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Comparative Advantage, Economic Growth, The Gains from Trade and Globalization, and Computational Trade Modeling: Festschrift Papers in Honor of Alan V. Deardorff

Various Authors

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COMPARATIVE ADVANTAGE, GROWTH, AND THE GAINS FROM TRADE AND GLOBALIZATION: A FESTSCHRIFT IN HONOR OF ALAN V. DEARDORFF

Edited by

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Preface and Acknowledgments

Alan Deardorff was 65 years old on June 6, 2009. To celebrate this occasion, a Festschrift in Alan's honor was held on Friday and Saturday, October 2-3, 2009, in the Rackham Amphitheater at the University of Michigan in Ann Arbor. The Festschrift was entitled "Comparative Advantage, Economic Growth, and the Gains from Trade and Globalization: A Festschrift in Honor of Alan V. Deardorff." It was co-organized by two of Alan's former students, Drusilla Brown of Tufts University and Robert Staiger of Stanford University, together with Robert Stern representing the University of Michiga.

The first day of the Festschrift involved a series of panels in which invited participants reflected on Alan's contributions, including his writings on: comparative advantage; trade and growth; the gains from trade and globalization; and computational modeling and trade policy analysis. The panel participants prepared written comments, setting out their evaluation of Alan's contributions combined with their own thoughts on the current state of knowledge and analysis of the particular topic. At the end of the first day, Paul Krugman of Princeton University and *The New York Times* delivered a Citigroup Foundation Special Lecture entitled "Reflections on Globalization: Yesteryear and Today."

The second day of the Festschrift involved "showcasing" the fruits of Alan's mentoring as an advisor, A number of Alan's former students were invited to present whatever paper they were currently working on and were most excited about presenting at the Festschrift. Those invited included: Drusilla Brown, Tufts University; Peter Debaere, University of Virginia; David Hummels, Purdue University; Marc Melitz, Harvard University; Robert Staiger, Stanford University; and David Weinstein, Columbia University. Discussants were appointed to critique the individual papers. Day 2 of the Festschrift was therefore more like a research seminar, with the paper presentations, and the link to Alan simply being that these were contributions from his former students. These papers were but a small sample of work by Alan's former Ph.D students.

The Festschrift was officially sponsored by the Gerald R. Ford School of Public Policy and the University of Michigan Department of Economics with generous support from the University of Michigan International Policy Center of the Ford School, College of Literature, Science, and the Arts, Office of the Vice President of Research, International Institute, the Stephen M. Ross School, and from John W. Sweetland.

Robert M. Stern

Ann Arbor, Michigan

March 26, 2010

Tribute to Alan V. Deardorff

Alan Deardorff is the John W. Sweetland Professor of International Economics and Professor of Economics and Public Policy in the Department of Economics and Gerald R. Ford School of Public Policy at the University of Michigan. He received his Ph.D. in economics from Cornell University in 1971 and has been on the faculty at the University of Michigan since 1970. He served as Chair of the Department of Economics from 1991 to 1995.

He has also served as a consultant to many government agencies and international organizations, including the Departments of State, Treasury, and Labor of the United States Government, and the UN Conference on Trade and Development, and he is currently on the editorial boards of several academic journals. His many publications span a large variety of topics dealing with international trade theory and policy. His writings on international trade theory have dealt primarily with the theory of comparative advantage and the Heckscher-Ohlin and other models that explain the patterns and effects of international trade. His writings on trade policy have included analyses of anti-dumping laws, the safeguards clause of the General Agreement of Tariffs and Trade (GATT), and arguments for and against extending intellectual property protection to developing countries.

Together with Professor Robert Stern, he has developed a computer-based model of production, trade, and employment in 34 major countries of the world. This model has been used for a variety of purposes, including analysis of the Tokyo and Uruguay Rounds of multilateral trade negotiations and possible outcomes of the current World Trade Organization (WTO) Doha Round. He, Professor Stern, and Drusilla K. Brown of Tufts University have also developed a series of models to evaluate the sectoral employment implications of various regional trading arrangements in North America, the Western Hemisphere, Asia, and Europe.

Over the course of his career, Professor Deardorff has authored/co-authored five books and monographs, six edited volumes, and nearly 90 academic papers. He has also published 84 conference papers in edited volumes.

Professor Deardorff currently maintains two widely used websites: *Academic Family Tree of Trade Economists*, since 2001, and *The Terms of Trade and Other Wonders: Deardorff's Glossary of International Economics*, since 1998

In recognition of his many accomplishments, Professor Deardorff has been honored and has delivered a number of special, invited lectures, including the Graham Lecture at Princeton University in 2006, Nottingham Lectures at the University of Nottingham in 2005, the Ohlin Lectures at the Stockholm School of Economics in 2003, and the World Economic Lecture at the University of Nottingham in 2002. Professor Deardorff's recent and current topics of theoretical research include the role of trade costs in determining patterns of trade, the determinants of international specialization, and the mechanisms by which trade liberalization may stimulate industrialization and growth.

COMPARATIVE ADVANTAGE, ECONOMIC GROWTH, AND THE GAINS FROM TRADE AND GLOBALIZATION:

A FESTSCHRIFT IN HONOR OF ALAN V. DEARDORFF

University of Michigan
Gerald R. Ford School of Public Policy/Department of Economics

Friday and Saturday, October 2-3, 2009
Rackham Amphitheater

Remarks

John Sweetland
The Winsford Corporation

Saturday Evening, October 3, 2009

Deardorff Festschrift – October 2-3, 2009

For years, The University of Michigan, as well as its colleges, schools, and departments, operated under the policy best described by Senator Moynihan of "benign neglect" toward its alumni. As a result, I had little contact with the College of LS&A, the Rackham School, or the Department of Economics from which I received both my bachelor's and master's degrees in the late 50s.

This began to change under President Harold Shapiro – formerly a professor of economics at Michigan – as he realized that the University had to look beyond state funding in major ways if it were to achieve its potential. Under his leadership, the Campaign for Michigan began and was carried out by his provost, then President Jim Duderstadt. Its goal was $1 billion – the largest ever sought by a state-supported university. It was a success at $1.4 billion, but more importantly, it brought out of the shadows thousands of loyal – and *generous* – alums. Since then, the recent $2.5 billion Michigan Difference Campaign, which ended last year, topped $3.2 billion and placed Michigan in the lead among state universities with the largest per student endowment among its peers.

It was this series of events that brought Alan and me into the same orbit. I had some reasonable degree of success ignoring what I was taught at Michigan by creating the largest cement import operation in the U.S. with facilities on the east and west coasts. Cement, I was taught, was too low value a commodity to be involved in international trade. By the early 90s when we sold our companies to Cemex and Lafarge, some 20% of the cement consumed in the United States was imported from Canada, Europe and the Far East.

Shortly thereafter, I received a call from a Southern Californian alumnus who asked if he could bring Saul Hymans to my office for a visit. I knew who Saul was because the Research Seminar in Quantitative Economics was well known in national circles. Saul's visit was the first step in my reintroduction to Michigan and the economics department. To those here from the academic community, please don't turn down such opportunities. Former students that I have talked to uniformly feel honored by such a meeting – they want to hear what's happening!

Soon the romance became more serious. Would I consider a gift to the Campaign for Michigan? That grew into a request that I fund a Chair in Economics for a major number – at least for me! I decided to create the Chair in International Economics even though my field of concentration was industrial organization. My reason? I very much enjoyed my Michigan experience, but the late 50s was a slow time in international trade. Europe and Japan were still recovering from World War II, most of the U.S. trade was exports – the first Volkswagen didn't appear until the late 50s and was viewed as a joke by the U.S. auto industry – and there was little evidence that change was coming quickly. My experience in developing new cement plants in Greece and Spain in the 60s, a time in the securities industry in the 70s bringing our investment products in Europe into compliance with the German equivalent of the Securities and Exchange Commission legislation and extensive anti-dumping litigation brought by domestic cement companies against our operations in the 80s, created an awareness that institutions like Michigan needed to look to the world and broaden the scope of their studies.

I then learned that the Department had the ideal candidate in mind to hold the first endowed chair at Michigan in Economics. Described as a scholar, a teacher, an author, a person with striking intelligence and a prodigious appetite for work, a recent chair of the department known for his collegial spirit – who else could it be but Alan Deardorff?

It has been a pleasure knowing Alan these past twelve years. I've had an opportunity to teach one introductory class in International Economics for each of the past 10 years. From this vantage, I could sense the student's respect for Alan and the high regard they have for him. I'm honored to have a part in this celebration.

Citigroup Foundation Special Lecture
by Paul Krugman

Hill Auditorium, University of Michigan
October 2, 2009

Introduction[1]

Good afternoon and welcome. I am Susan Collins, the Joan and Sanford Weill Dean of the Gerald R. Ford School of Public Policy. And I am simply delighted to see all of you and welcome you here on behalf of the Ford School, the International Policy Center, and the Department of Economics. It is really wonderful to have so much interest in our speaker today, who I will introduce in just a moment.

But as most of you know, we had to move the venue because of that interest, and I would like to thank Hill Auditorium for wedging us in, in the midst of performances by the University Symphony Band.

It is a great honor and a personal pleasure to welcome Paul Krugman to campus as the Ford School's 2009 Citigroup Foundation lecturer. This lecture series was established several years ago by the Citigroup Foundation as a gift in honor of Gerald R. Ford. We are very grateful to the Foundation for their generous gift, which has enabled us to bring distinguished policy leaders to campus, and we are extremely honored this afternoon to be able to add Professor Paul Krugman's name to the list of our Citigroup lecturers.

Today's lecture is the keynote address for an academic conference we are hosting on campus today and tomorrow. The conference was organized in honor of the distinguished career of our colleague and friend, Professor Alan Deardorff, who is currently the Associate Dean of the Ford School. Alan's wide ranging and astute

[1] This Introduction and Paul Krugman's lecture to follow are based on the editing of the transcript prepared for the occasion.

contributions have furthered our understanding of why countries trade, the implications for growth, and the impact of trade policy in a globalizing world. And the conference has also brought many of the world's leading trade economists to Ann Arbor, and I am very pleased to welcome all of them here today as well.

Well, like many of those conference attendees, I am an international economist. And while I am very proud of my profession and its contributions, I do have to concede that there are not many economists whose work is followed closely by the general public, whose opinions on economic matters stir great passions among lay people, and whose weekly writings are routinely discussed around the water cooler. Well, Paul Krugman is the exception. Whether they agree with him or not, people from all walks of life want to know what Paul has to say.

In just the past few days, for example, he has appeared in quite disparate settings such as the keynote speaker at a conference in Helsinki on Finland's Economic Competitiveness and as a guest on the HBO show, Real Time, with Bill Maher. Paul's even a hit over at YouTube where a little known performer scored a quarter of a million views with his song, and I promise I won't sing it for you, his song, Hey, Paul Krugman. And if you have not checked out the YouTube video, I encourage you to do so.

But of course they do not award Nobel Prizes for popularity or YouTube hits. Paul Krugman is one of the great economists of our time, and he was awarded the Nobel Prize for his analysis of trade patterns and the location of economic activity. Traditional theories of international trade emphasize why countries are different, and why they trade with each other, exporting and importing different products. Paul's work emphasized that much of the trade we see in the real world is between countries that are quite similar, and they are

trading relatively similar products. His models highlight both that firms can take advantage of economies of scale, that is, produce more cheaply by producing large quantities, and that consumers value variety and choice. Thus, he pioneered models of trade in which firms produce similar products and compete in a globalizing marketplace. These models also link globalization to economic geography, helping us to understand where firms and people choose to locate and why. Paul's academic work stands out because of its insights about the real world, in packages that economists love because they are mathematically elegant and deceptively simple. His work on trade, like his work on financial crises and in so many other areas, has launched new avenues of research and literally thousands of academic papers.

Paul's work is also remarkable for its clarity. The lucidity of the writing in his many articles, books, and columns has significantly raised economic literacy around the globe, and as Dean of a policy school, I particularly want to highlight his dedication to the importance of clear, analytic thinking as a guide for policy. On a more personal note, I can also attest to the fact that Paul has educated and inspired generations of international and policy-oriented economists. Nearly 30 years ago, his course on international trade was one of the first courses that I took in my doctoral studies at MIT, and I also had the great fortune to benefit from Paul's insights and perspective as a member of my dissertation committee and at numerous points during my career. For all of those reasons and more, I could not be more pleased to call to the stage our 2009 Citigroup Foundation lecturer. Please join me in welcoming Paul Krugman.

Reflections on Globalization: Yesterday and Today

Paul Krugman
Princeton University

Well, thanks, Susan, and thank you all for coming. I would like to thank the Ford School and the Economics Department for organizing this event, and especially the Festschrift to celebrate the work of Alan Deardorff. Today is a kind of homecoming for me. This is the world in which I started. Because today's occasion is the conference honoring Alan Deardorff's work, I am going to try to address different things than what I mostly talk about these days. Everyone wants to know about the economic crisis, and I will talk about that a bit at the end, and I am sure it will come up in the questions. But at least for starters, I want to talk about my home territory, originally and academically, which is the topic of international trade and globalization.

And since today is really all about honoring Alan Deardorff, I thought I would reminisce for a moment. I got into international economics coming straight out of graduate school in the late 1970s and joined what was then the conference circuit where international economists would meet and many of whom are here now and so somehow they all look older. That has not happened to me of course. Alan Deardorff was at many of the meetings I attended in the late '70s, early '80s. He was extremely distinctive because he was an American, which at the time was quite rare. When I got into international economics, there were only a few Americans and most others came from other places. The way I thought about it was that it was a field dominated by Colonials, some Indians, but mostly Canadians and Australians, it seemed at the time. That is probably not true literally, but there were an awful lot of them, which actually imparted a certain character to the conferences. I was later able to pinpoint this character.

Initially I would go to these meetings, and they were incredible. I would come home exhausted, even though I was much younger then obviously. But even so, I really was having a hard time, and then I actually went to one with a bad cold and was taking cough and cold medicine and could not drink. I did not dare to drink, which is funny because there were all these Canadians and Australians and an awful lot of beer and alcohol at these meetings.

There was a reason why Americans were not that prevalent in international economics at the time because even then international trade did not seem to be that big a deal for the United States. In 1970, which is about when a lot of people who were on the conference circuit then would have made their decisions to be in international economics, imports were only about 5 percent of GDP. Now they are 17 percent. So we have had this explosion of international trade, which has turned what was at the time a little bit of a back water within economics, into something that has become enormously important. So I want then to talk about globalization and what it has done, and finish by talking about the role of globalization and the mess we are now in.

But I want to first talk a little bit about history, about the forces of globalization. So the first thing you should know in terms of the history is that globalization is not a new phenomenon. It was ongoing in the late 19th century, encouraged by such key inventions as the railroad, steamship, and telegraph. There was a very extensive local economy created in the late 19th century. There is a lot to be learned even now from studying that period. But after World War I, the global economy went into abeyance for a long time. Between the two world wars, there was the Great Depression and protectionism, and a shift by much of the world to inward looking strategies of economic development. Globalization receded

significantly. By 1970, world trade as a share of gross world product was probably only back to around what it had been in 1913. Other aspects of globalization were nowhere near their pre-World War I levels. There was not nearly as much flow of capital. Even now, despite all the talk about immigration, there is still less migration of people than there was earlier because there are many legal barriers now that did not exist then, and the legal barriers, although porous, do actually matter.

But just about the time that I was getting into international economics, just about the time that I first met Alan Deardorff, all that was about to change. Now there has been some return. While international trade had grown substantially in the '60s and '70s, it had done so in a kind of limited fashion. Most of what we would now consider the emerging markets were still inwardly turned in their economic policies. What was happening was that there were agreements that had opened up trade between quite similar countries. There was a lot of trade between the United States and Canada and within Western Europe. But much of what we now think of as globalization, certainly China was not yet in the picture and even the smaller Asian economies were barely there. Things did not look the way they look now.

The analytical work that I and others did became a whole movement that ended up with the interesting event for me in Stockholm, was largely about growth and trade, trying to understand why the United States and Canada, which look so similar to each other, do so much trade. Why France and Germany ship automobiles back and forth to each other. It is kind of the way things tend to work in economics that as soon as you have a theory, the world starts moving in a way to make the theory less and less relevant, and so we have actually in some ways moved back to a completely different world, which in some ways,

but not in all, resembles the kind of trade that we had in that first age of globalization, before World War I.

What has changed? Two things I think really, and they were both happening together. When many of us were first involved in the *Handbook of International Economics* at a conference in Princeton in 1982, we had no idea in fact that the world was totally changing, and in a way that certainly I had no sense of at the time.

Two things were really changing. One was technology. The ability to ship things long distances fairly cheaply has been there since the steamship and the railroad. What was the big bottleneck was getting things on and off the ships. A large part of the cost of international trade was taking the cargo off of the ship, sorting it out, and dealing with the pilferage that always took place along the way. So, the first big thing that changed was the introduction of the container. When we think about technology that changed the world, we think about glamorous things like the internet. But if you try to figure out what happened to world trade, there is a really strong case to be made that it was the container, which could be hauled off a ship and put onto a truck or a train and moved on. It used to be the case that ports were places with thousands and thousands of longshoremen milling around loading and unloading ships. Now longshoremen are like something out of one of those science fiction movies in which people have disappeared and been replaced by machines.

I have just been rereading a very good book called *The Box*, which is about the big change that occurred between the late 1970s and mid '80s, with a sharp drop in the cost of transactions. This opened up the world and made it possible to do what we do now, which is to produce a good in many different places with the different stages of production and

different components. At this point, ask yourself where an iPod is made and the answer is that it is a really complicated question to answer.

The other thing that changed was policy. To some extent, in countries like the United States, we had actually already moved quite a long way towards free trade. What really changed was that many of the developing countries had followed, for 35 years after World War II, a policy of looking inward, of encouraging production for the domestic market. Whether by design or simply because that is the way the policy works, it ended up discouraging exports. What later followed was a great shift towards outward-looking policies, allowing foreign trade to become the engine for growth. The most extreme case, of course, was China, which went from virtually closed to the world to extremely open. And all of a sudden, with this explosion of world trade over a relatively short period of time, trade was no longer interesting just to Canadians, for whom it has always been of keen interest because they have their large neighbor to the south. It was also of great interest to all of us Americans.

What do we know about globalization? I think even now we do not have clear knowledge and are still adjusting our stories. In fact I have actually been changing my own story about globalization a little bit in the last few months because I have been noticing things that I was not paying sufficient attention to. I really should have been more aware, given my interest in globalization and trade. So let me now tell you what I did on my summer vacation. I actually took a vacation, "holidaying in Scotland," relatively recently, and it was kind of depressing. What can an economist do on vacation? They can go to museums that are focused on economics. So in Dundee, Scotland, there is the Verdant Works Museum, which is dedicated to the history of the Dundee jute industry.

If you have not been there, you may think of Dundee − with the name it sounds like some cute little town. But it is a grim industrial city trying to claw its way back to what it once was. Industrially, it was "juteopolis," the center of the world's jute trade and a long way from its source of jute in the late 19th century. Taking the fibers, which came from India, treating them, drawing them, and eventually ending up as burlap bags, it became a huge business. Dundee had more wealth per capita than any other place in Britain.

How should we think about Dundee? Part of it was comparative advantage, which has long pervaded our thinking, insofar as countries trade because they are different. They have different resources, different competencies, and they trade in effect to take advantage of these differences. Obviously Britain had to import the jute because it could not be grown in Scotland for sure. The manufacturing was taking place in Britain because Britain had the capital, the technological skill, and the certain kinds of skilled labor in a way that India at the time was lacking. Later on, actually, the industry moved back to India in the course of their development. But initially, at least, it was something that could be done more efficiently in Britain. But that is not the whole story because it does not say why you would be manufacturing in Dundee.

And there the answer is much closer to the kinds of things that I have spent a lot of time thinking about in my career, which is the role of increasing returns. As is characteristic of these stories, there are some accidental historical factors that got the industry started. In the early stages, the process of treating the fibers relied on whale oil. While it later turned to mineral oil, initially it was whale oil, and Dundee was a whale importer. It also had ample supplies of flax. The clustering that took place eventually resulted in the production process feeding on itself.

Some years ago, many of us became interested in economic geography and rediscovered the works of the great Victorian economist Alfred Marshall, who focused on these industrial clusters that were very much a story of the time. Marshall emphasized three things. First, there was the creation of a thick market for specialized skilled labor. Second, there were specialized suppliers of equipment and services needed in industry, and, third, there was what we would now call technological spillover. Marshall referred to the mysteries of the trade, but there was no mystery as the developments were in the air. Basically, everybody in Dundee knew all about jute, and so you have this kind of clustering. And that is actually quite typical. If you go back, we tend to think of 19th century trade as having been straightforward. There were different countries, tropical and temperate. There were countries that knew how to do manufacturing and countries that did not — there was actually a lot of clustering going on, not only jute in Dundee, but hosiery and lace in Nottingham, and cutlery in Sheffield. This was the case in the United States as well. Although the United States was protectionist and relatively closed at the time, we also had Patterson, New Jersey, which was the equivalent of Nottingham, and Troy, New York, which was the detachable collar and cuff center. Well, I always love these historical examples.

