff linear topological space*, which allows us to use the Glicksberg-Fan Fixed Point Theorem below. For simplicity of notation we will call $\mathcal{V}(\mathbf{t})$ the *ray space* for the point $\mathbf{t}$.

**Construction of the ray topological vector space.** We will now construct the the ray space $\mathcal{V}(\mathbf{t})$ for the element $\mathbf{t} \in \mathbb{R}^n$. Define $A(t) = \{ z \in \mathbb{R}^n \mid z > t \}$ where $>$ denotes the usual partial order in $\mathbb{R}^n$ and also define $B(t) = \{ z \in \mathbb{R}^n \mid z < t \}$.

We will first construct the set of elements which comprise the ray space for $\mathbf{t}$. Let $\beta_i(\mathbf{t})$ denote the set of lines in $\mathbb{R}^{n_i}$ passing through $\mathbf{t}$ and contained in $A(\mathbf{t}) \cup B(\mathbf{t}) \cup \mathbf{t}$. Let $\mathcal{Z}_i$ denote the set of continuous surfaces in $\mathbb{R}^{n_i}$, and let $\mathcal{Y}_i = \mathcal{Z}_i \cap A(\mathbf{t}) \cup B(\mathbf{t}) \cup \mathbf{t}$ be the restriction of these surfaces to the set $A(\mathbf{t}) \cup B(\mathbf{t}) \cup \mathbf{t}$.

Let $\mathcal{W}_i$ with representative element $\mathbf{w}$ be the set of these surfaces such that there is a unique element $t(\mathbf{w}, b) = \mathbf{w} \cap \mathbf{b}$ for each $\mathbf{b} \in \beta_i(\mathbf{t})$. Let $\mathcal{V}_i(\mathbf{t})$ be the set of $n_i - 1$ tuples of elements of $\mathcal{W}_i$ with representative element $(\mathbf{w}_1, \ldots, \mathbf{w}_{m-1})$ such that $t(\mathbf{w}_m, \mathbf{b}) \leq t(\mathbf{w}_{m+1}, \mathbf{b})$ for all $\mathbf{b} \in \beta_i(\mathbf{t})$, and $m = 1, \ldots, n_i - 2$.

**Definition 5.6.** Define addition in this space to follow the rule (for $m = 1, \ldots, n_i - 1$)

$$\mathbf{x}_m \oplus \mathbf{y}_m = \bigcup_{b \in \beta_i(\mathbf{t})} (t(\mathbf{x}_m, b) + t(\mathbf{y}_m, b))$$

where $+$ denotes vector addition in $\mathbb{R}^{n_i}$.

**Definition 5.7.** Define scalar multiplication in this space to follow the rule (for $m = 1, \ldots, n_i - 1$)

$$\alpha \circ \mathbf{x}_m = \bigcup_{b \in \beta_i(\mathbf{t})} (\alpha \cdot t(\mathbf{x}_m, b))$$

where $\cdot$ denotes the usual scalar multiplication in $\mathbb{R}^{n_i}$.
With $\mathbf{x} \oplus \mathbf{y} = (x_1 \oplus y_1, \ldots, x_{n-1} \oplus y_{n-1})$ and $\alpha \circ \mathbf{x} = (\alpha \circ x_1, \ldots, \alpha \circ x_{n-1})$, we see that the space $\mathcal{V}_i(t_i)$ forms a vector space.

Now we define the topology of $\mathcal{V}_i(t_i)$ in the sensible way.

**Definition 5.8.** Consider $\mathbf{x}, \mathbf{y} \in \mathcal{V}_i(t_i)$. Define $\rho : \mathcal{V}_i(t_i) \times \mathcal{V}_i(t_i) \to \mathbb{R}$ by

$$\rho(\mathbf{x}, \mathbf{y}) = \max_{m \in 1, \ldots, n-1} \left\{ \sup_{b \in \beta_i(t_i)} |t(x_m, b) - t(y_m, b)| \right\}.$$ 

Under this formulation, $\mathcal{V}_i(t_i)$ forms a convex Hausdorff linear topological space with the metric $\rho(\cdot, \cdot)$; hence we can use the Glicksberg-Fan Fixed Point Theorem as stated.