What about today's world? Today's world is extraordinarily complex, with enormous volumes of trade. When I was first getting into this, we could say that, in some ways, globalization still falls short of what it was in the Edwardian era. We cannot say that now. Now, what we have that did not exist in the past is these complex supply chains in which there are many stages of production. Take the iPod. The iPod's final assembly point is in China, but that assembly involves only about $1.50 of the price of the iPod. For the

rest, there are many other stages involving a large number of countries, which creates tremendous shipping back and forth. A lot of this now reflects again differences between countries. The wealthy countries still have advantages. They have still somewhat better technology. They have more skilled labor. They have all of the advantages of being in an advanced country environment in which there is quality control.

While I have not seen it, I understand that there is a new book called *Badly Made in China*. While even now there are still differences in competence, on the other hand, developing countries have inexpensive labor and in some cases reasonably good productivity and manufacturing capability. Thus, we have trade going back and forth that is based upon these differences. The goods and stages are still required to be produced in advanced country environments, but other stages are done in developing countries. What is going on is similar to my story about Dundee. Except what is interesting these days is that if you want to find those clearly defined industrial clusters, those cities where a particular sort of narrow competence leads to a dominance of the whole city economy, you find them best in the emerging markets in the developing world.

If you go around China, you will find, comparable to Dundee that was the "juteopolis" in the late 19th century, the "underwear" city of Yambol in the 21st century. There are these clusters. It is probably a foregone conclusion that we are going to have labor-intensive apparel produced in China or now moving down to even lower wage countries like Vietnam. But the details depend a lot on whether some particular town or city can develop a specialty and derive the advantages of this clustering, that is, the advantages of the scale of production in a particular locality.

I should mention by the way, since again this is Alan Deardorff's Festschrift, that this whole process of fragmentation of production, which has made it possible to have this huge volume of world trade, is one of the areas in which he has done much. When we were just starting to see the surge in exports from smaller Asian countries, we used to say that there is only a limited amount of these labor-intensive manufactures that they can export. I remember specifically saying what will happen when China tries to do this? There is not possibly enough labor-intensive manufactures to be able to segment the production of goods based on these labor-intensive stages of production.

Nonetheless, the process of fragmentation has gained a lot of momentum because of the interaction of technological and political changes. The technological changes meant that some countries could do very well by integrating with the global economy, which led other countries to be more willing to liberalize their policies and do the same thing, which resulted in the explosive growth of globalization. The question is whether this is a good thing or a bad thing. The answer of course is, yes.

First of all, the world economy is richer because of the increased globalization. It is richer both because we have countries concentrating on the things they do relatively well. Note that this does not mean they do absolutely well. Actually, on any given thing, it is almost certain that U.S. labor is more productive than Chinese labor, although this varies quite a lot. So by having the Chinese do the things in which they are relatively productive, we get the whole world producing efficiently, and this means that world wealth has increased. In addition, the world market makes it possible to do a lot of things on an efficient scale. In some cases, this is not just by having a really big factory, but in many

cases having many factories in a place where the firms produce mutually reinforcing advantages.

Thus, in the end, the world is a richer place because the underwear makers of Yambol are more efficient than any national, purely domestic, market-oriented underwear city could be. So we have a world that is clearly richer. That does not mean that everybody benefits equally, since there are many dislocations and distributional effects. The most obvious and the one that we worry about a lot is that workers with lower formal education in advanced countries are almost certainly hurt by imports. That inequality is wider to some extent because of globalization. I would argue that the evidence still suggests that this is a secondary factor. But inequality has widened, and globalization is probably part of it and has probably hurt workers in advanced countries.

If you take a global citizen point of view though, you may want to say that those losses are less dramatic than the huge gains that many workers have achieved in the developing world. There is a real trap here for concerned people in the advanced world. That is, there is a tendency to compare the ugly reality of life for workers in today's developing countries with an abstraction of what some may think it ought to be or with an idealized picture of what it used to be like, rather than with reality. So sometimes it almost comes out as condescending thinking about happy peasants living their traditional lives in comparison with the actual lives of workers, which may be terrible. But the fact of the matter is, given the reality, that developing countries were incredibly poor in 1970, that some of them have now achieved a really large increase in their standard of living. Even if this still looks pretty bad to us, there has nonetheless been a tremendous amount of

progress. Hundreds and perhaps billions of people now live better lives because of globalization. But it is a mixed picture, and it has also turned out to be much harder than I think many economists believed to actually reap those gains from globalization.

When the great takeoff of some East Asian economies took place, a lot of people thought that if you just opened yourself up to world markets, the benefits will be obvious. A number of countries, particularly in Latin America, did open themselves up to world markets and have not achieved great results.. So it has turned out that there is a much more mixed and more uncertain picture than we were hoping it would be. But if you had asked me two years ago how globalization is going, I would have said, well it is certainly not wonderful, but there are a lot of good things that have taken place. And that, on the whole, globalization has been a force for good.

But, as we all know, something happened to us recently, so we now have the world economy going through this terrible crisis. What can we say about the role of globalization in this and the future of globalization? Where are we currently? And by the way, of course − if you read your history − you cannot help but recall that the single biggest force killing the original global economy was the Great Depression of the 1930s. We are now in a world slump that bears a definite family resemblance to what happened in the early 1930s. Is it all going to happen again? What does it say about where we are going for now?

The current crisis has been awesome of course. The first year of the crisis tracks the (Great) Depression very closely. It actually turns out that the initial fall in industrial production was not as big as it was in 1929 and 1930, but the initial fall in world trade in the current crisis was actually sharper than it was in 1929 and 1930. While the fall in GDP in the current crisis may have been of the Great Depression scale, it does appear to have

stabilized. So it appears that Armageddon has been put on hold for at least a while. The apocalypse has been postponed, but it has been a pretty shocking crisis and of course we are nowhere near being out of the woods.

It is interesting to ask whether globalization paved the way for the crisis. Well certainly not in the simple sense that all this increased trade was directly responsible for the crisis. In this case, if you want to look for causes of the crisis, you should look more at the financial side of globalization, which of course is not independent. So, if you are looking for where things went wrong, you might say that, as China became more deeply integrated into the world economy, it also stumbled into a policy of accumulating huge reserves, which led to a lot of cheap money in the United States that helped feed our housing bubble. This is an indirect chain but certainly is part of the story. You would also say that, in a more limited sense, we tend to think of this crisis as having been a primarily U.S. event. But actually, much happened in Europe as well, and their more localized globalization played a big role. That is, there was a lot of lending to Eastern European emerging nations that was in its own way as big and imbalanced as the U.S.-China imbalance and has ended in similarly severe grief.

So you can certainly say that the opening up of world capital markets, the opening up of world capital flows, played a definite role in generating the current crisis. Globalization has certainly therefore played a role in propagating the crisis.

One of the things that has been remarkable is that you know obviously the places of the financial excesses were in the United States, the U.K., and arguably in different ways in some of the European countries that had enormous housing bubbles, such as in Spain. But the punishment has not been borne, if you look cross country, very much in

relationship to the crime. Thus, the steepest falls in GDP, at least initially, actually came in countries that did not have runaway financial sectors and did not have housing bubbles, in particular Japan and Germany. After all, what was their sin? Their sin was being deeply integrated in the world economy and being exporters of durable manufactured goods, which took the biggest hit. So the biggest declines in GDP, at least initially, have come in countries that were being hit through world trade, and all of this is possible because we have such an integrated global economy. And that contributes to what is in some ways the most troubling feature of this crisis looking forward, which is that it hit everybody.

There is another sense in which globalization helped lead to a synchronized crisis, and this is a little bit softer but still very important. One of the effects of globalization has been people looking for profit, which involves movement of goods and services and money. It also produces an integration of thought. More and more, we are all certainly culture bound. There has been concern about the horrors of cultural homogenization, which is, whatever you think of it, very real. We certainly all dress alike around the world. We all watch the same kind of entertainment, and we all think alike. This means that with intellectual trends, the conventional wisdom at the moment is now a global convention rather than a national convention of wisdom. And, in particular, pretty much everyone around the world thought it was a great idea to deregulate banking at the same time so that when the house of cards came down, it came down everywhere, which makes this very difficult currently.

We have had an awesome financial crisis. It is not, now that we have seen it happen, that hard to understand. We look at it, and it is a more or less historically standard banking crisis but dressed in different clothes. So, if you go back to the early 1930s, there

was a wave of banking failures and bank runs, and such things have happened in individual countries since then. This time, we had pretty good guarantees for banks as conventionally defined, that is, basically big marble buildings that take deposits. The trouble was that we had failed to do anything about the growth of institutions that functionally are banks, borrowing short and lending long, but were not called banks, did not look like banks, and were not strictly speaking depository institutions. But once you take all of this into account, what we have had is the 21st century functional equivalent of 1931 around the world. So this time, bank runs do not consist of hordes of people out in the street banging on the doors. They consist of hordes of people on the internet clicking their mouses, but it has the same effect and is played out very similarly. And we have had, thank God, a pretty big-risk emergency response. We have learned something these past 75 years and appeared to have contained it from being a total collapse.

But what comes next? Well, we have had a number of more localized banking crises around the world since the Great Depression. We have had Mexico and Argentina, and then Mexico again, and then Argentina again, and the Asian countries, and Sweden and Finland. All of these crises were very nasty. We know that the IMF has done a lot of reaching back in history to ask what happens in a crisis, and the answer is that financial crises not only are severe but may take a long time to recover. There is one other thing that becomes very clear from the record, which is that with all modern financial crises, the economic recovery relies crucially on the same thing, which is that the crisis-afflicted country recovers to a large extent at least for a while, by running big trade surpluses. It basically pulls itself out of its hole by selling a lot of goods and services to parts of the world that were not caught up in the crisis. I think you see the problem. Unless we can find

another planet to export to, the normal exit from a financial crisis, not the stabilization itself, which I think has been achieved, but the actual return to something that looks like a reasonably fully employed economy is not clearly available. I see crisis-afflicted countries like Argentina, the East Asian economies, or even Japan emerging temporarily from its lost decade of growth, being able to recover through export surpluses. But this may no longer be available under the present circumstances.

So if you are looking for a precedent for a world economy managing to emerge from a financial crisis and fully recovering from the effects of the crisis, where everybody is caught up in it and where countries are not able to do it by running trade surpluses, you actually have to go back to recovery from the Great Depression itself, when the full recovery was achieved through a large public spending program known as World War II. So it is not a very encouraging prospect

The last time we had a global crisis in the Great Depression, one of the effects was to roll back globalization for a long period of time. This does not seem to be happening right now. Although, yes, there are tariffs being imposed on tires and other products, but there has been nothing like the kind of protectionist response that took place in the 1930s, and not much sign that it is going to happen. The question I guess one might ask is, maybe, should it happen? We seem to have a global economy in which our institutions have been lagging. We are not in a position in managing to find global solutions to the crisis. We are just managing to find ad hoc patches to keep the global economy from totally falling apart. We are to a certain extent holding the economy together with scotch tape and chewing gum. But is there a reason, given the crisis, to roll back globalization? I think you could

actually possibly make that case, but I do not think that it is going to happen because the advantages of globalization are still very real.

It is widely understood that protectionism was a major cause of the Great Depression. This is perhaps arguably not true, and in any case it stands out as a cautionary tale. This means that we need to find a way to deal with the crisis. One way to look at the world right now is that we actually created this global economy without creating the institutions that we need to manage it. We are still in a world of national policies. Even though we have supranational institutions, they are not functioning very well. So, for example, the European Union (EU) is looking awfully disunited when it comes to economic policies these days. While the EU members are highly interdependent, yet they do not seem to be able to make policies jointly.

We have had international cooperation with some of the emergency measures in the crisis, but they have been amazingly dependent on personal contact. You could argue that we managed to save the world basically because Jean Claude Richet, Mervin King, and Ben Bernanke were able to agree on things that needed to be done in the heat of the moment. And while I would like to have a rule that the believers of policies would always be in the hands of smart, bearded Princeton professors, that is not something we can really count on in the future. So we have not yet come to terms with this enormously, moral degrading economy. This economy that I have to admit 30 years ago, when I was getting into international trade, I never imagined that it would be this relevant, and we have no choice in the end. One could imagine rolling back trade flows in the face of a crisis. It is not technologically impossible to go back to a world of relatively inward looking economies. There are other ways in which we are globalized, like it or not. The atmosphere

does not care where a ton of carbon dioxide gets emitted, and we are now at a stage where those global constraints bind enormously on all of us. In fact, we are globalized whether we like it or not.

It is an amazing and frightening time. I would like to think that we will come out of all this with the understanding that we really need to go beyond just trusting this vast global economic machine to do the right thing and figuring that we actually need to have some adult supervision of the entire system. Maybe it will actually happen. We are supposed to be optimistic, right, otherwise what is the point? So amazing times. As a citizen of the world, I am quite horrified of what we are going through. A little less frightened than I was six months ago but still uneasy with the prospect.

But this is an occasion to analyze economic research and to celebrate the accomplishments of Alan Deardorff. As an economic researcher, I have to say that I am in clover. It is like watching Mount St. Helens erupt, a great time for study, unfortunately not a great time to live through. Thank you.[2]

[2] Following the lecture, there were a number of questions posed by the audience to which Professor Krugman responded. These questions covered a variety of issues, many of which were not germane to the subject of the lecture. The questions and Professor Krugman's responses are available on request.

Alan Deardorff on Comparative Advantage

James E. Anderson
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October 12, 2009

Alphabetical order puts me at the head of a distinguished panel with far more authority than I to speak on the subject of comparative advantage. I will be appropriately brief. But perhaps my perspective as a consumer rather than a producer here will be useful.

In my opinion the writings of Alan Deardoff on comparative advantage are a great example of progress in economic theory and its connection to empirical confirmation. Almost 30 years later, it seems like we have always known these ideas. Appreciating the greatness of his 1980 and 1982 papers requires recalling the scene in which they appeared.

The theory of comparative advantage before 1980 was a compelling and beautiful insight essentially based on a toy world of two goods and two countries. The factor proportions theory of comparative advantage gave additional compelling insights in special cases such as two factors or factor price equalization. Only a little more generality had been achieved.

Moreover, technical difficulties with the logic of comparative advantage in a world of costly trade were suggested by demonstrations that introducing or changing trade costs could reverse the direction of trade in some goods. The distance of the assumptions from the real world was so extreme that empirical confirmation seemed impossible.

Those of us teaching trade theory in the 70's felt there must be some truth to the logic, but comparative advantage was like a parable, not science. We might have been accused of mistaking mathematical beauty for economic truth, a charge Krugman recently leveled at the macro-economic work of the last 25 years.

Progress made in the 70's in refining the dual approach to modeling trade

set the stage for using the mathematics of convex structure to analyze comparative advantage in high dimensions.

Alan discovered (more or less simultaneously with Dixit and Norman) the basic logic of comparative advantage extended to many goods and countries, many factors, without factor price equalization, and with costly trade. His propositions are an early example of the now common approach of looking for sufficient statistics that describe distributions of outcomes implied by models as opposed to a full catalog. On average, a country's trade vector will export goods that in autarky would be relatively cheap and import goods that in autarky would be relatively expensive. "On average" is defined as an easily interpreted covariance or correlation. On average, the factor content of a country's trade vector will export factors that in autarky would be relatively cheap and import factors that in autarky would be relatively expensive. Here the logic required "on average" to mean a covariance among 3 variables that Alan termed a "comvariance". His beautiful spare expressions contained enough real world complexity so that the theory could actually be tested. The work of Bernhofen and Brown (2004, 2009) shows that both the general theory of comparative advantage of 1980 and the factor proportions theory of 1982 are confirmed by the data.

On re-reading Alan's papers I was struck again by how general they are, and how much they look toward confirmation. In particular, I want to mention his treatment of costly trade in the 1980 paper and his treatment of the factor content of trade in the 1982 paper.

I have recently struggled with integrating trade costs with general equilibrium myself, so especially I appreciate his clean and very general model of resource costs of trade. The key insight is to model equilibrium working backward from delivered products through the technology of distribution and production. I suspect there may be clues in Alan's 1980 paper for going beyond iceberg trade costs and yet still getting something like gravity to work with.

As to factor content, Alan's concern for measurement led him to analyze the consequences of what looked like several reasonable ways of defining factor content when techniques differ internationally. His discussion clarified what would be needed in a world without factor price equalization and paved the way for Bernhofen and Brown's 2009 paper.

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COMPARATIVE ADVANTAGE, ECONOMIC GROWTH, AND THE GAINS FROM TRADE AND GLOBALIZATION:

A FESTSCHRIFT IN HONOR OF ALAN V. DEARDORFF

University of Michigan
Gerald R. Ford School of Public Policy/Department of Economics

Friday and Saturday, October 2-3, 2009
Rackham Amphitheater

Comparative Advantage in a Changing Global Economy

Avinash Dixit
Princeton University

8:45-10 AM, Friday, October 2, 2009
Panel Discussion: Comparative Advantage in a Changing Global Economy
Moderator: Robert Staiger, Stanford University
James Anderson, Boston College
Avinash Dixit, Princeton University
Wilfred Ethier, University of Pennsylvania
Ronald W. Jones, University of Rochester
J. Peter Neary, Oxford University

Remarks at a panel honoring Alan Deardorff
Ann Arbor, October 2, 2009
"Comparative Advantage in a Changing Global Economy"
by
Avinash Dixit
Princeton University

It is a special pleasure and privilege for me to be speaking at Alan Deardorff's 65th birthday celebration, and on the subject of comparative advantage. We have close connections in both respects. We were born only two days apart – he on D-day, and I on D+2. And for a while we worked along closely parallel lines, albeit in total ignorance of each other's work. I still remember the pleasure I felt when I discovered his papers on generalizing comparative advantage: the fact that someone deeply immersed in the traditions of international trade had independently thought it useful to reformulate the question in the same way, and proceed to develop the theory very similarly, was comforting to Victor Norman and me, who were relative amateurs bumbling into the field.

So let me begin by recalling some of this work, Deardorff (1980, 1982) and Dixit and Norman (1980, pp.94-102). The theory of comparative advantage used to be developed assuming that there were only two goods, implying that there was only one relative price. The country that had the lower relative price of a good in autarky would export that good when trade opened up. The theory then considered various determinants of the relative price in a closed economy, most notably productivities (Ricardo) and factor endowments (Heckscher-Ohlin). But when more goods were allowed, it was quickly found that strong generalizations of this prediction on a good-by-good basis were invalid, basically because with three or more goods, complementarity is possible, and that ruins monotonicity of the relationship between relative supplies and relative prices.

One way out of this would have been to assume gross substitutes, but that would be assuming away a significant real-world possibility. Alan, and independently Victor and I, came to the conclusion that the question had been

wrongly posed. Instead of asking under what highly (and unrealistically) restrictive assumptions one could get a good-by-good generalization of the traditional result, one should ask how far one can get with economically sensible assumptions. It turned out that a simple and intuitively appealing result was available. The two-good result generalizes in the sense of an average: there is a positive correlation across goods between the standard determinants of comparative advantage and the pattern of exports.

Let P^a and P^{*a} denote the vectors of autarkic equilibrium prices in the home and foreign countries, and let X denote the vector of home's net exports. Then a simple revealed preference argument shows that

$$(P^{*a} - P^a) \bullet X \geq 0,$$

where $\bullet$ denotes inner product. When prices are suitably normalized, the inner product becomes a covariance. Therefore the home country on the average exports those goods for which it has the lower autarkic relative price.

With many countries, Alan pushed the argument farther. Stack the autarkic price vectors of all countries into a giant vector P, and similarly stack the vectors of their exports into a giant vector X. Then the revealed preference and market clearing arguments for all the countries can be combined into the result $P^a \bullet X \leq 0$, which has a similar correlation interpretation.

In the Ricardian model, each country's autarkic prices of goods are proportional to its labor requirement per unit output of those goods, so the result directly translates into the result that a country on the average exports those goods for which it has lower unit labor requirements. In fact even stronger results are available in the Ricardian case. In the Heckscher-Ohlin model, we need a further step to get from factor endowments to autarkic relative prices, and again the generally valid result is a kind of correlation. The two lines of work on this were related but distinct.

Victor Norman and I worked with the GDP function $G(P,V)$ of output prices P and factor quantities V. Revealed preference arguments yield

$$G(P^{*a},V^*) - G(P^{*a},V) - G(P^a,V^*) + G(P^a,V) \leq 0.$$

For small differences in endowments, we have a Taylor approximation

$$(P^{*a} - P^a)' R (V^* - V) \le 0,$$

where $R = G_{PV}$ is the matrix of the Rybczynski terms, and therefore related to factor intensities. This can be interpreted as saying that the home country on the average has lower autarkic prices for those goods that use its relatively abundant factors relatively more intensively. This can be combined with the previous correlation between autarkic price differences and export quantities to get a vague sort of Heckscher-Ohlin conclusion.

Alan worked with factor prices and obtained a tighter result. With many countries, goods, and factors, he defined giant vectors ω, θ, and τ, where

$$\omega_{hij} = \left(\overline{w_h} - w_h^{aj}\right) / \overline{w_h},$$

the relative shortfall of country *j*'s autarkic (*a*) price of factor *h* below the average across countries for this factor (the right hand side is the same for all goods *i*),

$$\theta_{hij} = \overline{w_h}\, g_{hi}^{tj} / p_i^w,$$

where g_{hi}^{tj} is the actual factor requirement matrix under trade (*t*) and p_i^w are the world prices of goods, so the θ_{hij} are kind of Jonesian factor shares, and

$$\tau_{hij} = p_i^w X_i^j$$

are net exports valued at world prices (the right hand side is the same for all factors h). Then he showed that the "comvariance" between these three vectors, defined as

$$\mathrm{com}(\omega, \theta, \tau) = \sum_{h,i,j} (\omega_{hij} - \bar{\omega})(\theta_{hij} - \bar{\theta})(\tau_{hij} - \bar{\tau})$$

is non-negative (the bars indicate averaging across all three subscripts). This says that on average, countries export those goods which use their relatively cheaper (and more abundant in this sense) factors relatively more intensively. This is a cleaner result, although there are the usual problems, which Alan recognizes and discusses, in going from factor abundance in the price sense to that in the quantity sense. A by-product of this analysis is the interesting and more widely useful notion of comvariance.

Alan recently returned to this topic (Deardorff, 2005), and gave a detailed overview of the literature. In the intervening years, conventional comparative

advantage seemed to be on the way out. Trade among similar countries based on scale economies and product differentiation had attracted more interest from theorists and empirical economists alike. The traditional misunderstanding and suspicion of comparative advantage and gains from trade in the general public and special interests in policy debates was reinforced by these developments in the subject: they could now argue that the new ideas had rendered comparative advantage irrelevant. But the last decade or so has seen a revival of North-South trade based on differences in factor endowments and technologies, and therefore a revival of comparative advantage. To quote the prime mover of the new theories (Krugman, 2009): "nobody doubts that trade between the United States and Mexico, where wages are only 13 percent of the US level, or China, where they are only about 4 percent, reflects comparative advantage rather than arbitrary, scale-based specialization. The old trade theory has regained relevance."

On rereading the material on comparative advantage after many years, I see some significant differences between Alan's work and the Dixit-Norman work, and must admit that they mostly favor Alan. He pursued the issues much more tenaciously, seeking results with many countries, under restricted trade, for different concepts of factor content, and so on, whereas Victor and I were content to establish just the one main result for free trade between two countries. Alan also had a much deeper understanding and appreciation of the previous literature on the subject, and for the precise reasons for the anomalies that had been observed, and built his arguments on those foundations. More generally, Alan's writing shows, even at that young age, a mature and professional understanding of the subject, where Victor and I were amateur interlopers. I am happy to have participated in this line of research, and happier to acknowledge that Alan in many respects did better.

I want to mention another occasion when our research interacted, even though it is only indirectly connected to my assigned topic of comparative advantage. Victor Norman and I had developed the "integrated world equilibrium diagram" as a way to understand factor price equalization (Dixit and Norman, 1980, pp. 110-125, 289-292; see also Dixit, 2008). Our method gave a necessary and sufficient condition for factor price equalization in the case of two countries (and

any numbers of goods and factors): the point representing the two countries' endowments in the Edgeworth-type world factor quantity diagram should lie within a set, often called a "lens," obtained by chaining together the factor requirements for the production of the integrated world equilibrium quantities of the goods. The rough intuition is that factor endowments should vary less across countries than factor intensities vary across goods. But extensions to many countries and many factors remained elusive. In Deardorff (1994), Alan took a major step forward. He constructed a corresponding lens composed of all countries' factor endowments, and proved that for factor price equalization it is necessary that the countries' factor endowment lens lies entirely inside goods' factor requirement lens. His proof, following a suggestion of Bill Ethier, was very elegant. Subsequent work (Demiroglu and Yun, 1999) found further conditions under which the lens-inclusion property is also sufficient for factor price equalization.

International trade is not the first context in which I came across Alan's work. At the risk of departing even farther from my remit and encroaching on the subject of the next panel, namely trade and growth, I want to mention one paper, because in this group I may be the only person who knows and remembers it.

Samuelson (1975) set out to find the "goldenest rule of growth." In an overlapping generations model with production, he sought to choose not only the saving rule for each generation and the steady state capital/labor ratio, but also the rate of growth of population, to maximize the steady state utility of each. But Alan found (Deardorff, 1976) that the great man had made a small mistake: under the usual assumption of such models, namely Cobb-Douglas production and utility functions, the second-order condition shows that Samuelson's solution minimizes utility: it is the worst steady state! Samuelson's reply (1976) begins: "*Mea culpa*."

It ends: "Economists are in Professor Deardorff's debt, none more than I." This is the perfect occasion for all of us to join in Samuelson's encomium. And not only, or even primarily, for correcting Samuelson's error; no one would have chosen to implement his solution for population growth anyway. No; we applaud and thank Alan for his whole corpus of work.

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COMPARATIVE ADVANTAGE MEETS ALAN DEARDORFF

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30 September 2009

Comparative Advantage Meets Alan Deardorff

Wilfred J. Ethier
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International School of Economics at Tbilisi State University

We are here to praise Alan Deardorff—hopefully not yet to bury him. This is a delightful task (the praise, I mean), and not just because of his accomplishments, which I'll get to in a minute, but because Alan is one of the truly kind and decent people in our profession, and I feel privileged to have known him over these many years.

I am charged to address Alan's contributions to comparative advantage. This accounts for a considerable share of his total contribution.

Comparative-advantage trade is trade to exploit international differences, whether differences in tastes, technology, or factor endowments, or whether differences due to national economic policies. More formally, a Comparative-Advantage World is defined by the twin assumptions of perfect competition in all markets and no externalities.

The principle of comparative advantage describes the consequences of international trade in the Classical Setting where international factor markets do not exist. There are two aspects: the normative and the positive.

The normative component is the gains-from-trade theorem: If international trade replaces autarky, gainers gain more than losers lose. In each country and therefore in the world as a whole. This result is a direct reflection of the basic nature of a Comparative-Advantage World and, as such, remarkably free of other qualification.

The positive component offers predictions of the pattern of trade and of the effect of trade, for each country, on relative prices and on the pattern of production. But, in contrast to the normative component, these predictions are quite sensitive to model detail: the number of goods, especially.

The principle of comparative advantage was derived as a response to basic concerns of economic policy. Its derivation was critical to the development of international trade theory and to classical economics more generally, and it remains the preeminent accomplishment of the theory of international trade.

For trade theorists, it's been all downhill ever since.

Alan's contributions to comparative-advantage theory have been numerous and wide-ranging. These contributions were without doubt separately conceived, but, with the aid of hindsight, one can see that a remarkably coherent and wide-ranging research program was nevertheless accomplished.

First, nearly all of Alan's research—not just that directed explicitly at comparative advantage— has been conducted entirely in the framework of a comparative-advantage world. *Second*, his work on comparative-advantage trade theory has concentrated predominantly on the positive aspect of comparative advantage, not the normative. *Third*, that work has been successful in addressing the limitations of the positive approach in an impressively comprehensive way. *Fourth*, the whole effort has been characterized by an informed perseverance and clarity of vision consistent with a very large, deliberate, comprehensive, and early-conceived research program.

A fundamental contribution—both seminal in its own right and basic to Alan's larger accomplishment—was Alan's explication [**14**] of the general validity of the positive predictions of comparative advantage in higher dimensions. (Similar work was done contemporaneously and independently by Dixit and Norman [**20**]). These predictions had previously been understood and expressed in simple two-good, two-country models. This fundamental contribution, which resolved questions that had lingered since the very inception of comparative-advantage theory, was achieved relatively early in Alan's career.

So, for Alan also, it has been all downhill ever since.

Alan was able to generalize each of the positive predictions of traditional comparative-advantage theory to a correlation among the relevant variables. Each correlation reduced to the standard textbook result in the 2x2 case. But, as a single constraint on the relevant set of variables, each correlation had less and less bite as the dimensionality increased. Thus the sensitivity of the result to dimensionality was rendered quite clear.

Since these results are basic, they must have wide applicability to trade theory. Alan has indeed done such application, extending the results to the relation between price and output changes [**13**], considering the implications of transport costs [**9**] and of services [**18**], and considering in general the domain of relevance of comparative advantage ([**4**] and [**7**]). Not surprisingly, Alan's interventions have been especially effective when, as in [**11**] and [**15**], a multiplicity of goods is at center stage.

Comparative-advantage trade can be generated by international differences in tastes, technology, or relative factor endowments. Alan explores them all, singly and in combination (*e.g.*, [**10**] for preferences and [**5**] for technology), but the beauty is in the fruitful interplay with distinct and common features of basic trade models, an interplay for which Alan has always demonstrated an uncanny skill.

Alan utilized his basic correlation approach in deriving a general version [**12**] of the Heckscher-Ohlin theorem, which describes the pattern of trade in a comparative-

advantage world in which comparative advantage is determined solely by international differences in relative factor endowments. The Heckscher-Ohlin approach provides the framework for a wide array of contributions (*e.g.*, [**6**], [**8**], [**16**], and [**19**]).

In a series of papers ([**1**], [**2**], [**3**], and [**17**]) Alan, usually with Paul Courant, examines the trade, and general performance, of "lumpy" countries. These are countries that trade with the rest of the world and that may impose country-wide trade barriers, that are composed of distinct regions with limited interregional factor mobility (and thus regional disparities in factor endowments).

This is much in the spirit of Ohlin's [**21**] notion of interregional economic relations. It contrasts with, but is a very natural complement to, the "new" economic geography (which differs most notably from the "old" in its choice of heroes). The latter endogenizes regional disparities, whereas the lumpy-trade models analyze the relation of such disparities to international trade. While Alan deliberately remains in a comparative-advantage world, the economic geography literature consciously does not.

The theory of comparative advantage is central to trade theory and, indeed, is its crowning achievement. Alan has been outstanding in doing it justice. Sometimes nice guys do indeed finish first.

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In Defense of Cones

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A basic question asked of any model dealing with a country engaged in international trade is "what does this country produce?" This is a question that must be raised even if there is a specified list of what commodities the country consumes and what commodities it is technologically capable of producing. The reason is that international trade allows a country's production pattern to be even more specialized than its consumption pattern and, in special cases, for this degree of specialization to reach the extreme limit in which only one commodity is produced, with this commodity exported in exchange for a myriad of imported commodities that are consumed. At the other end of possible scenarios is one in which, with a given number of inputs available at home, the number of commodities that a country produces in a competitive, free-trade equilibrium setting need not exceed the count of its productive factors. For example, in a labor-only Ricardian model a trading economy facing given world prices (given independently of its own technology and tastes) need only produce and export a single commodity in which it has its greatest comparative advantage (relative to the given world commodity prices), and will import the rest of its consumption bundle from its export proceeds. In the simple 2x2 form of the Heckscher-Ohlin scenario with, say, capital and labor the only two factors of production, the country may be specialized to producing a single commodity, or may be required to produce a mixture of both commodities in order to achieve full employment of both its productive factors. In this latter case there will typically exist an entire range of possible factor endowments for which both these same commodities will

be produced in a trading equilibrium. Such a range is referred to as the *cone of diversification*.[1]

The Two-Commodity Case

Figure 1 illustrates such a cone for a two-commodity case in which the two curves depend both upon the country's best technology for producing commodities *1* and *2* and upon world prices (and let the dollar be the unit of account), so that these curves represent the pair of *unit-value isoquants*. The inner convex hull of this pair, including the tangent cord *ENF*, is often referred to as the Hicksian composite unit-value isoquant, or the array of best ways of earning a dollar by producing on world markets for given world prices. The actual production choice depends, of course, on the country's endowment bundle of capital and labor. If the endowment ray lies in the *cone* determined by the tangency points *E* and *F*, the factor price ratio, *w/r*, will be given by the absolute value of the slope of the tangent cord. Should the endowment ray lie outside the cone, the country will be completely specialized to producing a single commodity, say commodity *2* for a country with a high capital/labor endowment ratio, and the factor price ratio will be indicated by the slope of the isoquant. To see the importance and relevance of the tangent cord, *ENF*, consider an endowment ray that passes through point *M*. Producing just commodity 2 at point *M* would yield a dollar in world markets, and there is no other way in which a single commodity, whether the second commodity or, indeed, the first commodity, could, by itself, result in a dollar earned with a smaller bundle of

[1] For an early use of this phrase see the magisterial survey of international trade theory by John Chipman, *Econometrica* (1965, 1966), especially Part 3. The concept of a cone of diversification has frequently been used to good effect by Alan Deardorff, most recently in his article (2009) on the diagram made famous by Abba Lerner (1952) (after originally appearing as a student paper in 1933 at the London School of Economics).

labor and capital. However, producing along the tangent cord, say at point *N*, would also yield a dollar in world markets, and this entails producing *both* commodities, with, say, about 40 cents worth of the first commodity using the techniques at *F*, as well as 60 cents worth of the second commodity using the techniques at point *E*. The *cone of diversification* is the array of factor endowment ratios which would lead a country to produce along the *EF* flat.

An alternative way of illustrating a cone of diversification is shown in the right-hand quadrant of Figure 2. The pair of upward-sloping curves shows that techniques chosen to produce either commodity (that is, the ratio of capital to labor selected) depend upon the market value of wages to rents on capital, and more capital-intensive techniques will be selected the higher is the wage/rent ratio. The left-hand diagram illustrates the connection between the relative commodity price, p_1/p_2, and the wage-rent ratio, *w/r*, *if the country's endowment proportions were to allow diversified production*. Note that the sign of the slope of the locus reflects the assumption made in the right-hand diagram that commodity *2* is the relatively capital-intensive commodity. A further often-assumed property of technology is exhibited in the left-hand diagram: A ray from the origin always cuts the locus so that the ray is flatter than the locus at such a point. That is, an increase in the relative price of the first commodity would, if both commodities can be produced, result in a *greater than proportionate increase* in the ratio of wages to rents. This must be the case if, as is usually assumed, there is *no joint production*: Each commodity is produced *separately* by using inputs of capital and labor.[2]

[2] As discussed in Jones (1965), there is a *magnification effect* whereby relative changes in each commodity price are flanked by the relative change in each factor price. Letting $\hat{x}$ represent *dx/x*, if commodity *1*'s relative price increases, $\hat{w} > \hat{p}_1 > \hat{p}_2 > \hat{r}$.

Suppose that the commodity price ratio is fixed at *0G* on the left-hand side of Figure 2. If both commodities are produced the ratio of wages to rents must be shown by 0H, and the *flat* in the right-hand side displays the array of possible endowment rays, *IJ*, in which the economy can produce both commodities in a competitive equilibrium. These endowments are those shown in the cone of diversification shown in Figure 1.

Figure 2 can be used to illustrate two possible scenarios. First, suppose the relative price of the first commodity should increase. Clearly there would emerge a different, higher, flat in the right-hand diagram. This can also be illustrated in Figure 1 by shifting the unit-value isoquant for the first commodity radially towards the origin.[3] This would serve to rotate the cone of diversification counter-clockwise, with a corresponding steeper tangent cord (and an increase in *w/r*).

Secondly, keep the commodity price ratio unchanged (at *0G*) and consider the changes in production patterns (and wage/rent ratios) either for an economy growing to ever higher capital/labor endowment proportions or for a comparison of the original economy (with an endowment ratio in the cone of diversification) with another economy that shares the same technology but has different factor endowments. In the first interpretation note that if the economy is very labor abundant, it would be completely specialized to the first commodity and, as its relative capital endowment increases, so does its relative wage rate until it enters the cone of diversification. In the cone, until extreme point *J* is reached, the economy's relative wage rate stays constant despite its growth in *K/L*. Although this rules out any accommodation in techniques or factor prices at the *intensive margin*, such growth will be accommodated by changes in the *extensive*

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[3] For simplicity I assume that p_1 increases for a given value of p_2.

margin – the change in the composition of outputs *1* and *2*, with both capital and labor being released from production in the labor-intensive first commodity towards capital-intensive commodity *2*.[4] Further growth in the capital/labor endowment proportions will eventually lead to the economy becoming completely specialized in producing the capital-intensive commodity. The second interpretation introduces a second country, sharing the same technology. Again suppose with trade that the equilibrium price ratio settles at the *0G* level in the left-hand part of Figure 2, and the home country's endowment ray is in the cone of diversification. Will free trade result in the same factor price ratio in the two countries? To some this seemed unlikely since the assumption is being made that factors of production are not mobile internationally. However, such equality would indeed take place if the foreign country's endowment ratio were not too different from that at home, i.e. if it also lay within the cone of diversification.[5] If the foreign country's endowment ratio lies even further from that at home, factor price equalization cannot take place.

Factor Intensity Reversal in Technology

With this simple case in mind, turn now to a different possible outcome, one that was discussed after Leontief (1953) cast doubt on Heckscher-Ohlin predictions by suggesting that American exports were more labor-intensive than American import-competing commodities. It was subsequently argued (e.g. Jones (1956)) that even if countries

[4] In Jones (2004) I showed how this was relevant to development in *open* economies, where even smooth aggregate growth can be hiding strong churning activity between sectors as resources are reallocated at the micro-level.

[5] The possibility of factor-price equalization was shown in Samuelson (1948), but the general surprise shown in the profession led him to restate the argument the next year (1949) in the same journal.

shared the same technology and were both producing the same pair of commodities in a cone of diversification, the technology could allow more than one such cone to exist. Figure 3 illustrates this possibility. The technology for producing commodity *2* is assumed to be less flexible than that for the first commodity so that when labor is relatively inexpensive the first commodity is labor intensive (just as in Figure 2), but at much higher relative wage rates the more flexible technology for producing the first commodity results in its becoming more capital intensive than the second commodity.[6] There are two cones of diversification. The more labor-abundant home country might be incompletely specialized in cone *A* while the foreign country might also be incompletely specialized, but in cone *B*. If so, obviously these two countries, which both share a common set of production functions, would not have their factor prices equalized by free trade. As for the Leontief paradox, it is now a logical impossibility that for this pair of countries each is exporting the commodity that is more intensive in its relatively abundant factor than is its import-competing commodity. Why? Either both countries export the commodity that is capital-intensive in its country, or each exports the commodity that is labor-intensive in its country (Jones, 1956).

Figure 4's right-hand panel illustrates this phenomenon of *factor intensity reversal*. The two positively sloped curves are assumed to intersect each other (and there could be more than one intersection point), a reflection only of the comparison in technologies for the two commodities.[7] The relevant ranges of points along this pair of curves depend

[6] Nonetheless, for an economy with a *given* endowment the commodity that is labor intensive at some level of outputs must remain so for all possible outputs. That is, for constant returns to scale technology, the contract curve in a production box diagram either lies everywhere above the diagonal of the box, below it, or must itself be the diagonal.

[7] It is interesting to note that in subsequent decades much reliance was placed on a particular form for production functions: that of a constant elasticity of substitution (the CES function). When such functions

upon the value of the commodity price ratio, especially since each commodity-price ratio may support more than one factor-price ratio. The locus relating these two ratios is shown in the left-hand panel of Figure 4, and is non-monotonic. Commodity price ratio *0G* is supportive of two flats in the right-hand panel (or two cones of diversification in Figure 3). The lower of the two factor-price ratios supports the flat *A* in Figure 4, and if two countries have endowment ratios on this flat, their factor prices would be equal. If commodity *1* should become a bit more expensive, flat *A* would be shifted upwards, commensurate with the first commodity being labor intensive in this region. Along the upper flat (*B*) an increase in the relative price of the first commodity would lower the relative wage rate. Whereas factor-price equality would prevail if both countries have endowments placing them on flat *B*, this would not be the case if the home country is relatively labor abundant along flat *A* and the foreign country has its endowment ratio anywhere else. If this is in flat *B*, a commonly-faced increase in commodity *1*'s relative market price would lower the foreign country's relative wage rate while wages would increase, relatively, in the home country. They share a common technology and face a common change in commodity prices and yet have factor prices moving in opposite directions.[8]

Finally, consider the case in which the home country starts off by being very labor-abundant, producing nothing but the first, labor-intensive, commodity. Assuming the commodity-price ratio stays the same when the home country experiences growth in its

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have different elasticities, the kind of factor intensity reversal phenomenon discussed here becomes ubiquitous.

[8] Note that the factor-price ratios in the two countries move together in the case in which the price rise is for the commodity that is more flexible in its technology. If, instead, there is a relative price rise for the commodity that has a less flexible technology, the factor-price discrepancy is enhanced.

capital/labor endowment ratio, this country would experience the following changes in its production: Eventually it reaches flat *A* so that resources are gradually shifted out of producing labor-intensive commodity *1* towards the second commodity. When it becomes completely specialized to the second commodity and continues its capital growth, it remains specialized to commodity *2* until flat *B* is reached (i.e. in Figure 3 when the endowment ray, moving in a counter-clockwise manner, enters cone-of-diversification *B*) until further capital accumulation encourages it again to specialize in its capital-intensive commodity, which now is the first commodity. Thus in this two-commodity case in which there is a technological factor-intensity reversal, steady growth in a country's capital/labor endowment proportions can witness a stage when it is transferring resources from commodity *1* to commodity *2* and, following a period of complete specialization, once again produces both commodities but now switches resources back to the first commodity.

Cones in the Multi-Commodity Setting

The discussion of cones of diversification can be extended to the case in which many commodities can be produced and many countries engage in trade. However, a diagrammatic treatment is much easier to pursue while limiting the number of factors of production to two, labor and capital. Figure 5 displays a five-commodity case for a given technology and, as well, a given set of commodity prices. Clearly this combination rules out production of commodity *5* for any country with this technology. Any of commodities 1 – 4 could be produced competitively by an economy with this technology if its factor endowments were appropriate. Given capital and labor as the only productive

inputs, a country engaged in free trade at the given prices could concentrate on producing only a single commodity or a pair of commodities if its endowment ray should lie within cones *A*, *B*, or *C*.