Now, for a strategy $\mathbf{x} \in \mathbf{X}$ and $t_i \in T_i$, let $R_i(\mathbf{x})$ denote the set of player $i$’s best responses to her opponents’ joint strategy $\mathbf{x}_{-i}$. We have already observed that to establish the existence of a PSNE in the original incomplete information game, it must simply be shown that there exists a PSNE of the game if we restrict our attention to strategies in $\mathbf{X}$. So for ease of reading we present the Glicksberg-Fan Fixed Point Theorem, which will be used to establish this restricted result:

**Theorem 5.1.** (Glicksberg-Fan, 1952) Let $X$ be a compact and convex subset of a convex Hausdorff linear topological space $\mathcal{V}$, and suppose that the set-valued map $R : X \to 2^X$ is convex-valued and has a closed graph. Then $R$ has a fixed point, that is, there is some $\mathbf{x} \in X$ such that $\mathbf{x} \in R(\mathbf{x})$.

For our purposes we will have $\mathcal{V} = \bigtimes_{i=1}^l \mathcal{V}_i(t_i), X = \mathbf{X}$ and $R(\mathbf{x}) = \bigtimes_{i=1}^l R_i(\mathbf{x})$. So now it suffices to show that $R$ is convex-valued and has a closed graph.

**Lemma 5.3.** $R$ is convex-valued.

**Proof.** Pick an arbitrary player $i$, and let $\mathbf{y}_i, \mathbf{w}_i \in R(\mathbf{x})$. Also, let

$$a_i^*(a_i, t_i \mid \mathbf{x}) = \arg \max_{a_i \in A_i} V_i(a_i, t_i \mid \mathbf{x}),$$

so that $a_i^*(\cdot \mid \mathbf{x})$ is nondecreasing in the strong set order by ESCC.

Consider $\mathbf{z}_i = \lambda \mathbf{y}_i + (1 - \lambda) \mathbf{w}_i$ for $\lambda \in (0, 1)$. Since the type distribution is atomless, it suffices to show that $A_m$ is optimal for every $t_i \in T_i$ such that, for some $b \in \beta_i$, $t_i > t(\mathbf{z}_i, b)$ but $t_i < t(\mathbf{z}_i, b)$, $b$ is optimal. Observe now that there is some $A_k \in a_i^*(\mathbf{x}, t_i)$ by finiteness of $A_i$.

By the choice of $t_i$, it must be true that either $t(\mathbf{y}_i, b) \neq t(\mathbf{y}_{i+1}, b)$ or $t(\mathbf{w}_i, b) \neq t(\mathbf{w}_{i+1}, b)$. Without loss of generality, suppose that $t(\mathbf{y}_i, b) \neq t(\mathbf{y}_{i+1}, b)$, so
that $t(y_{im}, b) < t(y_{i(m+1)}, b)$. From this point onward, since $b$ is fixed we will let $y_m = t(y_{im}, b), y_{m+1} = t(y_{i(m+1)}, b), w_m = t(w_{im}, b)$ and $w_{m+1} = t(w_{i(m+1)}, b)$. The remainder of the proof follows from Athey’s (2001) Lemma 2 because $a^*_i(\cdot | l x)$ is nondecreasing in the strong set order along the vector $b$. \hfill \Box

Now we must establish closure of the graph of $R$.

**Lemma 5.4.** $R$ has a closed graph.

**Proof.** Observe that since the type distribution is atomless, it follows that $V_i(a_i, x \mid t_i)$ is continuous in the elements of $X$. So consider $(x^k, x^k) \rightarrow (x, y)$ where $y^k \in R(x^k)$ for all $k$. Consider player $i$, and a type $t_i \in T_i$ such that for some $m$ in $1, \ldots, n_i - 1$, $t_i > t(y_m, b)$ but $t_i < t(y_{i(m+1)}, b)$.