Figure 6 displays this information in a different fashion.[9] With commodity prices given and fixed, production patterns depend upon factor endowments (as in Figure 5), and the heavy locus charts out the path that would be taken if prices remain constant but the country is growing from low to high levels of capital per unit of labor. Note that I have assumed that there are no technological factor intensity reversals, such as shown in Figure 4. Steady growth leads to a production response that starts at an extremely labor-abundant stage calling for complete specialization in the most labor-intensive commodity, *1*, followed by diversified production in flat *A* during which growth favors production of the second commodity, aided by a reallocation of resources used to produce the first commodity. Note that production along every different flat is flanked by ranges in which only a single commodity is produced.[10]

As discussed earlier, such a diagram is also useful in comparing the activities undertaken, and relative factor prices established, in two economies that, although sharing the same technology and facing the same prices for commodities found on world markets, have different factor endowment bundles. Are their factor prices equalized in the global market? Yes, if endowments happen to be located in the same cone of diversification, producing the same pair of commodities, which presupposes that their endowment ratios are fairly similar. Otherwise the more capital abundant region will, perhaps not surprisingly, have higher wage rates relative to the returns to capital, with a

[9] An early use of this kind of diagram for the multi-commodity case is found in Jones (1974).
[10] An exception has to be made for the case in which isoquants are right-angled, so that there is only a single way of producing a commodity regardless of changes in the wage/rental ratio.

different pattern of production. In the spirit of the Heckscher-Ohlin Theorem, it must then be the case that *all* capital/labor ratios found in production in the more capital-abundant country must exceed *any* found in the labor-abundant country. In particular this must imply that the capital-abundant country's exportable is produced by capital-intensive techniques compared to those utilized in producing exportables in a more labor-abundant country.[11] However, this was *not* the test used by Leontief (1953) in his examination of American input-output data. Instead, the Leontief procedure involves comparing factor intensities used in American exports with those in American import-competing production. If, as he found, American import-competing products were more capital intensive than those utilized in the export sectors, would that necessarily imply that America was the more labor-abundant country? Figure 6 shows how, in a multi-commodity setting, such a conclusion is not warranted. Let Home be the capital-abundant country, with factor endowment proportions shown by point *I* on Flat *C*, while Foreign, the more labor abundant country, produces at point *J* on Flat *A*. These two production points suggest that Home devotes most of its resources to produce commodity *3*, for export as well as local consumption, and will be importing commodity *4* (as well as commodities *1*, *2*, and *5* since it does not produce any of them). Labor-abundant Foreign has an opposite kind of trading pattern – exporting its capital-intensive good, *2*, and importing, *inter alia*, its import-competing commodity produced, commodity *1*. The Leontief type of procedure, inferring a factor abundance ranking by comparing (for each country) the ranking between the use of capital and labor in that country's exportable

[11] And this is the case whether or not these two countries trade with each other in a multi-country world, as long as they share a common technology and face the same set of world market prices.

production with the ranking used in import-competing production, would judge Home to be the labor-abundant country! [12]

In discussing the case in which there is a technological reversal of the factor intensity ranking in Figure 4, I pointed out that an increase in the relative price of the first commodity would serve to raise relative wage rates in a country whose endowment ray lay in flat *A*, while lowering relative wages in a country sharing the same technology but possessing a capital/labor endowment proportion in flat *B*. In the current case there are no technological reversals, but much the same result occurs if in two countries factor endowment proportions result not in their sharing a common flat, but rather in having proportions relatively close so that they do share in the production of a common commodity, but also with each producing a separate commodity that is not produced in the other. This is illustrated in Figure 6 by endowment points *J* and *M*. A *decrease* in the price of the second commodity would serve to raise the relative wage rate in the labor-abundant country and lower it in the more capital abundant country, much as in Figure 4's illustration of a *technological* reversal of factor intensities in the two-commodity case even though there are no technological reversals in Figure 6's many-commodity illustration.

Another query that may be raised also concerns the effect of an increase in the price of one of the traded commodities, say commodity *3* in Figure 6. Although not shown, such a price increase would serve to raise the flat in *cone C* and lower it in *cone B*. Does such a price change encourage countries to specialize in production even further? The answer is typical: it depends. For a country at point *I*, originally producing commodities *3* and *4*, a sufficient increase in p_3 would serve to induce the country to specialize completely in

[12] This argument is developed in more detail in Jones (2008).

the third commodity, abandoning its production of the fourth commodity. By contrast, an economy with factor endowments that initially serve to promote specialization in the second commodity may, if the rise in p_3 is large enough, end up in *cone B*, becoming less specialized by producing both commodities *2* and *3*. It all depends.

Concluding Remarks: The Significance of Cones of Diversification

A question that can be raised in any general equilibrium model depicting international trade is how a country can absorb a change in its relative factor endowments (say growth in the labor force with no change in the capital endowment) if all commodity prices are determined in a larger world market. In principle there are two ways: (i) through a change at the *intensive margin*, i.e. through an increase in the amount of labor used per unit of capital throughout the economy, and (ii) through a change at the *extensive margin*, i.e. in the quantities of commodities produced. For example consider a simple version of the *specific-factors* model (e.g. Jones, 1971) in which each of two sectors employs a type of capital utilized only in that sector along with labor drawn from a common pool available to both sectors. If, say, the labor supply expands, the wage rate must fall, serving to raise the return to capital in both sectors (remember that commodity prices are determined on world markets). At the *intensive margin* new labor is absorbed in part by the use of more labor-intensive techniques in both sectors. At the *extensive margin* outputs in both sectors increase, perhaps not in the same proportion.[13] However, in different model settings where the number of commodities produced is as large as the number of productive factors, such as in the 2x2 model illustrated in Figures 1-4 in the

[13] Output in the first sector increases relatively more if the first sector is more labor intensive and/or has more flexible technology.

cones of diversification, adjustment to endowment changes at given commodity prices is achieved by changes *only* at the *extensive margin* . No changes in factor prices (and in the *intensive margin*) are required. This is the basis for the factor-price equalization theorem. With commodity diversification within cones, sufficient to provide the same number of competitive profit conditions (zero profits in equilibrium) as there are inputs, factor prices are completely determined by commodity prices.[14]

Finally, this discussion of the characteristics of the cones of diversification, even in the case of factor-intensity reversals of a technological kind or in the multi-commodity case, reveals the *richness* of Heckscher-Ohlin trade theory. Although the outcome in which factor-price equalization for two countries sharing the same cone takes place at constant commodity prices, with both countries experiencing the same effect on factor prices if commodity prices change, is standard fare in Heckscher-Ohlin trade theory, these results are no longer the only possibilities for the Heckscher-Ohlin model.

A *cone of diversification* entails a trading economy producing as many commodities as there are productive factors in an economy. This is not possible if the number of factors exceeds the number of commodities (as in specific-factors models), in which case any alteration in factor endowments at given commodity prices must result in changes both in the intensive and extensive margins and factor prices must change in order to accommodate changes in factor proportions. However, if the number of commodities an economy is technologically capable of producing is at least as large as the number of its productive factors, one or more cones of diversification exist for each set of commodity prices. Alterations in factor endowments within these cones can be accommodated *without* making use of changes in factor prices and techniques of production, and this is a

[14] Perhaps not uniquely, as Figure 4 illustrates.

phenomenon not shared by any set of factor endowments outside these cones. Heckscher-Ohlin theory is rich in its possibilities for income distribution as endowments and commodity prices change, with the consequences for income distribution depending critically on whether or not the economy's factor endowments lie within a *cone of diversification.*

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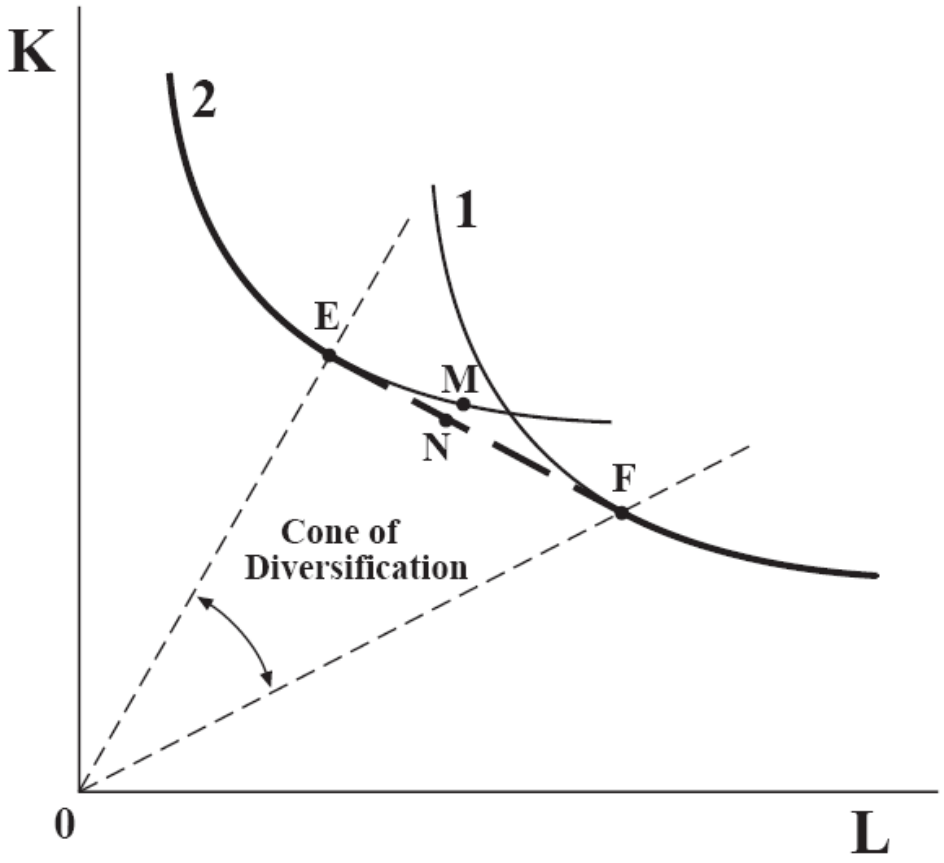

Fig. 1: Cone of Diversification

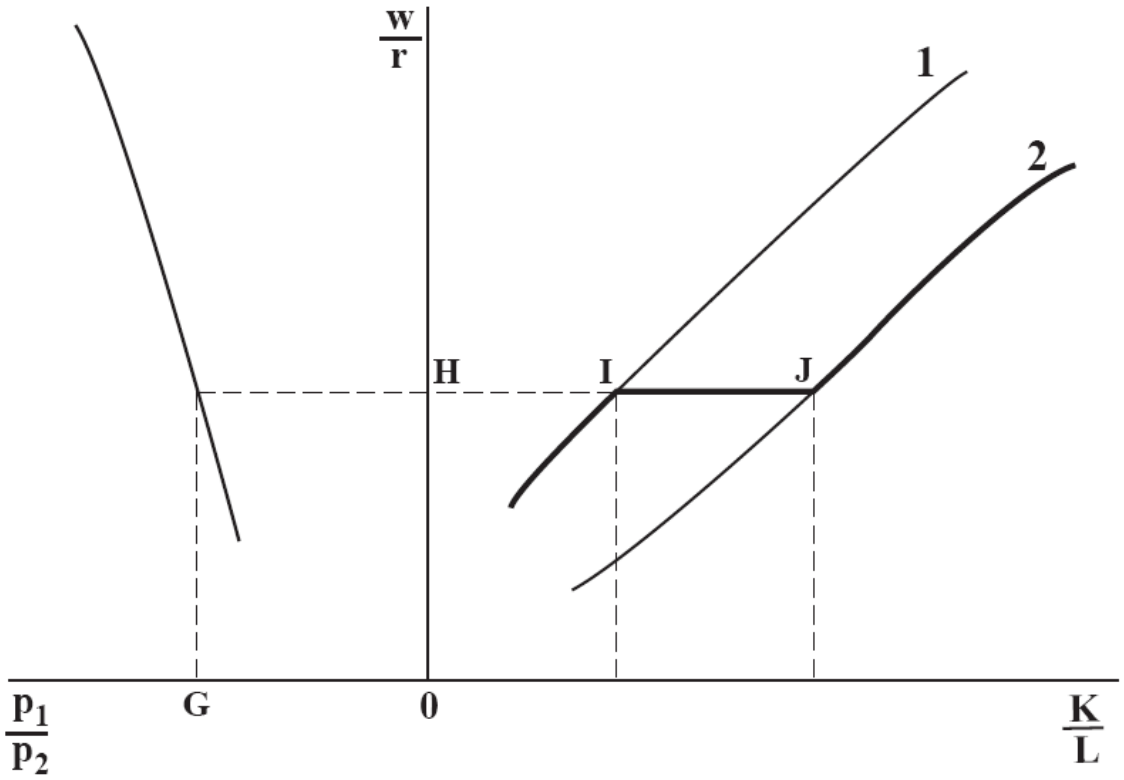

Fig. 2: Prices and Factor Intensities

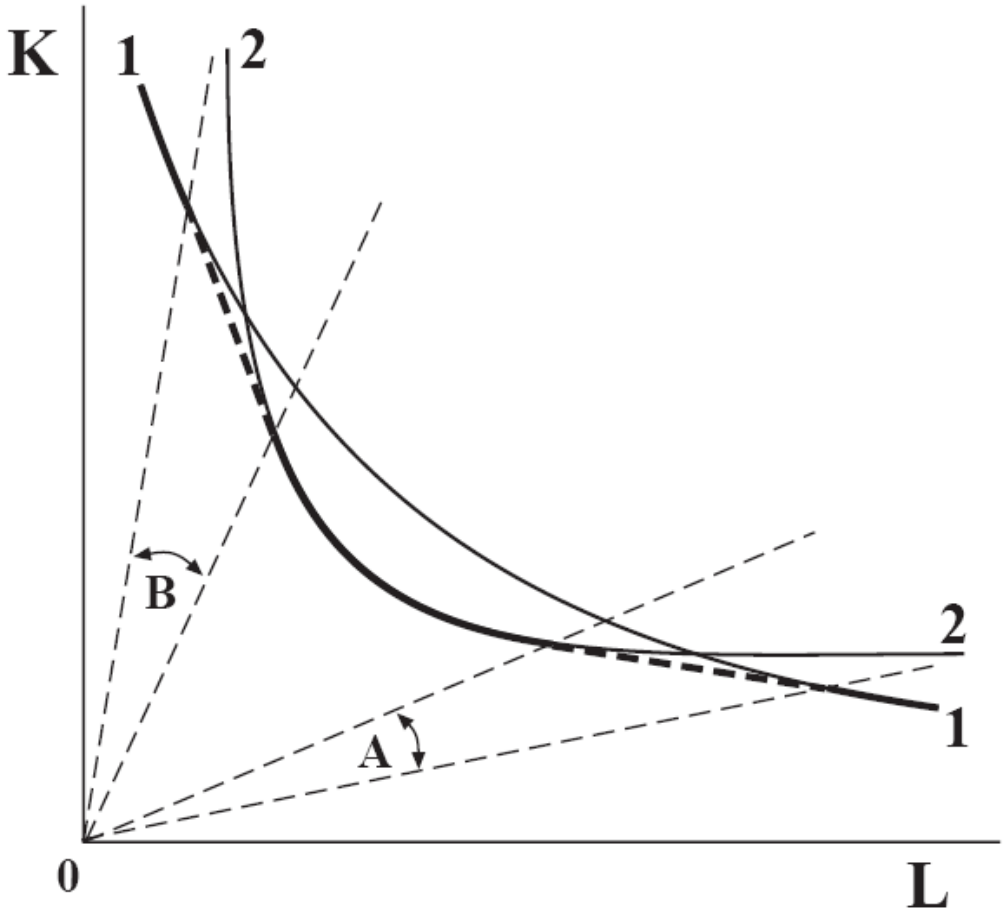

Fig. 3: Factor-Intensity Reversal

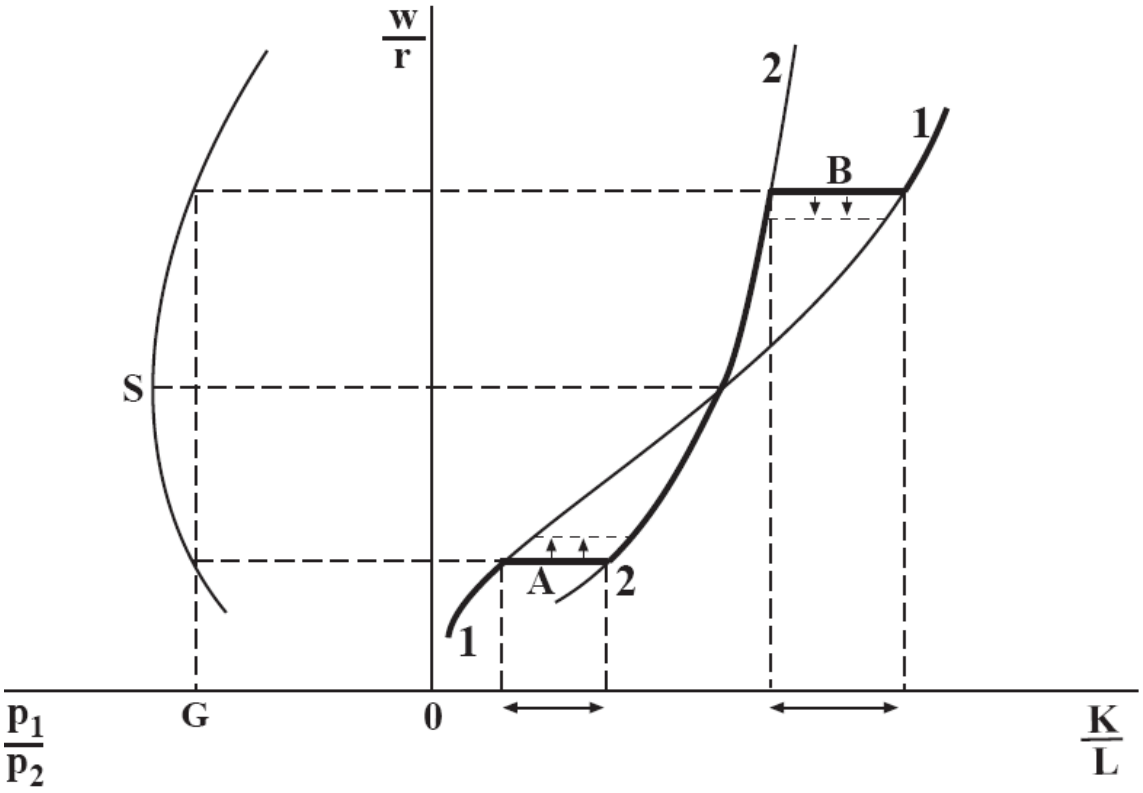

Fig. 4: FIR and Price Change

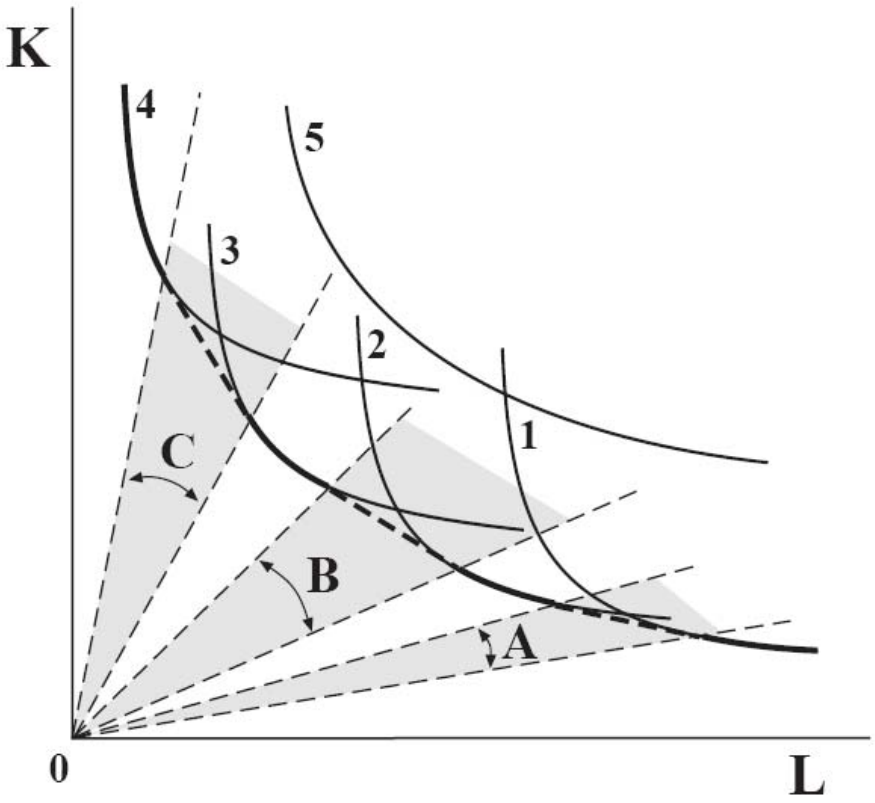

Fig. 5: Cones with Many Commodities

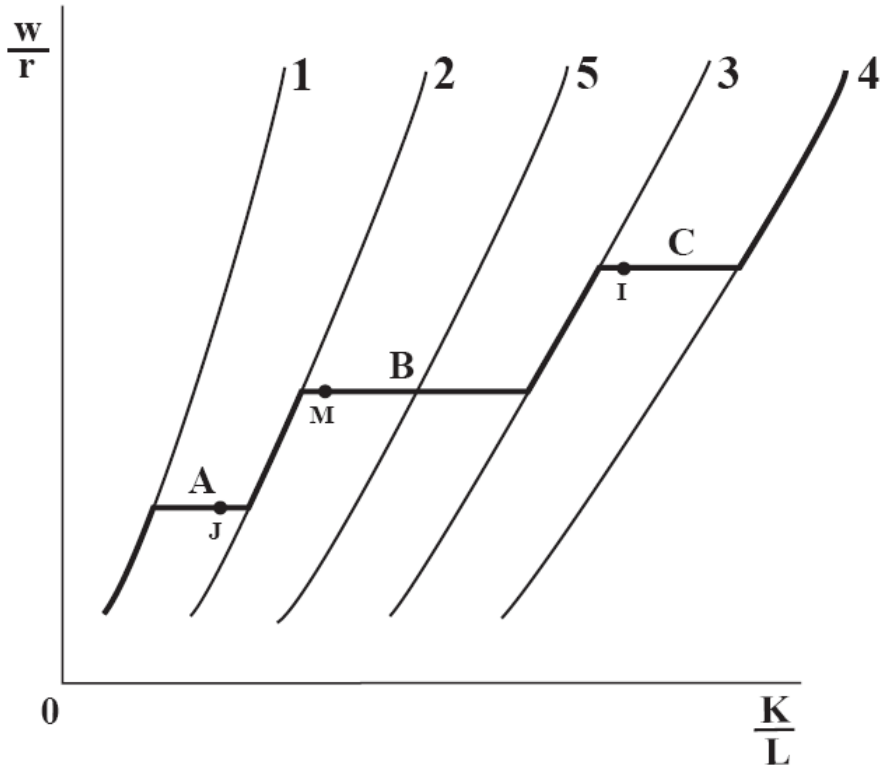

Fig. 6: Growth Path with Given Prices

INCREASING RETURNS IN A COMPARATIVE ADVANTAGE WORLD

Paul Krugman

November 2009

1. *The old new trade story*

I like to begin classes on international trade by telling students that there are two basic explanations of international trade. The first is comparative advantage, which says that countries trade to take advantage of their differences – a concept that lay at the heart of Alan Deardorff's beautiful, classic paper "The general validity of the law of comparative advantage" (1980). The second is increasing returns, which says that countries trade to take advantage of the inherent advantages of specialization, which allows large-scale production – which is what the "new trade theory" was all about.