Since $y^k_i$ converges to $y_i$, by definition of $\rho(\cdot, \cdot)$ there must be some $K$ such that, for all $k > K, t_i > t(y^k_m, b)$ but $t_i < t(y^k_{i(m+1)}, b)$. Hence $A_m$ is one of $t_i$’s best responses to $x^k$. Because $V_i(a_i, x \mid t_i)$ is continuous in the elements of $X, V_i(A_m, x^k \mid t_i) \geq V_i(A_{m'}, x^k \mid t_i)$ for all $k > K$ and all $m'$ implies that $V_i(A_m, x \mid t_i) \geq V_i(A_{m'}, x \mid t_i)$. \hfill \Box

Hence $R$ satisfies the requirements of the Glicksberg-Fan Fixed Point Theorem, and it then easily follows that there is some $x \in X$ such that $x \in R(x)$. So there is a monotone PSNE of the game restricted to $X$, and hence by ESCC a monotone PSNE of the original game. Noting that in fact it is only BR-ESCC that is needed in this proof when given atomless types, we state the full proven result.

**Theorem 5.2.** Under the assumption of atomless types and BR-ESCC, there exists a monotone PSNE of this game of incomplete information.

As an aside, this theorem would also apply to supermodular games and log-supermodular games.

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**References**


APPENDICES

Carroll Round Proceedings
**APPENDIX A: Fourth Annual Carroll Round Presentation Schedule**

**Session 1A** Chair: Holger C. Wolf (Associate Professor, Georgetown University)
Jonathan Kirschner (Georgetown University)
**A Steady Rain: The Impact of Migrant Remittances on Economic Development**
Ana Maria Romero (Illinois Wesleyan University)
**Comparative Study: Factors that Affect Foreign Currency Reserves in China and India**
Nathan Saperia (Dartmouth College)
**Deposit Insurance and Underlying Banking Sector Regulation: Does Deposit Insurance Cause Banking Crises?**

**Session 1B** Chair: Anders F. Olofsgard (Assistant Professor, Georgetown University)
Bogdan Tereshchenko (Georgetown University)
**Waiting for Godot? Revisiting Productivity Spillovers from FDI in Czech Crises?**
Katharine Mullock (University of Western Ontario)
**The Role of Democracy in Famine Prevention**
David Rogier (Washington University)
**Retaliatory Tariffs: Electoral Punishments**

**Session 1C** Chair: Anna Maria Mayda (Assistant Professor, Georgetown University)
Jasmina Beganovic (Georgetown University)
**Evaluating the Effects of FDI in the Croatian Financial Sector**
Kevin Goldstein (Dartmouth College)
**The Unemployed Terrorist: Another Look at the Relationship Between Economics and Terrorism**
Ee Cheng Ong (Wellesley College)
**Do Capital Controls Protect Crony Capitalism?**

**Session 2A** Chair: Douglas M. Brown (Associate Professor, Georgetown University)
James Liao (Dartmouth College)
**Corruption and its Effects on Total, Horizontal, and Vertical FDI: U.S. Affiliate Sales Data Evidence**
Jose Mustre del Rio (Ohio State University)
**The Social Capital Effect on Economic Growth**

**Session 2B** Chair: Arik M. Levinson (Associate Professor, Georgetown University)
Xun Bian (Illinois Wesleyan University)
**Predicting Olympic Medal Counts: The Effects of Economic Development on Olympic Growth**
Tom Vogl (Princeton University)
**Effects of Land Titling on Child Nutrition: Evidence from Lima, Peru**

**Session 2C** Chair: Robert Cumby (Professor, Georgetown University)
Leah Nelson (Georgetown University)
**Do Micro-credit Programs Lead to Female Empowerment? An Empirical Study of Pipelining and Micro-credit Program Participation**
Shiying Lee (Duke University)
**Financial Market Development: Sequencing of Financial Liberalization and Regulatory Governance Reform**

**Session 3A** Chair: Chris Griffin (Carroll Round Founder, Yale University)
Suzanne Zurkiya (Emory University)
**The Interaction of Economic Efficiency, Economic Growth, and Islamic Economic Practices**
Matthew Phan (Columbia University)
**Technological Catch-Up in the Indian Biopharmaceutical Industry, 1970-2005**
Session 3B Chair: Arik M. Levinson  
(Associate Professor, Georgetown University)  
Lidia Barabash (Dartmouth College)  
*The Effects of Market Reform in Post-Soviet Central and Eastern European Countries: Did Intensive Reformers Continue to Enjoy Positive Economic Growth 1995-1999?*  
Nina Rendelstein (Washington University)  
*Will Educating Women Reduce Civil War?*

Session 3C Chair: Maurice Obstfeld (Class of 1958 Professor, University of California at Berkeley)  
Wee Lee Loh (Cornell University)  
*Using Spatial Dependence to Characterize Productivity Growth: Evidence from Singapore Manufacturing Industries*  
Michael Furchtgott (Columbia University)  
*Price Uncertainty, Investment, and the Natural Resource ‘Curse’ Hypothesis*

Session 4A Chair: Susan Vroman (Professor, Georgetown University)  
Jonathan Wolfson (Washington University)  
*Does Tort Reform Increase Minority Access to Medical Care?*  
Michael Gechter (Pomona College)  
*Examining the Sex Ratio in Pakistan*  
Michael Insel (Claremont McKenna College)  
*Prenatal and Postnatal Gender Bias in Pakistan: Substitutes or Complements?*

Session 4B Chair: James Albrecht (Professor, Georgetown University)  
Olga Timoshenko (University of Western Ontario)  
*Trade Liberalization and Highly Regulated Economies: The Mechanism through Which Government Intervention Influences Growth*  
Kenneth Ward (University of Chicago)  
*Equilibria in Games with “Auction-Like” Discontinuities*  
Brian Lichter (Washington University in St. Louis)  
*Taking Bribes: The Politics of Transnational Hostage Negotiation*

Session 4C Chair: William Easterly (Professor, New York University)  
Michael Haase (University of Copenhagen)  
*Terms of Trade Volatility and Investments: Why Does Volatility Reduce Investments in Developing Countries?*  
Alice Luo (Duke University)  
*Recent Currency Crises in Context: Do Past Indicators Still Apply?*  
Dennis Huggins (Georgetown University)  
*An Empiric Investigation into the Relationship between Capital Controls and Foreign Direct Investment Inflow*
APPENDIX B: Past Speakers

First Annual Carroll Round (April 5-7, 2002)

Roger W. Ferguson, Federal Reserve Board of Governors
Donald L. Kohn, Federal Reserve Board of Governors
Lawrence B. Lindsey, Assistant to the President and National Economic Council
Edwin M. Truman, Institute for International Economics
John Williamson, Institute for International Economics

Second Annual Carroll Round (April 11-13, 2003)

R. Glenn Hubbard, Council of Economic Advisers and Columbia University
Donald L. Kohn, Federal Reserve Board of Governors
John Williamson, Institute for International Economics

Third Annual Carroll Round (April 15-18, 2004)

Donald L. Kohn, Federal Reserve Board of Governors
John F. Nash, Jr., Princeton University (1994 Nobel Laureate)
Peter R. Orszag, The Brookings Institution

Fourth Annual Carroll Round (April 22-24, 2005)

Ben S. Bernanke, Federal Reserve Board of Governors
William Easterly, New York University
Maurice Obstfeld, University of California at Berkeley
Edwin M. Truman, Institute for International Economics
APPENDIX C: Former Carroll Round Steering Committees

First Annual Carroll Round
(April 5-7, 2002)

Christopher L. Griffin, chair (SFS ‘02)
William B. Brady (SFS ‘02)
Cullen A. Drescher (COL ‘04)
Meredith L. Gilbert (COL ‘04)
Joshua M. Harris (SFS ‘02)
Andrew T. Hayashi (SFS ‘02)
Mark R. Longstreth (SFS ‘04)
Kathryn E. Magee (SFS ‘02)
Ryan F. Michael (SFS ‘02)
J. Brendan Mullen (SFS ‘02)
Scott E. Pedowitz (SFS ‘02)
Waheed A. Sheikh (SFS ‘04)