I also like to illustrate these concepts from everyday experience. Everyday illustrations of comparative advantage are, of course, a staple of introductory textbooks – why sports stars shouldn't mow their own lawns, etc. But it's equally easy to illustrate the role of increasing returns. Even if two people are equally suited for the roles of rocket scientist and brain surgeon, it makes sense for one to specialize on surgery and the other on rockets, because mastering either skill takes years of study, and it would be wasteful for both people to master both disciplines.

So far, so good. But I have also usually tied this potted explanation of what trade theory is all about to a potted version of world economic history as a play in three acts: the fall and rise of comparative advantage. Act I goes as follows: before World War I there was a high level of

world trade, and this trade fitted the comparative advantage paradigm pretty well; it was mainly between very different countries exporting very different goods. British trade, in particular, was mainly a matter of exporting manufactured goods and importing raw materials, and as a result most of the trade was with primary-product exporters that either had much higher land-labor ratios or were at a much lower level of economic development.

This first global economy was largely dismantled by wars and protectionism. Act II focuses on the recovery of trade after World War II, which took a very different form. Much of the growth of trade was the result of liberalization agreements among advanced countries, so that trade between similar countries came to dominate overall flows. And much of this trade between similar countries was also trade in similar goods – intraindustry trade – driven mainly by specialization due to increasing returns, a point noticed early on by Balassa (1966). The new trade theory – or, as my students tend to call it, the old new trade theory – began by using models of monopolistic competition to make sense of this similar-similar trade, essentially formalizing the Balassa's original story.

Finally, in Act III comparative advantage staged a comeback. Trade liberalization in developing countries led to a sharp rise in North-South trade, which meant that once again much of world trade was taking place between very different countries. Unlike in the pre-WWI era, however, developing countries weren't mainly exporting primary products. Instead, they were exporting labor-intensive manufactures. This trade was able to grow so much in part because reductions in transport cost made it possible to fragment production into labor-intensive and skill-intensive stages (the subject of another line of Alan Deardorff's work, e.g. Deardorff (2001). So trade in today's world, like trade before World War II, is largely driven by comparative advantage, in which countries trade to take advantage of their differences.

As I said, this is the story I and many others have been telling for some time. And it's right in many respects. I now believe, however, that it misses an important point: the key role played by increasing returns, mainly in the form of localized external economies, even in times when the broad pattern of trade reflects comparative advantage. These localized externalities played a large role in the world economy of the early 20th century – and they play, if anything, an even larger role today.

2. *Collars and cuffs, buttons and cigarette lighters*

The rise of the "new economic geography" and the increasing use of gravity-type relationships for empirical trade analysis (e.g. Deardorff 199x and Eaton and Kortum 2001) have put space and distance into the mainstream of international economics. Yet we still tend, much more often than not, to model countries as dimensionless points. That's a strategic simplification that makes a great deal of sense for many purposes. But I have recently convinced myself that it's a habit that leads us to miss much of what was really going on in Acts I and III of the story described above.

Let's start by talking about the geography of industrial economies in the late 19th and early 20th century.

Many writers on economic geography have found inspiration in Chapter 10 of Alfred Marshall's *Principles of Economics* (1880), on "the concentration of specialized industries in particular localities." Marshall mentioned such examples as the Sheffield cutlery industry and the Staffordshire pottery industry, but there were many other examples that would have been familiar to his readers: the Nottingham lace industry, the Dundee jute industry, and so on.

On the other side of the Atlantic, the twelfth (1900) census included a quantitative assessment of industry localization (Hall 1902), which demonstrated the extraordinary degree to which some industries were geographically concentrated: detachable collars and cuffs in Troy, NY, underwear in Cohoes NY, costume jewelry in and around Providence, silk in Paterson NJ, and more.

Some of these localized industries owed their origin to specific advantages of the site, but many were the result of historical accident – the blacksmith's wife who supposedly invented the detachable collar in Troy, the local entrepreneur named Egbert Egberts who installed the world's first power knitting machine in Cohoes. And regardless of origins, each localization was sustained by the trinity of agglomeration effects described by Marshall: information spillovers ("The mysteries of the trade become no mysteries; but are as it were in the air"), specialized suppliers, and thick labor markets. In short, external economies of scale.

And here's the thing: at least in the case of Britain, many of these localized industries were export-oriented, selling much of their production overseas. Dundee, for example, dominated global jute manufacturing – and since burlap bags were in demand everywhere, it was largely an export-oriented cluster.

Notice that I'm not asserting that increasing returns in the form of localized external economies actually caused international trade. It was probably the case that in the mid-19th-century world economy only Britain had the right combination of resources, skills, and general technological competence to export many of the manufactured goods it did, in fact, export. In other words, comparative advantage determined the pattern of trade. Nonetheless, increasing returns were clearly evident in the local geography of production. And as I'll argue shortly, this has important implications for how we think about the gains from trade.

Before I get there, however, let me fast forward to today's world – a world in which comparative advantage once again determines much of the pattern of trade. Thus, China's dominant role in the export of many labor-intensive manufactured goods surely reflects its combination of relatively abundant labor and relatively high manufacturing competence. There's not much historical accident in the fact that China makes the bulk of the world's buttons.

But there probably is a lot of historical accident and cumulative causation in the fact that 60 percent of the world's buttons are manufactured in the small town of Qiaotou, where, the story goes, three decades ago three brothers saw some discarded buttons lying in the gutter, realized there was a money-making opportunity, and planted the seed of an industrial cluster. And Qiaotou is characteristic of China's industrial landscape. As was the case for industrial Britain in the 19th century, many of China's manufactured exports are produced by highly localized industries whose geographical concentration shows clear evidence of the importance of external economies. Wenzhou produces 95 percent of the world's cigarette lighters; Yanbu is the underwear capital (the Cohoes of the 21st century!); and on and on.

Again, industrial localization within China probably has little if any impact on the pattern of trade measured at a national level, which basically reflects comparative advantage. But this does not, it turns out, mean that a pure comparative advantage approach tells the whole story. In particular, the story we should be telling about the gains from trade requires that we take account of the effects of external economies, even if these external economies don't affect the overall pattern of trade.

Actually, this should be obvious (but wasn't, at least to me, until I wrote this paper) from the everyday examples we use to illustrate the roots of trade. Suppose that Harry and Louise have to choose between rocket science and brain surgery – and that Louise has a clear advantage in the

surgery department (Harry faints at the sight of blood). In that case, their pattern of specialization is fully determined by comparative advantage: Harry does rockets, Louise does brains. Yet the gains from trade are to a large extent the result not of the differences between the two individuals, but of the inherent advantages of specialization: because Harry can launch Louise while Louise fixes his brain, each of the two only needs to master one skill.

So how do we model this result – trade patterns determined by comparative advantage, but trade gains nonetheless including a strong element of increasing returns – more formally?

3. *Localized external economies and the gains from trade*

When one tries to model the role of localized external economies in international trade, it turns out that the key strategic decisions involve what one assumes about factor prices. *Within* countries, should one assume that factors are perfectly mobile, and therefore equalize across industries, or should one think in terms of "lumpy" countries (Courant and Deardorff 1992) across which wages and other factor prices differ? If factor prices are uniform within countries, what happens *between* countries? Should we assume that trade leads to factor price equalization, or should we model a world in which factor prices are unequal and in which countries that are lucky enough to get a disproportionate share of increasing-returns industries have higher wages?

In reality, there's a strong case for arguing that the lumpy-country representation is more realistic than the assumption of perfect internal mobility. China is famously still very much a dual economy, with an industrial coast and a still-backward interior. In fact, China still has legal restrictions on internal migration, even if these are largely ignored.

And with Chinese hourly compensation in manufacturing still only a tiny fraction of Western levels (Lett and Banister 2009), it's obvious that factor-price equalization does not prevail internationally.

But this paper is an exploratory effort, which means that simplicity is of the essence. So I'm going to do violence to reality and assume both that factors of production move freely to equalize factor prices within countries and that trade leads to factor price equalization internationally. (One can, if one likes, make a partial excuse by assuming that factors are measured in efficiency units, with the productivity of labor in particular varying across countries). The meaning of the first assumption is obvious; the second will take a little explaining.

So let's bring on Samuelson's angel.

In 1949 Paul Samuelson sought to explain the fundamental logic of factor-price equalization with a parable inspired by the story of the Tower of Babel (Samuelson 1949). He asked readers to envision an original state of the world with no impediments to mobility of productive factors, so that all factor prices would be equalized. Then, he suggested, an angel came down to smite each unit of each factor on the forehead – that is, to divide labor, capital, and so on among nations, with the new rule that factors from each country could only work with other factors from the same country.

The question then becomes, how much damage did the angel do? And the answer is that if factors are not too unevenly divided among nations, none at all. For trade can, under certain circumstances, allow the world to produce the same quantity of each good, using the same factor inputs, as it would have if the angel had never made his visitation.

The basic logic is illustrated in Figure 1, which shows a three-good world economy. I'll initially assume constant returns. There are assumed to be two factors of production, capital and

labor, with the sides of the box representing the total world supply of each factor. There are three goods, A, B, and C. The vectors labeled A, B, C represent the factors that would have been employed in the production of each good in the integrated, pre-angel economy.

Now the angel does his smiting. This divides the world's productive resources between two countries, Home and Foreign. In Figure 2, the sides of the box continue to represent total world resources; resources belonging to Home are measured from the southwest corner, resources belonging to Foreign from the northeast corner, so that the division of resources can be represented by the endowment point E.

Does this division do any damage? Not as drawn. In a constant-returns world, as long as the endowment point lies within the irregular hexagon shown it is possible to allocate world production between Home and Foreign in such a way as to reproduce the integrated economy – producing the same quantities of each good, using the same factor inputs, as would have happened if there had been no avenging angel. In such a world equilibrium factor prices will be equalized. It's also straightforward to show that the pattern of trade will reflect factor abundances – specifically, if we look at the factor content of trade we will find each country exporting the factor in which it is abundant.

Now, how does this change if we introduce localized external economies? In the integrated economy, production of each good subject to such localized economies would be concentrated in a single location. To reproduce the integrated economy post-angel, this must continue to be true – which means that each good subject to localization economies must be concentrated in a single country. And this is a case already analyzed in Helpman and Krugman (1985).

Figure 3 shows how it works. Assume that good A is subject to localized external economies, while B and C remain constant returns. Then to reproduce the integrated economy production of

A must be concentrated either in Home or in Foreign, while B and C can be allocated between the countries. This in turn implies that the integrated economy can be reproduced as long as the endowment point lies within either the upper parallelogram – corresponding to concentration of industry A in Home – or within the lower parallelogram, corresponding to concentration of A in Foreign. In the figure as drawn, the endowment point lies in the upper but not the lower parallelogram, so that the only equilibrium that reproduces the integrated economy is one in which Home produces A. (There may be other equilibria that don't reproduce the integrated economy, but I disregard that possibility).

The equilibrium portrayed in Figure 3 may not look significantly different from the equilibrium shown in Figure 2. In both cases the pattern of specialization and trade is determined by resources. In both cases factor prices are equalized, and the factor content of trade reflects national factor abundances. So one might be tempted to say that localized external economies don't matter for the story.

But that turns out not to be true once we turn to the gains from trade.

The standard proof of the gains from trade – the proof that lies behind Deardorff's generalized version of comparative advantage -- is, of course, stated in terms of goods volume and goods prices. As Helpman and I pointed out (1985), however, when trade leads to factor price equalization it is also possible to think of gains from trade in terms of the dual. This isn't especially useful in most contexts. But it offers a convenient way to think about the role of localized external economies.

Figure 4 shows the constant returns case. Note that in this case we're not comparing pre- and post-angel situations – we're back to the more usual comparison between free trade and autarky. In this case the curve shows the unit isoquant for some good. The dotted line represents the

vector of resources that *would have been used* to produce the good under autarky. When trade is opened, however, factor prices – which are, remember, assumed to become equalized internationally – are different from what they would have been under autarky. And what the figure shows is that at the new factor prices, the bundle of resources that was used to produce one unit of each good in autarky now has a purchasing power that is more than enough to purchase that unit in a trading economy. Hence the nation as a whole, which consists of all its productive factors, is more than able to afford its pre-trade consumption: gains from trade.

So far, nothing new. But now introduce localized external economies. These shift the unit isoquant for each good subject to these externalities. The isoquant shifts outward in countries that don't end up producing the good, and therefore lose the external economies they had. But as long as factor prices are equalized, the only thing that matters for welfare is how a country's pre-trade isoquant compares with the post-trade isoquant in the country that ends up producing the good. And it's a reasonable presumption that this isoquant lies inside every country's pre-trade isoquant, since world production of the good and hence the strength of external economies will normally be larger than any individual country's production would have been in the absence of trade.

Figure 5 shows the implications. As before, the bundle of factors that would have produced a unit of the good in autarky are more than able to buy that unit after trade, showing that trade increases national purchasing power. But when goods are subject to localized external economies, there are two reasons for that gain. One is that countries are different, which leads to a change in factor prices. The other is that the concentration of world production in a single location allows greater exploitation of external economies, and hence raises efficiency. There are gains from trade due to the specialization of China in labor-intensive industries like button

manufacture, but there are further gains from trade – gains that accrue to the world as a whole – from the concentration of world button production in the single small town of Qiaotou.

Over the past century world trade has gone through a great arc. At the beginning of the century trade was primarily between countries with very different resources exporting very different goods, so that it seemed to be a comparative advantage world. By the 1980s trade was largely between countries with similar resources exporting similar goods, so that economists turned to increasing-returns models to make sense of what they ~~say~~saw. But today, with the rise of China and other low-wage economies, we seem once again to be in a comparative advantage world, in which countries with very different resources export very different goods.

What I've argued in this paper, however, is that even during comparative-advantage eras increasing returns in the form of localized external economies plays a significant role. In fact, the same eras in which comparative advantage seems to have ruled international trade are also the eras in which increasing returns has seemed to exert its strongest influence on *intra*-national economic geography. And this observation isn't irrelevant even in the trade context: gains from localization arguably are a significant source of gains from trade, even if they don't seem to affect the pattern of specialization.

Does this have any relevance to current policy disputes? Well, many people – myself included – have argued that imports of labor-intensive goods from developing countries exert a depressing influence on the real wages of less-skilled workers in advanced countries. This may still be true, but the role of local external economies may offer a partial offset: if Chinese buttons are cheap not just because of low wages but also because of the advantages of the Qiaotou cluster, U.S. imports of buttons have an ambiguous effect on low-skill wages rather than a definite Stolper-Samuelson effect.

I don't want to push this too far, however. The main point of this paper is simply to point out that increasing returns – made apparent by the localization of industries – have historically played an important role in world trade even in eras when comparative advantage seems to reign supreme.

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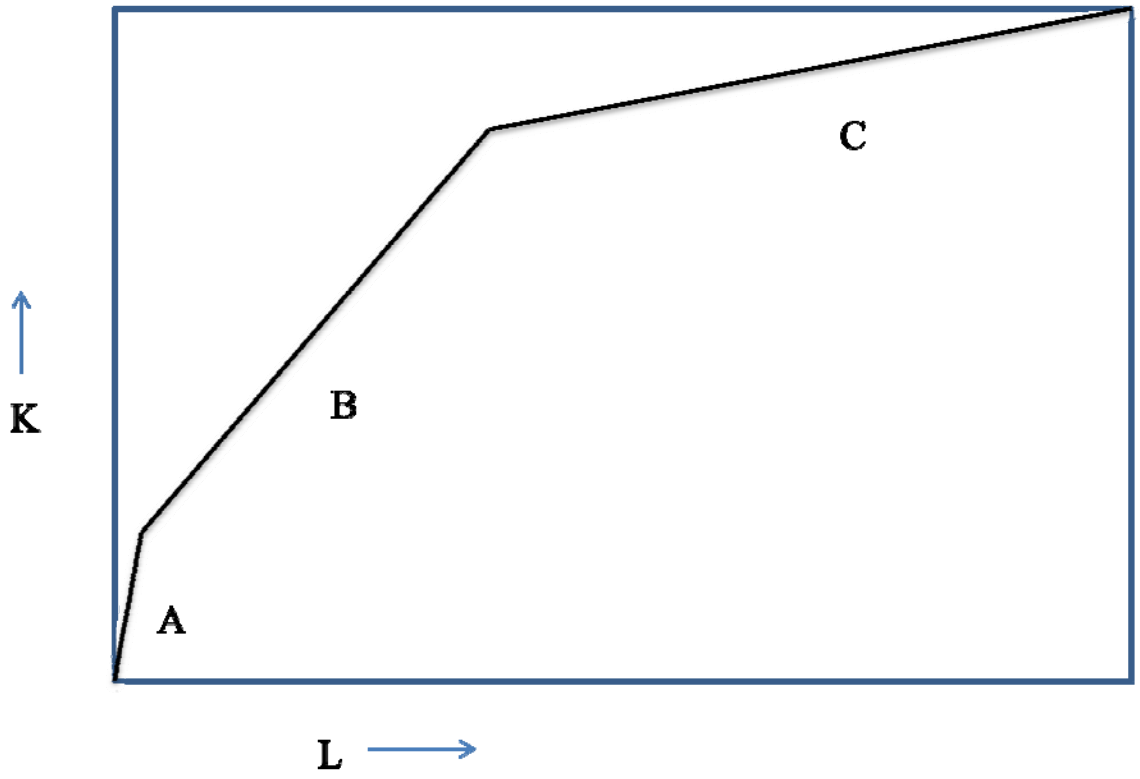

Figure 1: The integrated economy

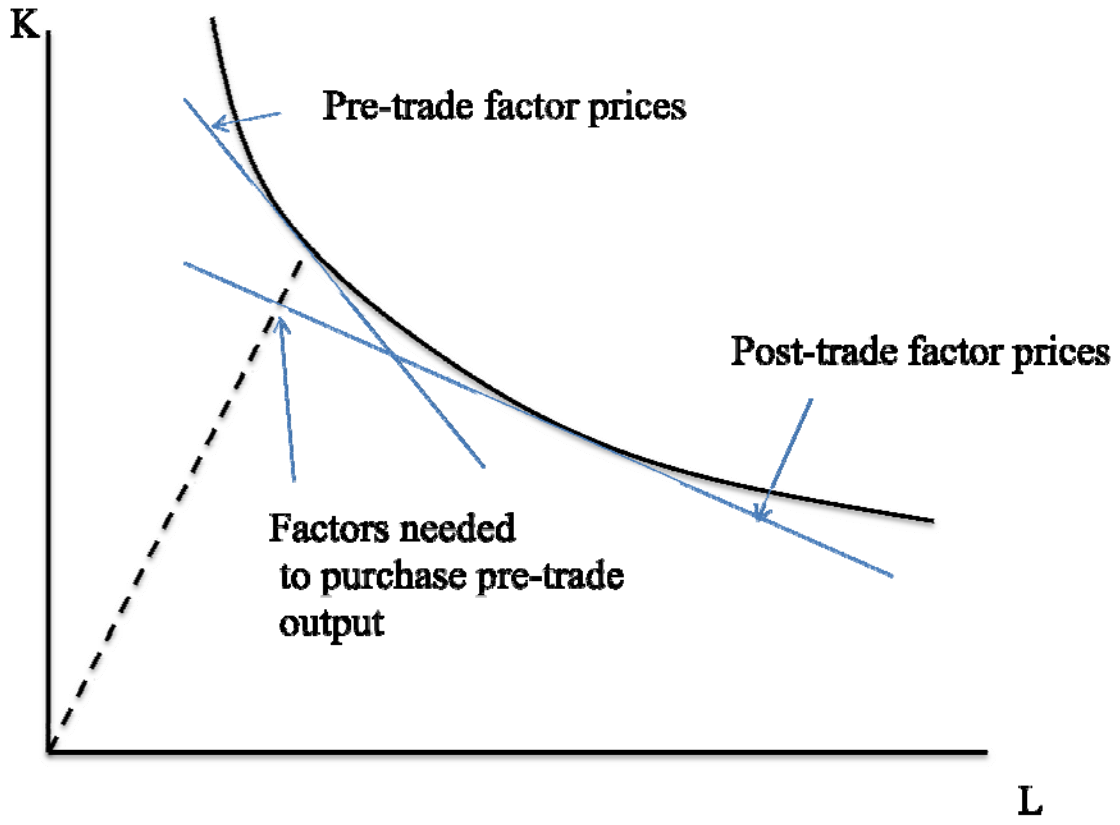

Figure 4: Gains from trade in a constant returns world

Heckscher, Ohlin, and Deardorff

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Contribution to a Panel Discussion on
Comparative Advantage in a Changing Global Economy