Second Annual Carroll Round
(April 11-13, 2003)

Seth M. Kundrot, chair (SFS ‘03)
Nada M. Abdelnour (SFS ‘03)
Maria M. Arhancet (SFS ‘04)
Victoria E. Bembenista (SFS ‘03)
Michael J. Callen (SFS ‘05)
Eric M. Fischer (SFS ‘03)
Daphney Francois (SFS/GRD ‘04)
Meredith L. Gilbert (COL ‘04)
Jeffrey M. Harris (COL ‘03)
Robert S. Katz (COL ‘04)
Marina Lafferre (SFS ‘06)
Lu Shi (SFS ‘03)
Stacey H. Tsai (SFS ‘03)
Robert T. Wrobel (SFS ‘03)
Erica C. Yu (COL ‘05)

Third Annual Carroll Round
(April 15-18, 2004)

Meredith L. Gilbert, chair (COL ‘04)
Héber M. Delgado-Medrano (SFS ‘06)
Ryan V. Fraser (SFS ‘04)
Tetyana V. Gaponenko (SFS ‘07)
Yunjung Cindy Jin (SFS ‘05)
Sarah H. Knupp (SFS ‘04)
Robert S. Katz (COL ‘04)
Marina Lafferre (SFS ‘06)
Alia F. Malik (SFS ‘04)
Susan M. Work (SFS ‘04)
Beatka J. Zakrzewski (SFS ‘04)

Fourth Annual Carroll Round
(April 22-24, 2005)

Erica C. Yu, chair (COL ‘05)
Jasmina Beganovic (SFS ‘05)
Lucia Franzese (SFS ‘07)
Dennis L. Huggins (SFS ‘05)
Yunjung Cindy Jin (SFS ‘05)
Jonathan W. Kirschner (SFS ‘05)
Susan C. Kleiman (SFS ‘05)
Yousif H. Mohammed (SFS ‘06)
Amy M. Osekowski (SFS ‘07)
Daniel P. Schier (SFS ‘05)
APPENDIX D: Members of the Advisory Panel

Meredith L. Gilbert, The Washington Group
Christopher L. Griffin, Yale University
Andrew T. Hayashi, University of California at Berkeley
Mitch Kaneda, Georgetown University
Robert S. Katz, World Resources Institute
J. Brendan Mullen, The Advisory Board
Scott E. Pedowitz
APPENDIX E: Past Participants

First Annual Carroll Round (April 5-7, 2002)

Azhar Adbul-Quader  Columbia University
Santosh Anagol    Stanford University
William Brady    Georgetown University
Daniel Braun    Oberlin College
Jacqueline Bueso  University of Pennsylvania
Karla Campbell    University of Virginia
Benn Eifert    Stanford University
Courtney Fretz    University of Pennsylvania
Carlos Galvez    Stanford University
Aniruddha Gopalakrishnan    Duke University
Christopher Griffin    Georgetown University
Casey Hanson    Lehigh University
Joshua Hanson    Georgetown University
Andrew Hayashi    Georgetown University
Marco Hernandez    Massachusetts Institute of Technology
Katia Hristova    Illinois-Wesleyan University
Maria Jelescu    Massachusetts Institute of Technology
Fadi Kanaan    Yale University
Avinash Kaza    Stanford University
Vinay Kumar    Duke University
Anisha Madan    Illinois-Wesleyan University
Kathryn Magee    Georgetown University
Ryan Michaels    Georgetown University
Jack Moore    Stanford University
Brendan Mullen    Georgetown University
Andrei Muresianu    Brown University
Scott Orleck    Duke University
Scott Pedowitz    Georgetown University
Jonathan Prin    University of Pennsylvania
Jeremy Sandford    Illinois-Wesleyan University
Deborah Slezk    Illinois-Wesleyan University
Conan Wong    Brown University
APPENDIX E: Past Participants

Second Annual Carroll Round (April 11-13, 2003)

Nada Abdelnour  
Amanda Barnett  
Andrea Bell  
Patrick Byrne  
David Chao  
Sylvia Ciesluk  
Adam Doverspike  
Benn Eifert  
Adam Engberg  
Alexandra Fiorillo  
Eric Fischer  
Zlata Hajro  
Samina Jain  
Avinash Kaza  
Eric Kim  
Seth Kundrot  
Lada Kyi  
Lee Lockwood  
Sunil Mulani  
Holly Presley  
Duncan Roberts  
Lu Shi  
Shanaz Taber  
Jiang Wei

Georgetown University  
Emory University  
Wellesley College  
University of Colorado  
Cornell University  
Lehigh University  
Georgetown University  
Stanford University  
Georgetown University  
Connecticut College  
Georgetown University  
Wellesley College  
Georgetown University  
Stanford University  
George Washington University  
Georgetown University  
Rice University  
Northwestern University  
New York University  
Vanderbilt University  
University of California at Berkeley  
Georgetown University  
Barnard College  
University of Michigan
APPENDIX E: Past Participants

Third Annual Carroll Round (April 15-18, 2004)

<table>
<thead>
<tr>
<th>Name</th>
<th>University</th>
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<tbody>
<tr>
<td>Jeffrey Arnold</td>
<td>Dartmouth College</td>
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<tr>
<td>Julia Berazneva</td>
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<td>Mehmet Cangul</td>
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<td>Richard Carew</td>
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<td>Ashley Coleman</td>
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<td>Dilyana Dimova</td>
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<td>Fernando Galeana</td>
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<td>Meredith Gilbert</td>
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<td>Marc Hafstead</td>
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<td>Andrew Hayashi</td>
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<td>Katherine Howitt</td>
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<td>Sohini Kar</td>
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<td>Josh Lewis</td>
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<td>Satish Lohani</td>
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<td>Alexis Manning</td>
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<tr>
<td>Sara Menker</td>
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<td>Elizabeth Mielke</td>
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<td>Stratos Pahis</td>
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<td>Alicja Pluta</td>
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<td>Caroline Schmutte</td>
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<td>Matt Sekerke</td>
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<td>John Soleanicov</td>
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<tr>
<td>Kai Szakmary</td>
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<td>Brandon Wall</td>
<td>Yale University</td>
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<tr>
<td>Kenneth Ward</td>
<td>University of Chicago</td>
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<tr>
<td>Susan Work</td>
<td>Georgetown University</td>
</tr>
</tbody>
</table>
APPENDIX E: Past Participants

Fourth Annual Carroll Round (April 22-24, 2005)

Lidia Barabash Dartmouth College
Jasmina Beganovic Georgetown University
Xun Bian Illinois-Wesleyan University
Michael Furchtgott Columbia University
Michael Gechter Pomona College
Kevin B. Goldstein Dartmouth College
Michael Haase University of Copenhagen
Dennis Huggins Georgetown University
Michael Insel Claremont McKenna College
Jonathan Kirschner Georgetown University
Shiying Lee Duke University
James Liao Dartmouth College
Brian Lichter Washington University
Wee Lee Loh Cornell University
Alice Luo Duke University
Katharine Mullock University of Western Ontario
Jose Mustre del Rio Ohio State University
Leah Nelson Georgetown University
Ee Cheng Ong Wellesley College
Matthew Phan Columbia University
Nina Rendelstein Washington University
David Rogier Washington University
Ana Maria Romero Illinois-Wesleyan University
Nathan Saperia Dartmouth College
Bogdan Tereshchenko Georgetown University
Olga Timoshenko University of Western Ontario
Tom Vogl Princeton University
Kenneth Ward University of Chicago
Jonathan Wolfson Washington University
Suzanne Zurkiya Emory University
Note on Paper Submissions

The Carroll Round Proceedings is a publication of synopses and full-length papers from the Carroll Round Undergraduate International Economics Conference at Georgetown University. We do not accept paper submissions from the general public. If you are interested in presenting at the conference, please log on to our website: http://carrollround.georgetown.edu. All undergraduate students who have written or are in the process of writing original work in the field of international economics (broadly defined) are encouraged to apply.