Comparative Advantage, Economic Growth, and the Gains from Trade and Globalization:
A Festschrift in Honor of Alan V. Deardorff
Gerald R. Ford School of Public Policy
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It is a huge pleasure to contribute to this happy event. I have known Alan Deardorff for over thirty years and have enjoyed his company and savored his insights on countless occasions. He is not just a great scholar, but also a great guy, an indefatigable champion of the field of international trade, and a disinterested provider of public goods. We are all in his debt for his web resources, useful as well as fun, that shine like a good deed in a naughty world, or, to push the public goods analogy further, like a lighthouse towering over shark-infested seas. (I will refrain from naming any sharks.) Of course, we are also in his debt for his scholarship, and I want to make some remarks today inspired by rereading his classic papers on generalizing the theory of comparative advantage and the Heckscher-Ohlin theorem.[2]

I want to concentrate in particular on the generalization of Heckscher-Ohlin, since I believe that there is more that can be said about this. Alan derived the key result that the value at autarky factor prices of the factor content of trade (which I denote by w^0 and M^1 respectively) must be positive:

$$w^0.M^1 > 0 \tag{1}$$

where M is the vector of factors that would be needed to produce domestically the imports of goods. So, in a very general competitive framework, factors which are expensive in autarky will on average be imported: not directly, but embodied in the goods

[2]Avinash Dixit and Victor Norman (1980) also deserve credit for their independent work on these topics: taken together, the work of these three made a huge advance in explaining what we know and what (ex ante) we cannot know about trade patterns in general equilibrium.

that are actually imported. However, Alan, and others subsequently, were very uneasy with this result. The problem is that we cannot be sure that the net imports of factors as measured by the vector M^1 have a zero mean, and so we cannot use (1) to derive a correlation between the two vectors. In a sense, the problem is that we have failed to address the question expensive relative to what? when we say that factors are expensive in autarky.[3] Alan's response to this was to seek implications of (1) which do yield correlation-type results, and he pursued some ingenious routes to deriving them. One of these was to consider all countries in the world together. Assuming that (1) holds for each, he showed that we can stack the autarky factor prices and net factor imports of all countries to form two giant vectors, and the world version of (1) now yields a true correlation since all countries overall cannot import factors on average, so the stacked world vector of the M^1 must have a non-positive mean.

By contrast, I want to stick with equation (1) and to tease out its implications. One reason for this is empirical: we are unlikely ever to be able to observe autarky factor prices in all countries of a hypothetical non-trading world, so the stacked result is not going to help empirical work, despite its theoretical interest and importance. By contrast, in some exceptional cases we can observe autarky factor prices for a single country, which opens up the possibility of checking whether (1) holds in practice. This is exactly the approach which Daniel Bernhofen and John Brown adopt in an unpublished paper, which extends their earlier work on testing comparative advantage. (See Bernhofen and Brown (2004, 2009).) They have access to an extremely rich data set on Japan for the periods just before

[3]Note that there is no problem of units of measurement: changing the units in which factors are measured can be thought of as pre-multiplying the M vector by a diagonal transformation matrix T. But then the factor prices must also be pre-multiplied by its inverse, T^{-1}, and when we form the inner product (1), T cancels so the result is unit free.

and just after it opened up to trade in the 1860s, and are able to estimate autarky prices for a range of factors, as well as the net factor flows embodied in imports after trade. Reassuringly, they find that equation (1) holds, as the theory predicts. They also find some unexpected implications. For example, when they decompose the inner product to consider the contribution of different factors, they find that much of the implied value of embodied net imports is accounted for by female labor: pointing towards an unanticipated implication of Japan's opening up to trade, that the resulting shifts in industrial structure worked against this factor.

Turning from empirics to theory, I find it instructive to look at the implications of (1) in a number of special models. This shows both the usefulness of the result and its limitations. It is a result we had better like because, in many cases, it may be all we have. To pursue this approach, I use the tools that Albert Schweinberger and I adopted to deriving (1) and some other corollaries in our 1986 paper. Like Dixit and Norman, this uses dual techniques, with the added feature that we introduced a single function to summarize the economy as a whole in its role as a virtual trader of factors. Thanks to Avinash and Victor, most of us are familiar with the GNP function, $g(p,v)$, as a shorthand summary of an economy's technology, giving the maximum value of GNP attainable facing given commodity prices p and with given factor endowments v . It is a tiny step from that to subtract GNP from national expenditure, represented by a consumer expenditure function $e(p,u)$, where u is aggregate welfare, to form what Albert and I called the Trade Expenditure Function:

$$E(p,u,v) \equiv e(p,u) - g(p,v) \tag{2}$$

This equals the difference between national expenditure and GNP, so not surprisingly its

derivatives with respect to prices equal the vector of net imports of goods: $E_p = m$. The next step is to assume that prices equal unit costs in each sector, and to replace the goods prices p with the vector of unit cost functions $c(w)$. Now we can define a Factor Trade Expenditure Function:

$$\tilde{E}(w,u,v) \equiv E[c(w),u,v] \tag{3}$$

This has the nice feature that its derivatives with respect to factor prices equal the net factor content functions, and shows explicitly that they equal the product of the unit factor requirements in each sector (given by the matrix of derivatives of the unit cost functions, c_w or A) and the vector of actual net imports of goods, m :[4]

$$\tilde{E}_w = c_w E_p = Am = M \tag{4}$$

Armed with these tools, return to (1) and ask why it does not extend easily to comparisons between countries. (Similar arguments apply to comparisons between autarky and free-trade equilibria in a single country. However, they require a little more notation and I am already above my quota.) Assume for simplicity that the rest of the world can be represented as a single country, and that it also exhibits a result such as (1), with asterisks denoting foreign variables:

$$w^{0*}.M^{1*} > 0 \tag{5}$$

Now add this to the corresponding result for the home country (1) to get, after a little manipulation:

$$\left(w^0 - w^{0*}\right).M^1 + w^{0*}.\left(M^1 + M^{1*}\right) > 0 \tag{6}$$

If we could show that the first term on the right-hand side is positive, we would have a

[4]All these derivatives are evaluated at domestic factor prices, which becomes important shortly.

significantly stronger generalization of the Heckscher-Ohlin theorem: this term equals the free-trade value of net factor imports, valued at the difference between the home and foreign autarky prices. The second term can therefore be interpreted as a measure of the deviation from Heckscher-Ohlin: factors that are more expensive in autarky at home relative to abroad may nevertheless be exported rather than imported on average if this term is sufficiently positive. Recall that, in deriving the general proof of comparative advantage, there is a parallel derivation with the big difference that it simplifies a lot, since it yields:

$$\left(p^0 - p^{0*}\right).m^1 + p^{0*}.\left(m^1 + m^{1*}\right) > 0 \tag{7}$$

Here the second term vanishes because, in this two-country world, the sum of the net goods trade vectors, $m^1 + m^{1*}$, is equal to zero. Hence we have a prediction about the direction of goods trade which can be reexpressed as a correlation: goods that are more expensive in autarky at home relative to abroad are always imported on average after trade. By contrast, the sum of the net factor trade vectors in (6), $M^1 + M^{1*}$, is not equal to zero in general. Substituting from (4) into (6) we can see why:

$$\left(w^0 - w^{0*}\right).M^1 + w^{0*}.\left(A^1 - A^{1*}\right)m^1 > 0 \tag{8}$$

The problem is that the net factor import vector M^1 in equation (1) must be evaluated using the techniques of production used in the home country, A^1 , whereas M^{1*} in (5) must be evaluated using the techniques used in the foreign country, A^{1*} . Requiring these to be equal is a tall order, though there is one important special case where it holds: as every schoolgirl knows (perhaps I exaggerate just a little), this is when technology is identical internationally and factor prices are equalized by free trade. In that case the second term in (8) vanishes, and we are in a Heckscher-Ohlin-Vanek world where factor

content functions can be estimated directly, as long as both countries remain in the same cone of diversification. Equation (8) also implies a new result: if the home country uses more efficient techniques in all sectors than foreign, then every term in $A - A^*$ is negative, and so the Heckscher-Ohlin correlation $\left(w^0 - w^{0*}\right)M^1$ is positive, even though factor prices need not be equalized.

I want to end with two other, less orthodox, applications of (1). Both involve models which are not usually thought of as having much in common with the Heckscher-Ohlin model. However, both have production sectors which can be represented by a GNP function, allowing the application of the tools developed so far.

The first is to the specific-factors model, often seen as the antithesis of Heckscher-Ohlin, though of course just another special case of a general competitive model. Dixit and Norman derived the GNP function for this model, but it takes a much simpler and more tractable form in a special case recently introduced by Jim Anderson (2009). This assumes that production functions in each sector are Cobb-Douglas, and that each has the same share of labor. Thus the GNP function is the solution to the following maximization problem:

$$g(p,L,k) \equiv \max_{l_i} \left[\Sigma_i p_i x_i \ : \ x_i = \phi_i l_i^{\alpha} k_i^{1-\alpha}, \Sigma l_i = L \right] \tag{9}$$

where L is the scalar endowment of mobile labor, while k is the vector of the endowments of sector-specific capital stocks k_i . Now define $K \equiv \Sigma k_i$ as the aggregate capital endowment, and $\lambda_{Ki} \equiv k_i / K$ as the share of capital in each sector. Jim's result is that the GNP function for this model can be expressed in a particularly simple form:

$$g(p,L,K,\lambda_K) = L^{\alpha} K^{1-\alpha} G \qquad \textit{where :} \qquad G \equiv \left[\Sigma \lambda_{Ki} \left(\phi_i p_i \right)^{\frac{1}{1-\alpha}} \right]^{1-\alpha} \tag{10}$$

This is the product of two sub-functions, one a Cobb-Douglas aggregate of the overall factor endowments L and K, and the other a CES aggregate of goods prices, where the weights are the sectoral capital shares. The nice feature of this specification is that we can get explicit expressions for all variables in general equilibrium. In particular, we can evaluate the Heckscher-Ohlin deviation term in (8) and explore the conditions under which we might expect to observe Heckscher-Ohlin properties even in a specific-factors world.

My second non-standard application is to the model of monopolistic competition with heterogeneous firms developed by Marc Melitz (2003). This model has already proved its usefulness as a guide to empirical work and as a workhorse for many exciting theoretical developments. Only recently, however, has it been shown that it is closely related to traditional general equilibrium models. I am referring in particular to the demonstration by Rob Feenstra and Hiau Looi Kee (2008) that the production sector of the Melitz model, with a Pareto distribution of firms, can be represented by a GNP function essentially identical to the one I have used above. Of course, goods prices are endogenous in a monopolistically competitive equilibrium, but we can take foreign demand parameters as exogenous and relate domestic goods prices to factor prices using standard properties of monopolistic competition with CES preferences. This allows a Heckscher-Ohlin-type result to be derived for a multisectoral version of the Melitz model too, by applying the approach I have used above.

It is appropriate to end by relating one of Alan's great results to the work of one of his students. I hope it shows that we have not heard the last of Heckscher and Ohlin, and also reminds us of another public good which Alan has provided through the outstanding students he has mentored, many of them here today. Heckscher and Ohlin have a lot to be grateful for to Alan, and so have we all.

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Alan Deardorff's Contributions on Trade and Growth*

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1 Introduction

It has been a pleasure to re-read some of Alan Deardorff's papers on trade and growth, and to read others for the first time. These papers are typical of Alan's work; they artfully tease new insights on important issues from simple, familiar models.

It is fitting to begin my review with "A Geometry of Growth and Trade." Alan loves diagrams and given his skill in developing them, it is easy to see why. His diagrammatic analyses are as incisive as any algebraic treatment and more pleasing to the eye.

Deardorff (1974) provides a simple geometric tool for analyzing trade and growth in a small open Solovian economy. Consider a small economy that produces a single consumer good and a single investment good from two factors of production, capital and labor. For simplicity, take the labor force as fixed.[1] Suppose that households save a constant fraction s of income and that capital depreciates at constant rate δ. In Figure 1, $R(p, K)$ represents the *revenue* or *national-product* function for an economy facing world relative price p of the consumer good and having a stock of capital K. As is well known from microeconomic theory, a competitive economy maximizes the value of national output given prices. Therefore, the equilibrium allocation of capital and labor is such that $R(p, K)$ is the economy's national income. And, as is well known from trade theory, a two-sector economy facing a given relative price will specialize in producing the labor-intensive good when its capital stock is small, specialize in producing the capital-intensive good when its capital stock is large, and will produce both goods in an intermediate "cone of diversification." Therefore, the national-product function has two curved portions that depict the diminishing returns to capital when only one good is being produced, and a linear segment whose slope represents the constant marginal product of capital within the diversification cone.

With a constant savings propensity, $sR(p, K)$ represents national savings, which fully finances national investment in an economy that cannot borrow or lend internationally. The dashed line, δK, represents aggregate deprecation, and the gap between the two is net investment. The capital stock grows when $sR(p, K)$ exceeds δK and shrinks when it is smaller. The intersection of the two curves depicts the steady state. The diagram readily yields predictions about the evolution of the trade pattern and about the effects of changes in savings behavior or world prices on the growth path and the ultimate steady state. For example, an increase in the savings propensity leads to a larger steady-state stock of capital, more output of the capital-intensive good, and greater exports (or fewer imports) of that good.

Deardorff (1974) employs the simple assumption that national savings is a constant fraction of national income. But a similar tool to his can be used to study transitional dynamics in an open economy with optimal savings behavior. Suppose the representative consumer allocates spending

[1] The original paper incorporates constant, exogenous population growth by treating the capital-to-labor ratio as the state variable.

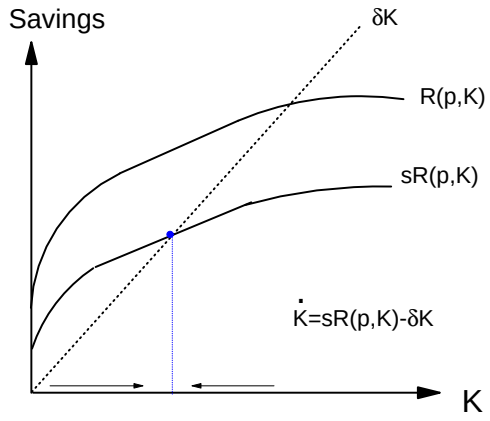

Figure 1: Two-Sector Solovian Trade and Growth

to maximize an intertemporal utility function of the form[2]

$$\int_t^\infty e^{-\rho(\tau-t)} \log c\,(\tau)\, d\tau$$

where $c\,(\tau)$ is consumption at time τ and ρ is a constant discount factor. Then, as is well known, the Euler equation implies

$$\frac{\dot{E}}{E} = i - \rho; \tag{1}$$

i.e., the households adjusts expenditure $E = pc$ so that the rate of growth of spending is equal to the difference between the interest rate and the discount rate. Capital is the only asset in the model and the investment good is numeraire, so the rate of interest i must equal the real return on capital net of depreciation; i.e., $i = r\,(p, K) - \delta$, where $r\,(p, K) = \partial R/\partial K$ is the rental rate on capital. Finally, savings—which is the difference between national income and spending—finances net investment as in Deardorff (1974):

$$\dot{K} = R(p, K) - E - \delta K. \tag{2}$$

Equations (1) and (2) can be used to construct a phase diagram that bears a strong similarity to the Deardorff diagram. In Figure 2, the $\dot{K} = 0$ curve represents the equation $E = R\,(p, K) - \delta K$. The qualitative properties of this curve follow from those of the national-product function, which Deardorff has discussed. The $\dot{E} = 0$ curve depicts the values of K and E such that $r\,(p, K) = \delta + \rho$. Two comments are in order about this curve. First, the level of spending E does not affect anything in this equation, so the "curve" is in fact a vertical line. Second, the factor-price equalization theorem implies a single value of r for all values of K in the diversification cone. If this value of r

[2]It is easy to handle the case of a constant elasticity of intertemporal substitution; the text describes the special case where this elasticity is equal to one.

does not happen to equal $\delta + \rho$, as it generally will not for arbitrary p, then the $\dot{E} = 0$ curve will not be located at any value of K in the diversification cone.

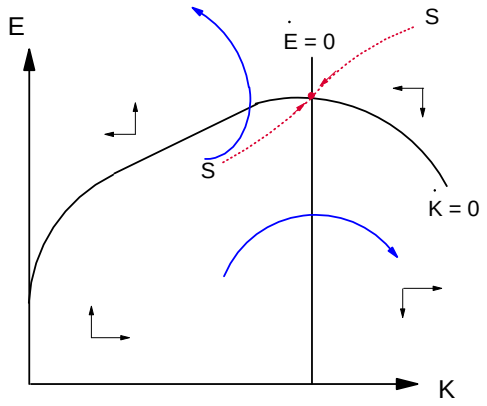

Figure 2: Two-Sector Neoclassical Trade and Growth

The figure shows the "arrows" of adjustment that apply to either side of each curve. It is readily seen that the system exhibits saddle-path stability. For given initial K, there is a single value of the initial level of spending that avoids $K \to 0$ and $K \to \infty$ as time progresses. This initial value of E is the only one that allows for satisfaction of the intertemporal budget constraint and the transversality condition for optimization of lifetime utility. The economy approaches the steady state along the stable arm, denoted by SS in the figure.

The figure can be used much as Deardorff's original diagram. It is easy to track the evolution of the trade pattern and to perform comparative statics with respect to changes in the discount rate or the international relative price. One conclusion differs from that in the Solovian world: a small open economy with optimal savings and a constant discount rate is quite unlikely to remain incompletely specialized in the long run.

I see several important substantive themes in Alan's other writings on trade and growth that have gained traction in the more recent literature. First, trade may be harmful to a growing economy in some circumstances. Second, and related, an open economy may be trapped in poverty in a world with multiple steady states. Third, growth may be sustained by trade in a neoclassical economy that would be doomed to stagnation if it remained closed to international exchange. I take up each point in turn.

In Deardorff (1973), Alan analyzed the effects of trade on *per capita* consumption in steady state and in the approach to steady state. He considered an open economy capable of producing a single consumer good and a single investment good that saves a constant proportion of its income, as in Deardorff (1974). He proved, for example, that a small economy that saves in excess of the golden rule savings ratio will experience a reduction in steady-state consumption if the world relative price

of the consumption good is a bit above its autarky price.[3] If its savings rate falls short of the golden rule savings ratio, then steady-state consumption falls with an opening to trade if the world relative price of the consumption good is a bit below the autarky price. Intuitively, steady-state consumption increases if a country starts in autarky with less investment than is needed on the margin to maintain a unit of capital and it exports the investment good, or if it starts with more capital than is needed on the margin to maintain a unit of capital and it imports the capital good.

The paper also considers the effects of trade on per capita consumption in the short run; that is, in the moments after an opening of trade. If trade causes the relative price of the consumption good to rise, thereby generating exports of this good, then *per capita* consumption will initially fall. If the relative price moves in the opposite direction and the country exports the investment good, *per capita* consumption will rise.

This analysis suffers from two shortcomings. First, as Alan himself recognized, it is not typically optimal for households to consume a constant fraction of their current income. Alan thus relates his findings to the theory of the second best. But convincing second-best arguments that question the gains from trade usually refer to realistic market failures, not to empirically unsupported and somewhat arbitrary assumptions of sub-optimal behavior. Second, it is impossible to evaluate the welfare effects of an opening of trade that induces short-run gains and long-run losses (or *vice versa*) without reference to some intertemporal utility function. The Solow model offers no such utility function and therefore no metric for welfare comparisons. Subsequent to Deardorff (1973), Samuelson (1975) and Smith (1979, 1984) showed rigorously that a neoclassical economy with well-functioning markets always gains from trade when savings decisions derive from utility maximization, no matter what is the form of its intertemporal utility function.

But the possibility of losses from trade has been emphasized in recent writings on trade and growth in non-neoclassical settings. Most common are models in which growth is driven by local knowledge spillovers. These can be spillovers in human capital accumulation, as in Lucas (1988) and Stokey (1991), or spillovers in the R&D process, as in Young (1993), Feenstra (1996) and Grossman and Helpman (1991, ch. 8; 1994).

The idea is quite simple. Consider a two-sector economy, one in which technology is static and another in which technology can improve with the accumulation of human capital or knowledge. There are spillovers in the accumulation process that offset the private diminishing returns, so that growth can be sustained. In the autarky equilibrium, the economy is incompletely specialized and the ongoing activity in the dynamic sector ensures the continuing accumulation of knowledge. Although the autarky allocation of resources to the dynamic sector will be sub-optimally small in the absence of a Pigouvian subsidy that addresses the externality, growth is sustained. Now open the economy to trade and suppose that the country has a comparative disadvantage in the dynamic sector, either due to its relatively unsuitable resource endowments or to an initial disadvantage of history that gives its trade partner a technological head start. In either case, the opening of

[3] The golden rule savings rate is the value of s that generates the golden rule capital-to-labor ratio as its steady state. The golden rule capital-to-labor ratio, in turn, is the value of K/L that makes the marginal product of capital equal to the sum of the population growth rate and the depreciation rate.

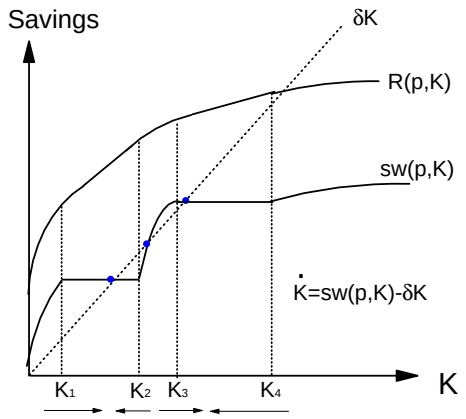

Figure 3: Multiple Steady States

trade will cause the country to specialize relatively and perhaps fully in the industry with a static technology. Its growth in output will slow and perhaps cease as a result of trade. Even so, trade may be gainful, since the country will be able to import the good produced in the dynamic sector at a lower price than in autarky. But it is easy to construct examples in which trade is harmful in these circumstances, for reasons to do with the theory of the second best. Inasmuch as the autarky equilibrium entails too little production of the dynamic good, if trade drives resources out of this industry it can generate losses by exacerbating a pre-existing distortion. Of course, losses from trade would not be possible if the opening of trade were accompanied by an appropriate Pigouvian subsidy to the externality-generating activity.

Deardorff (2001) makes a related but different point, drawing on work by Galor (1996). He considers a neoclassical economy that potentially can produce three goods, one investment good and two consumption goods, with capital and labor. The industries differ in their factor intensities, so there are two cones of diversification. Following Galor, he supposes that savings are approximately proportional to the wage bill, perhaps because there are overlapping generations and each generation earns capital income only in the last period of life, when it consumes all. Figure 3—analogous to Figure 1—shows the aggregate savings for this economy as a function of its capital stock. For low values of K, the economy is incompletely specialized and the wage bill rises as capital is accumulated. The region between K_1 and K_2 represents the first diversification cone, where the country produces the two least capital-intensive goods. In this range, factors prices are insensitive to factor endowments, so the wage bill is constant, as is aggregate savings. Further capital accumulation leads to a range of specialization in the intermediate good, again with a rising wage bill, and then a second region of diversification, for capital stocks between K_3 and K_4. Finally, if capital were to accumulate beyond K_4, the economy would specialize in producing the most capital-intensive good, and savings would rise with K.

As is clear from the figure, this economy can have three distinct steady states, the first and third of which are locally stable. In other words, an economy such as this can get stuck in a "poverty

trap." If it starts with a capital stock less than K_1 and trades with an otherwise identical economy that begins with more capital, then it will accumulate capital until it reaches the first steady state, whereupon its growth will cease at a relatively low level of *per capita* income.[4] Differences in initial conditions are sufficient to generate long-run differences in income and welfare for countries that are otherwise the same in terms of their technologies and savings behavior.

This is an interesting finding inasmuch as multiple equilibria are not common in neoclassical growth models. The allusion to an overlapping-generations setup is intriguing, as it seems possible to have a poverty trap together with fully optimal savings behavior and convex technologies.

The potential for multiple equilibria among identical countries also arises in non-neoclassical settings. In fact, this possibility is quite natural in models with static or dynamic increasing returns to scale. Azariadis and Drazen (1990) offer an example with multiple steady states even in the closed economy. They consider an economy with "threshold externalities"; i.e., externalities generated by human capital that are relatively weak when the stock of human capital is small, but grow stronger as the skill level increases. In such a setting, an economy can get trapped in an equilibrium with low skills, despite the fact that it has the potential for sustained growth were it to manage somehow to escape the trap.[5] Young (1993), Feenstra (1996), Grossman and Helpman (1991, ch.8) and others show the possibility for trade to generate permanent income (or growth rate) differences between otherwise identical countries that differ in their initial levels of technological development. They consider an international equilibrium with trade between countries that differ only in their initial levels of technological development. Were the countries to remain closed, they would converge upon similar long-run steady state growth paths. However, with trade, the leading country gains an initial advantage in the more dynamic sector, and the advantage is perpetuated (or even extended) over time.

In neoclassical growth models, diminishing returns to capital typically spell the stagnation of growth in *per capita* incomes as increases in the capital-to-labor ratio drive down the marginal return to investment. Growth need not peter out however, as Solow (1956) himself noted, if the return to capital is bounded from below. This idea of bounded long-run returns to capital has featured prominently in a branch of the literature on endogenous growth, where models with such features have been termed "AK models." See, for example, Jones and Manuelli (1990) for an application to the open economy. However, many have questioned the plausibility of the assumption that marginal returns will be bounded from below as the capital-to-labor ratio grows indefinitely.

Deardorff (1994) was one of the first to point out that growth can be sustained in some circumstances in an *open* neoclassical economy even if the technology does not admit a lower bound on the return to capital. His explanation relies on cross-country differences in population growth rates and the opportunities afforded by international investment.[6]

[4] If the economy is large, the equilibrium prices may be changing in the transition, in which case the national income and aggregate savings curves will be shifting about. Nonetheless, the point remains that there can be multiple steady states and a stable equilibrium at a low level of national income. With more than three goods, the number steady states can increase.

[5] One way out might be with a "big push," as emphasized by Murphy, Shleifer and Vishny (1989).

[6] Deardorff (1999) uses a similar framework to study the evolution of international inequality in *per capita* incomes.

Consider a pair of Solovian economies that each produce a single good. Let the population growth rates and the savings rates be exogenous and country specific. Alan refers to the country with the slower population growth as the North and the country with the faster population growth as the South. Technologies are such that both the North and the South will approach constant steady-levels of *per capita* income in their autarkic equilibria. But suppose now that the North can invest its savings in the South. Then, for some savings rates, it avoids the otherwise inevitable rise in the capital-to-labor ratio by making use of the ever-larger Southern labor force. When the North has slower population growth and a sufficiently large savings rate, *per capita* income in the North grows forever. For even higher Northern savings rates, national income growth in the North matches the rate of population growth in the South, and residents of the North come to own a significant portion of the world's capital despite being a vanishing fraction of the world's labor force. Deardorff (1994) observes that, in circumstances in which the North enjoys sustained growth in *per capita* income but national income growth less than the rate of population growth in the South, a change in the North's savings propensity will change its long-run growth, just as in models of endogenous growth. In short, Alan points out that, by investing abroad, a relatively small country (in terms of population) can escape diminishing returns at home.

This argument bears a family resemblance to a related point made by Ventura (1997). He considers a small, Heckscher-Ohlin economy that trades freely at fixed prices. The economy has two sectors with diminishing (and non-bounded) returns to capital in each, and savings derived from intertemporal utility maximization. Without trade, this economy would approach a steady state. With trade, it will do so as well, as was illustrated in Figure 2. But, Ventura points out, the country will experience a potentially-long growth phase when its endowments are within the diversification cone during which the return to capital will remain constant. The constancy of returns to capital reflects the factor-price equalization theorem applies during this phase. But as long as the country remains incompletely specialized, it is as if it had access to an AK technology. So the growth experience for a long time might mimic that which would be predicted by such a model. And, of course, changes in policy and in savings behavior will alter the growth rate during this episode.

Deardorff's (1994) story of sustained growth is an interesting one that deserves further attention and development. To me, it seems to beg for the endogenization of population growth. Can populations diverge forever? Might the South of Deardorff's model experience a demographic transition at some stage? Or might trade postpone or even prevent such a transition? Going further, can we justify sustained differences in savings behavior? Are these differences "cultural" or do they reflect the growth experience? There is much to be done with endogenous preferences and endogenous procreation in models of trade and growth.[7]

Let me end this review where I began. I have long been a big fan of Alan Deardorff, whose work is always clean, crisp and elegant. His papers on trade and growth complement the many other areas to which he has contributed, including his brilliant work on comparative advantage and his

[7] See Galor and Weil (2000) for a very interesting contribution of this sort.

very useful applied research on trade policy. I am happy to be part of this celebration and look forward to his continued productivity for many years to come!

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COMPARATIVE ADVANTAGE, ECONOMIC GROWTH, AND THE GAINS FROM TRADE AND GLOBALIZATION:

A FESTSCHRIFT IN HONOR OF ALAN V. DEARDORFF

University of Michigan
Gerald R. Ford School of Public Policy/Department of Economics

Friday and Saturday, October 2-3, 2009
Rackham Amphitheater

Alan Deardorff Festschrift Remarks

Anne O. Krueger
Johns Hopkins School for Advanced International Studies
Stanford Institute of International Development

10–11 AM, Friday, October 2, 2009
Panel Discussion: International Trade and Economic Growth
Moderator: Robert Staiger, Stanford University
Gene M. Grossman, Princeton University
Anne O. Krueger, Johns Hopkins School for Advanced International Studies, Stanford Institute of International Development
TN Srinivasan, Yale University

Alan Deardorff Festschrift Remarks

Anne O. Krueger

September 30, 2009

I am pleased and honored to participate in this celebration of Alan Deardorff. He has contributed enormously to the profession through his research, his teaching, his policy contributions, and his good citizenship in the profession. I won't comment on his teaching and good citizenship except to say that I've encountered many of Alan's former students, both graduate and undergraduate, and all speak enthusiastically about his support and role in their education, including in some cases their decision to go on to graduate school in economics. And many of his former students, who are participating in this symposium, have continued down paths opened up by Alan, and of course, his colleagues.

One of the many impressive things about Alan has been the breadth of his interests and contributions, as the organization of today's program attests. And not only have his interests and contributions been broad, they have encompassed both positive and normative theoretical and empirical work.

The marching orders for these comments included the request that we reminisce a bit about the development of the field of international economics. In thinking about comparative advantage and growth, that is almost a natural starting point.

Recall that the Heckscher-Ohlin model has been around for a long time. Even Ellsworth's classic 1938 textbook presented it, suggesting that there would be a "tendency" toward factor price equalization as labor-abundant countries exported their labor-intensive goods and capital-abundant countries their capital-intensive goods. The Heckscher-Ohlin model was very attractive intuitively. It seemed to fill in a hole left by the Ricardian model by explaining – apparently – why there were differences in relative costs and prices between countries.

But in the late 1940s, Paul Samuelson contributed his paper showing that with incomplete specialization (and the other assumptions well known to all of us) there would be factor price equalization. And, at about the same time, Leontief came up with his famous factor content of trade paper, now referred to universally as the Leontief paradox.

Both of these papers raised enormous and challenging questions about the HOS model, as it was soon called, which occupied much of the intellectual energy of international trade theorists and empiricists over the next several decades. For, while the HOS model was appealing in its original "tendency to" form, the logical conclusions that derived from careful examination of the underpinnings of the model seemed entirely at variance with the facts, and Leontief's empirical findings were even more challenging. When the workhorse model seemed to fly so much in the face of reality, it was small wonder that we focused on trying to figure out why.

Efforts were theoretical and empirical. On the theoretical side, more goods and factors, specific factors (at the extreme there was a paper with one specific factor for each good, which seemed somewhat tautological), constant or varying elasticities of substitution (with the possibility of factor intensity reversals), many countries (was Germany labor-abundant relative to the U.S. or capital-abundant relative to developing countries?), and many more variants were tried. While examination of the bilateral factor content of trade was shown theoretically not to be the correct test, empirically many pairwise countries' trade patterns were examined with mixed results.

Alan's early contributions focused on this central range of issues (although, to his credit, he never forgot that comparative advantage and the arguments for free trade rested on differences in relative autarkic prices and NOT on the reasons for them in many plausible models). Much of his early work, "Weak Links in the Chain of Comparative Advantage', "General Validity of Law of Comparative Advantage", "General Validity of the Heckscher-Ohlin Theorem", and "An Interpretation of the Factor Content of Trade" with Bob Staiger were all of this ilk, as was his masterful contribution to the Jones-Kenen handbook on "Testing Trade Theories and Predicting Trade Flows". That interest has continued, as perusal of his c.v. shows, with his 2001 EJ paper producing a 3 good model permitting two cones of diversification with factor price equalization in each cone but divergence

between them. He believes that the “two-cone” world economy better fits the facts than a single factor-price-equalization outcome, and has contributed significantly to understanding some north-south issues on that basis, arguing that as the south now attempts development, countries in the north are threatened in a way they were not earlier in the growth of the world economy.

But Alan has also delved into issues of trade and growth going way beyond the HOS model (which, of course, could immediately be transformed into a growth model). Perhaps because of his focus on many-goods models, his range of interests has covered a wide area: intellectual property, outsourcing, sources of the rich-poor divide in trade negotiations, political economy, and, of course, the impact of alternative proposed liberalizations of trade under the WTO.

In addition to twists and turns of HOS models, of course, we have in recent years begun to understand other sources of gains from trade: imperfect competition when the variety and quality of goods can be greatly increased, while costs are lowered, through trade; the effects of increased competition resulting from international trade on individual firms’ incentives to produce more efficiently; and much more. I doubt that any of us now thinks that any one model fully explains the pattern of trade. But I also doubt that any would deny that factor proportions are part of the overall explanation. Alan’s contribution to our understanding of the

power and the limits of factor proportions in multi commodity, multi country, models has contributed significantly, and advanced, that understanding.

In each of these areas, and many more to be covered in other panels, Alan has been thoroughly professional in seeking to understand the underlying sources of comparative advantage, the benefits of international trade, and the effects of alternative policies on trade. His work is cited in professional journals, in policy analyses, and in textbooks. A perusal of two textbooks that I happened to have on my shelf showed Alan cited several of his early papers on the HOS model, for his "Weak Links in the Chain of Comparative Advantage", for much of his work with Bob Stern on the impact of trade liberalization in the various MTN rounds, and for much that will be discussed in other panels.

Alan, I salute you for your intellectual contributions, your thorough professionalism, and for your many advances in our understanding of the international economy. This celebration is well deserved.

Panel Discussion: International Trade and Economic Growth[1]

T.N. Srinivasan
Yale University

Let me begin by saluting Alan Deardorff for his enormous contributions to trade theory per se and importantly to parts of theory that have served as formulations for empirical analysis. There are many I could cite from his large body of work. I will cite just three: Alan Deardorff (1998) is among those who provided a theoretical foundation for the workhorse of empirical analysis of bilateral trade flows, namely the gravity model that goes back to Jan Tinbergen (1962) and Hans Linneman (1966) of the Tinbergen School. The others are his classic papers on the general validity of comparative advantage, one (Deardorff, 1980) Ricardian model-based and the other (Deardorff, 1982) Heckscher-Ohlin-Samuelson (HOS) based. Alan embeds each in a multi-country, multi-factor, multi-commodity Arrow-Debreu competitive general equilibrium model and then asks and answers a well-posed question: which of the basic propositions of the simple Ricardian or HOS models survive in more general settings and if they do, in what form. More generally, Alan, like many distinguished theorists, uses propositions of theories with their strong and unrealistic assumptions, about consumer, producer behaviour, and the markets as benchmarks for asking and answering in a systematic and coherent way, the implications of well-specified departures from the strong assumptions. Thus, in his use the role of theories and their conclusions is only as a device for generating propositions rigorously which serve as benchmarks for systematic

[1] In preparing these remarks, I have drawn on Srinivasan (2001), Srinivasan (2008) and Srinivasan and Wallack (2004).

analysis of reality. He does not have to believe the theories literally for this purpose. I doubt whether he or any distinguished theorist ever did,

Recently there has been a flood of critiques by economists and media persons, some times by economists serving as newspaper columnists, of macroeconomic theory and policy making prior to the onset of the financial crisis. It would seem that the critics show little understanding of the proper role of theory in thinking about policy making in the real world. Some, including distinguished theorists of trade and open economy macroeconomics, who ought to know better, charge those theorists from whom they apparently differ for other reasons possibly including political beliefs of theorists as literal believers in the conclusions of their theory, be it of efficient markets or of dynamic stochastic general equilibrium, unbounded rationality or what have you! Some even go far as basing their charges on a “pithy” quote or two in and out of context from those they criticize. Clearly such economist critics and their critiques do not advance our discipline.

Recent contributions to trade theory are clearly exciting and continue their traditional base on general equilibrium theory. Unfortunately, trade policy making and debates, for example, on globalization continue to be prime examples of what Alan Blinder calls Murphy’s Law of economics, namely, that economists have the least influence on policy in areas such as trade where they know more than others and are least divided.

Turning to the topic of this panel, I want to draw attention to an important and policy relevant distinction between economic growth and economic development.

Although the two have important linkages and openness to international trade and investment contributes to both, they are not the same. In many ways objectives of development go beyond the objective of accelerating growth, and achieving the former often depends on overcoming or alleviating domestic institutional constraints including governance much more intensively than for achieving growth objectives. In addition, both sets of objectives are multidimensional, involving different characteristics, different time horizons and so on. Lack of understanding of this distinction and its complexity has led to the misnaming of the Doha Round of Multilateral Trade Negotiations as the Development round that has led, on the one hand, to unrealistic expectations that once the Doha Round is successfully concluded with an agreement with a "balanced outcome," then the development problems would be solved and its goals achieved as well, and, on the other hand, to fears, if not despair, that if Doha fails, achievement of development goals will be stalled forever. Neither the expectations nor the fears are warranted. This is because the sources of most constraints that inhibit faster development are domestic. A successful conclusion of the Doha Round could, though not necessarily would, ease some of the external constraints on development, it certainly would not ensure development success if the domestic constraints are not addressed.

On the relation between economic growth and international trade, long ago Dennis Robertson (1940) described "trade as an engine of growth", meaning that greater openness to trade would trigger faster growth. On the other hand Irving Kravis (1970) described "trade as a handmaiden of growth", meaning that faster growth would lead to greater trade. The existence of a possible two-way relationship between the

two, that is, the endogeneity of outcomes of openness and growth means the results of empirical analyses based on a single equation, a “reduced form” kind with one of them as the variable to be explained and the other as one of the explanatory variables could vary depending on how the endogeneity is addressed. This opens the door for the search for clever instruments, a search that has unduly occupied some of the creative members of our profession recently! Apart from this, most empirical studies do not recognize the results of “second best” theory, as applied to trade and domestic distortions. For example, removing some distortions on trade while keeping intact others on trade and also non-trade related ones, need not lead to the “first best” expectations of improvements in efficiency. Moreover, whether or not it would depends on the local context.

Simply put, the sources of aggregate real GDP growth of an economy are basically three: growth of inputs into the production process, efficiency in the allocation of inputs across the production of goods and services, and technical progress in the sense of successful innovation in discovering new products and more and more productive technologies and in their adoption into production. Openness could potentially contribute to all three sources: first by separating the domestic use of inputs from their domestic endowments or supply. For example, a country which wishes to use more than or less of its endowment capital (or for labour of any type) can import or export some of it. By exporting its excess capital endowment, for example, it could earn more from its use abroad than at home. Thus, trade in inputs yields gains both trading partners. The link between improvement in efficiency through exploitation of comparative advantage, by shifting use of inputs towards goods and services in which

the domestic economy has a comparative cost advantage and growth is straightforward. To the extent the gains in efficiency though such reallocation of inputs are in part saved and invested, obviously such efficiency gains from trade contribute to growth. Even if the efficiency gains are fully consumed, their contribution to increasing welfare is evident. Finally, the mechanisms through which openness serves as a source of innovation in the domestic economy are several: horizontal and vertically spillovers of knowledge from foreign direct investment, learning of new products or more productive ways of producing existing products by domestic exporters and others.

Whether or not the potential contribution of greater openness to the three sources of growth are realized will depend on the functioning of domestic institutions including importantly the financial and legal systems, domestic political economy, the existence of relevant markets, their depth and efficiency and so on. Distortions in any of these could limit the beneficial effects of openness and could even reverse them. Unfortunately, much of the recent empirical literature on globalization on growth, poverty, employment, etc., does not often explicitly build the various mechanisms by which globalization could have effects and test for their absence or presence, but taking into effect any constraints that may inhibit their full use. I am deeply skeptical of the "dummy variable" approach for assessing the effects of domestic factors. In my view, the dummy variables are mute and dumb on what the mechanisms factors through which they might have contributed to the observed effects.

In saying all this, I am not dismissing the very impressive recent theoretical developments on foreign trade, investment and growth based on preference for variety, economic geography of agglomeration effects, the development of process-based trade

as compared to trade in products and the related phenomena of outsourcing and off-shoring, and above all, shifting the analysis to the incentives operating at the firm level for participating in foreign trade and increasing the extent of their participation, if they decide to participate. Nor do I dismiss the surprisingly few empirical studies which rest on sound theoretical foundations. I expect to see in future the recent trend in exciting theoretical developments to continue now that more of the recent Ph.D. cohorts have entered trade theory and not only theory, but also theory with a focus on their empirical applicability and policy relevance. By their research these cohorts would be paying a fitting tribute to Alan Deardorff and his contributions.

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COMPARATIVE ADVANTAGE, ECONOMIC GROWTH, AND THE GAINS FROM TRADE AND GLOBALIZATION:

A FESTSCHRIFT IN HONOR OF ALAN V. DEARDORFF

University of Michigan
Gerald R. Ford School of Public Policy/Department of Economics

Friday and Saturday, October 2-3, 2009
Rackham Amphitheater

Comments on Alan Deardorff's Contributions on the Subject of the Gains from Trade and Globalization

Robert E. Baldwin
University of Wisconsin

11:15 AM –12:15 PM, Friday, October 2, 2009
Panel Discussion: The Gains from Trade and Globalization
Moderator: Drusilla Brown, Tufts University
Robert E. Baldwin, University of Wisconsin
Edward Leamer, UCLA
Arvind Panagariya, Columbia University

COMMENTS ON ALAN DEARDORFFS CONTRIBUTIONS ON THE SUBJECT OF THE GAINS FROM TRADE AND GLOBALIZATION

Robert E. Baldwin

It is an honor to participate in a festschrift for Alan Deardorff. Alan is a master theorist. He has made major contributions to our understanding of so many economic concepts and relationships in international economics with his modeling and analytical skills. Moreover, he has done so in an exceptionally clear manner, often using geometry as well as algebra to make his points.

I have been asked to comment on Alan's contributions on the topic of gains from trade and globalization. Very rightly, I think, Alan takes a very broad view of what constitutes globalization. He takes globalization to mean the increase in international transactions in markets for goods, services, some factors of production, plus the growth and expanded scope of institutions that straddle national borders such as firms, governments, international organizations, and nongovernmental organizations. As he and Bob Stern say in one of their papers, globalization is not only growth in international trade but expansion of foreign direct investment, multinational corporations, integration of world markets and resulting financial capital flows, extraterritorial reach of government policies, attention by NGOs to issues that span the globe, and the constraints imposed on government policies imposed by international institutions.

Alan has written a number of papers exploring the welfare and other economic effects of some of the newer and less familiar forms of globalization such as fragmentation, business and social networking and outsourcing.[1] Let me summarize some of his contributions on these topics. Following Jones and Kierzkowski (1997) who first introduced the term, Alan defines

[1] See References for a listing of Alan's papers covered in this comment.

fragmentation as the splitting of a production process into two or more steps. We generally think of a two step fragmentation process as arising because of technological progress that permits a country to specialize in the fragmented segment in which it has a comparative advantage and import the other intermediate input. This enables the country to produce a larger amount of the final good than formerly possible and thus move to a higher budget line than it faced before that fragmentation process. If the country is small so that world prices are fixed, the country cannot lose in welfare terms, as Alan shows. However, as we know from the Stolper-Samuelson relationship, particular groups within a country can lose even if the country as a whole gains. Moreover, if a country is large so that world prices can change as a result of the fragmentation process, he also shows that it is possible for the country's terms of trade to worsen sufficiently for it to end up at a lower welfare level. However, he concludes that fragmentation is more likely to benefit countries rather than make them worse off.

In his analysis of networking, which he regards as a decline in trade costs, Alan disagrees with the pioneer in this topic, namely, Jim Rauch, when it comes to the question of whether an increase in networking can reduce a country's welfare. Rauch argues that this is possible whereas Alan argues that it is not, at least in an undistorted world economy. The reason is simply that trade costs are real costs, using up real resources whereas, in contrast, tariffs do not. Because a reduction in real costs uses real resources, a reduction in these costs permits the world economy to do exactly what it did before and still have some resources left over. As he says, a competitive economy will then use these released resources to produce more and yielding a world output that is worth more at the new equilibrium prices than the outputs previously produced. But perhaps Rauch has in mind an economy in which there already exists economic distortions.

Before leaving the topic of the welfare effects of such activities as fragmentation, I want to discuss briefly just what economists mean when they say that a country or the world gains from trade. As Alan points out, our current understanding of what is meant by a country gaining from trade dates from two articles by Samuelson, one in 1939 and another in 1962, almost 25 years later. Assuming for simplicity that there are only two individuals and two goods in a distortion-free economy, Samuelson in his 1962 article introduces the notion of *point* and *situation* utility possibility frontiers that depict, respectively, the maximum ordinal utility reached by each individual by distributing between the two individuals a particular quantity of goods attainable under autarky or free trade in every possible manner and by distributing between the two individuals the sets of optimal quantities of the goods that can be obtained under autarky or free trade. The *situation utility possibility frontier* is the envelope of all the optimal collections of goods that could be obtained under one of these policies, i.e., all the *point utility possibility curves* attainable under autarky or free trade.

Since the maximum quantities of the two goods achievable under a *policy of free trade* is greater (except for one point) than under a *policy of autarky*, the utility possibility curve based on the *free trade situation* lies entirely outside the utility possibility curve based on the *autarky* situation. This means that that by appropriate lump sum redistribution (assumed to be costless) that would change production and trade levels it is possible to make everyone better off under the *free trade situation* than under *the autarky situation* no matter what the initial free trade distribution of goods. This is the sense in which it can be said that the *policy* of free trade is potentially welfare improving for a country compared to a *policy* of autarky. For similar reasons, it can be said that a *policy* of imposing optimum tariffs is welfare improving compared to a *policy* of free trade. However, free trade in the sense of the particular collection of goods

obtained under this policy is not potentially welfare improving compared to the particular collection of goods obtained under autarky. The *point* utility possibility curves obtained in these cases may intersect.

It seems to me that trade economists (but not Alan) too often fail to be clear that when they say free trade is better than autarky that they are talking about the *policy* of free trade and the *policy of autarky* and not the particular collection of goods obtained by following these policies.

The last topic in Alan's writings on the gains from trade and globalization that I want to discuss briefly is his interesting analysis of the making the rules of globalization in political economy terms. He points out that corporations have played a significant role in formulating these rules in international organizations such as the GATT, the WTO and NAFTA. For example, the stimulus to focus the Tokyo Round of trade negotiations on nontariff trade barriers came mainly from business interests. Similarly, the political pressure to include trade related intellectual property rights as a negotiating subject in the Uruguay Round came mainly from the business sector. We know from direct observation and assume in our economic models, that corporations are not interested in promoting general economic welfare but their rather own welfare, namely, profits. As Alan points out, while economic theory is reassuring about the effects of the profit motive when it drives behavior in competitive marketplaces, there is no such reason to trust its effects in the political arena. In short, there is no reason to expect the invisible hand to guide governments that are under the influence of corporations toward desirable outcomes in political markets.

Alan cited two instances where he believes corporations have shaped the rules of globalization in a manner that increased their profits at the expense of the general public. One is

the TRIPS agreement in the Uruguay Round and the other is Chapter 11 of NAFTA. The TRIPS agreement requires all countries to enact and enforce intellectual property laws that are comparable to those that exist in developed countries. This, in his view, is a change that can only benefit rich-country owners of intellectual property and harm poor-country consumers.

Chapter 11 of NAFTA requires that any expropriation of the property of a foreign investor be accompanied by appropriate compensation. What Alan finds particularly objectionable is that the victim of such expropriation can bring a case before a NAFTA tribunal against a national government of the country in which the expropriation took place. Moreover, it seems that it is being used not just against direct expropriation but against governments whenever they introduce a policy or regulation that reduces a corporation's profits. Alan believes that both of these provisions go too far in giving corporations power over foreign governments, a conclusion with which I think most of us would agree. Thus, I think that Alan's broadening of his studies of the gains from trade and globalization to include investigations into the political economy of how the rules for globalization are determined is very worthwhile and encourage him and other economists to pursue this line of investigation further.

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On Some Aspects of Globalization

Arvind Panagariya[*]

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On Some Aspects of Globalization

Arvind Panagariya

In his wide-ranging *World Economy Lecture*, Alan Deardorff (2003) embarks upon a journey of the writings of globalization critics. In the course of the journey, he identifies their complaints with which he agrees, those with which he disagrees but understands within the context of the standard trade models and those that do not fit the conventional theory. In the latter case, he goes on to develop alternative models that may better capture the concerns of the critics. In addition to his usual analytic clarity, rigor and originality, the lecture also brings to fore a most admirable characteristic of Alan's personality: his eagerness to listen to the opposite view and, if persuaded by it, a willingness to modify his own thinking. For the benefit of his friends who may have missed reading this lecture, I can scarcely resist quoting from its concluding section:

"In preparing for this talk, I read more than I ever had before of the writings of globalization critics, including several books and numerous items on the web. …

"As I mentioned to colleagues along the way, I sometimes felt that I was brainwashing myself by reading the works of globalization critics. Particularly, perhaps, because I was determined to keep an open mind to their point of view rather than constantly marshalling my economist's presumptions against them, I found as I read that I too sometimes became appalled at the state of the world that they described. I too sometimes easily accepted that it was globalization that had in some manner contributed to this situation.

"In the end, what I realized was that my previous defensive posture towards the critics of globalization had perhaps prevented me from giving proper weight to the flaws

in the world system that even defenders of globalization have long deplored. I tended, before this, to dismiss those flaws as exceptional and to focus instead on much broader good that I thought globalization could do and had done. The latter, I still think, was appropriate, but the flaws deserve attention too."

My objective in this short paper is to honor Alan by imitation, "the sincerest of flattery" in the immortal words of Charles Caleb Colton. As in his lecture, I select a set of themes underlying the writings of globalization critics. Given the scarcity of time and space, it is not possible to touch on all the themes Alan has covered in his *World Economy Lecture* and elsewhere. Instead, I limit myself to issues relevant to developing countries—my current preoccupation—on which I have something new or different to say.

1 Developed Country Protection and Subsidies in Agriculture

Globalization critics have often pointed out that while preaching liberalization to the developing countries, developed countries have themselves retained high level of protection and subsidies in agriculture. They not only accuse the developed countries of hypocrisy but also vehemently criticize them for hurting the poorest developing countries by driving down the prices of agricultural products in which the latter enjoy comparative advantage. Most economists embrace this criticism and gladly join the globalization critics in calling for the removal of agricultural protection and subsidies.

Yet, as I discuss in Panagariya (2003, 2005), while tariffs and subsidies in agriculture deserve to be criticized and removed for their usual trade distorting effects, criticisms by globalization critics and some economists, most notably Stiglitz (2002),

focusing on the hypocrisy of developed countries and injury to the poorest countries are misplaced for at least four of reasons.

First, regarding hypocrisy, the truth of the matter is that until the launch of the Uruguay Round, the developing countries themselves had no interest in market access in agriculture. They sought to industrialize and therefore were focused on either import substitution or market access in industrial products, often through trade preferences rather than reciprocal bargaining in the GATT (General Agreement on Tariffs and Trade) rounds of multilateral negotiations.

Second, in so far as the effects of the subsidies and protection are concerned, the facts are largely the other way around: they benefit rather than hurt the poorest countries. European tariffs and subsidies have the effect of driving down the world prices of most agricultural products and raising them internally within Europe. Whether an outside country loses or benefits from this depends on whether it is an exporter or importer of agricultural products. It turns out that an overwhelming majority of the Least Developed Countries (LDCs) is a net food importer and a significant majority is a net agricultural importer. The decline in the world prices of agricultural products therefore benefits the majority of the LDCs at least at the national level.

This point came to the fore recently when food inflation struck the world economy. Rather than celebrate the price hike as a boon to the fortunes of the poor countries, virtually all saw it as a curse for the poor countries. There was near universal outrage that the poor countries suffered the most from food inflation!

Third, once we take account of the trade preferences available to the LDCs in the European Union (EU) market, it can be shown that virtually all LDCs benefit from the

existing system of protection and subsidies. Under the Everything But Arms (EBA) initiative, the EU permits the products of LDCs to be sold free of duty in its markets. This means the LDCs sell their exports at the high internal EU price and buy their imports at the low external, world market price. On both counts, they benefit.

Finally, agricultural protection is not purely a developed country phenomenon. True, the Cairns Group developing countries have a comparative advantage and low protection in agriculture. But many developing countries that are net importers do have high agricultural protection. Recall that it was the Indian demand for a very generous special safeguard in agriculture that has been one of the important stumbling blocks to the conclusion of the Doha Round.

Before I conclude this section, an objection to the above points as also an exception to which these points do not apply may be noted. The objection is that even if the LDCs gain from the low world prices because they are net agricultural importers, the poor may be hurt because they must compete against the subsidized imports. Deardorff (2003), who has clearly thought through this issue more deeply than most critics, clearly anticipates this point when he writes,

> "As a trade economist, I am fond of pointing out that in the aggregate such subsidies hurt the country whose government pays them and actually benefit the rest of the world. And if the subsidies were in fact delivering affordable food to the world's hungry, I would not mind them at all as long as they could be depended on to continue. But in fact, as I understand it, most of the hungry in the developing countries are in rural areas where, instead of benefiting from this cheap food, they have to compete with it for livelihood. In the long run, that may or may not be best

use of their labor, but in the short run these subsidies are simply driving small developing country farmers further into poverty. That is inexcusable."

But even this objection is subject to two qualifications. First, in principle, the LDC farmers can access the internal EU price under the EBA. Their competition is not with the subsidized external, world price but instead with the EU internal price. Second, even if competition with the subsidized external price is a problem, the LDCs are far better off employing a countervailing duty on imports, which is entirely legal under the WTO rules. Such duty would allow the LDCs to realize the higher price for their farmers while also contributing to their revenue kitties.

The exception to the proposition that developed-country subsidies benefit the LDCs arises in the case of cotton. As it turns out, the EU produces no cotton and therefore applies no subsidies and tariffs to it. As a result, its internal cotton price equals the border cotton price and the EBA offers no relief to LDC exporters of the product. The culprit in this case is the United States, which subsidizes cotton production and drives down its world price. Four small West African countries are net exporters of the product and are hurt by the low price. But even here, the subsidy benefits Bangladesh, which is a net importer of cotton. Unsurprisingly, cotton is the only product cited as an example of rich country subsidies hurting the poor countries. Even sugar turns out to be a mixed case.

2 Intellectual Property Rights, Labor Standards and Rule Making

The issue of geographical expansion of intellectual property right (IPR) protection to include all countries in the world has been another important contentious issue in recent years. A key component of the Uruguay Round Agreement was the Agreement on Trade

Related Aspects of Intellectual Property Rights (TRIPS), which extended the approximate intellectual property protection standards in the United States to the entire world. All countries except the LDCs were required to introduce these standards in their domestic laws latest by January 1, 2005. The LDCs were given a temporary reprieve in pharmaceuticals sector but they too must introduce them by January 1, 2016.

The key contentious element of TRIPS negotiations related to the extension of 20-year patent protection to both process and product in the area of pharmaceuticals. By maintaining a weak intellectual property regime that recognized only process patents, some developing countries, most notably India, had successfully created substantial indigenous low-cost medicine industry. Local firms in these countries could alter the production process of medicines still under patent in the developed countries and sell the generic version so produced at a fraction of the price of the original medicines. These countries opposed the extension of product patent in pharmaceuticals to them.

Deardorff (1992) provides a formal model that brilliantly captures the sources of the tensions associated with the TRIPS negotiation. The model hypothesizes a fixed cost of each medicine to be invented of which there are potentially numerous. These medicines may be ranked based on their present value of the consumers' surplus net of production costs and the cost of innovation. Ideally, one will want all medicines with zero or positive net present value to be innovated and produced. But since innovations are a public good they must be supported by either a government subsidy or patent protection. Because government subsidies bring their own problems, patent protection remains the principal viable practical option under most circumstances. The social cost of patent protection is, of course, the monopoly distortion in the product market. The patent gives

the innovator to sole right to manufacture and sell the medicine. The longer the patent, the more medicines are innovated. But the longer the patent, the higher the social cost of monopoly distortion in medicines that are innovated even under a shorter patent. The optimal patent is the one that equates the gain from the last medicine innovated to the increased social cost of distortion on intra-marginal medicines. It is evident that the optimal patent is finite. For producers, a longer patent is almost always better than a shorter patent since it gives them monopoly rights for a longer period. The consumers must weigh the benefits from additional innovation on the margin against the monopoly cost incurred on the intra-marginal medicines.

The tension between costs and benefits, which arises when the patent is extended over time, also arises when it is extended in space. When the intellectual property protection of a given length of time is extended to another country, it brings more innovation on the margin but it also extends the monopoly distortion in all existing innovations to that country. Such extension may or may not be beneficial from the global welfare viewpoint. Even if it is beneficial, it will turn harmful as we keep adding more and more countries. If innovating firms are concentrated in the countries already covered by the patent and the newly included country is relatively poor so that the beneficial impact on new innovations is minimal, the former gain while the latter loses.

This simple Deardorff model of intellectual property protection neatly brings out all the tensions at work in extending intellectual property rights to the poor countries: pharmaceutical firms acquire the right to collect royalties in the poor countries, developed countries that do much of the innovation also benefit and the poor countries stand to lose since they losing royalty-free access to patented medicines.

The only possible source of significant gain to the poor countries is the possibility that the patent would stimulate innovation in medicines specifically relevant to them such as those relating to malaria and tuberculosis. But even this gain will fail to materialize, as has been the case so far, if the purchasing power in the poor countries is insufficient to support the research necessary to innovate the medicines. This is likely to be the case since the initial cost of research in an area in which pharmaceutical companies have not been engaged before are likely to be large while the ability to pay for medicines in the poor countries is likely to be small.

The central theme of Alan's *World Economy Lecture* is that globalization critics view globalization as benefiting corporations and hurting workers. Deardorff (2008) picks up this theme and develops the idea that a key avenue through which corporations exploit the globalization process to their advantage is through rule writing. In this latter paper, he offers the TRIPS Agreement as an example of rule writing by corporations.

There is no doubt that the United States pharmaceutical firms were the key driving force behind pushing and perhaps even drafting some of the language of the TRIPS Agreement. By extending the patent protection to the developing countries, these firms stood to reap extra rents on the innovations they would have undertaken anyway to serve the developed country markets. They also had the necessary political muscle to get the United States Trade Representative to negotiate the desired agreement on their behalf.

Nevertheless, it was perhaps the north-south rather than capital-labor tension that dominated rule writing in the TRIPS negotiations. Benefits from the TRIPS Agreement were to accrue to the United States pharmaceutical firms not so much at the expense of the United States labor or labor anywhere for that matter as the developing country

consumers. The corporations could exercise their muscle in the TRIPS negotiations principally because the United States government was backing them up. And the counterweight to the corporations was provided not be the United States or other countries' labor lobbies but, instead, the developing country governments.

As it turns out, at least as of now, the AFL-CIO (2008) officially supports the pursuit of intellectual property protection in the international trade negotiations. A statement by the Executive Council of the organization dated March 4, 2008 explicitly endorses this position. To quote from this statement, "The AFL-CIO has worked to ensure that intellectual property protection is pursued as a key component of our international trade agenda. Foreign intellectual property rights infringement robs the U.S. of tens of billions of dollars in sales, with the resulting loss of jobs and income for America's workers."

Indeed, asymmetry in the negotiating power in favor of the United States gives all of its powerful lobbies greater clout in rule writing than their developing country counterparts. The AFL-CIO support for the pursuit of intellectual property rights protection is not an accident. They want to gain the same benefit from rule writing for workers as corporations at the expense of the developing countries. As a result, they have made common cause with corporations and sought their support for extending U.S. labor standards to the developing countries. While they remain some ways from achieving this goal in the WTO, they have made significant progress in the free trade area (FTA) negotiations with small southern countries that have virtually no negotiating power vis-à-vis the United States. The process of labor groups jumping into rule writing had already begun in the North American Free Trade Agreement (NAFTA) when the Clinton administration insisted on a side agreement on labor rights before giving it final

approval. Subsequently, the labor clauses have been a central element of FTA agreement signed by the United States.

In a similar vein, it is the north-south rather than capital-labor dimension of rule writing that provided the counterforce to the promotion of corporate interests in the Doha negotiations. Driven by its corporations, the EU had strongly pushed for a multilateral investment agreement in the Doha negotiating agenda. But a more or less united offensive by the developing countries forced it to withdraw this demand immediately following the 2003 WTO ministerial meeting in Cancun. While corporations have thus used rule writing to advance their interests as globalization proceeds, northern labor has not been too far behind. In both cases, the counterweight has come from the developing countries that too have learned the importance of rule writing and actively participate in the process.

3 Third-country Effects of Trade Liberalization

An important policy question is how non-discriminatory trade liberalization among developed countries impacts developing countries. The specific context is the multilateral liberalization prior to the Uruguay Round Agreement that was confined to developed countries. Most developing countries eschewed active participation in the negotiations until the Uruguay Round, choosing to benefit from free riding the developed country liberalization. Was this a wise choice?

Deardorff and Stern (2003) provide a neat theoretical analysis of this question, answering it in the negative. They use a multi-product, multi-country political economy model with additively separable preferences, a constant marginal utility from the consumption of the numeraire good and production functions that allow one specific

factor and one common factor in all non-numeraire goods and only the common factor in the numeraire good. This model has the property that all substitution in production as well as consumption is between individual non-numeraire goods and the numeraire good. Alternatively put, it fully validates the partial equilibrium analysis, allowing welfare conclusions to be drawn from the sum of the consumers' and producers' surplus and tax revenue.

The political economy component of the model postulates that liberalization is driven solely by producer profits. This is not a necessary assumption but it suffices to obtain the key results while simplifying the analysis. In this setting, it is straightforward that developed countries choose not to liberalize any product exported exclusively by the developing countries. Such liberalization produces no benefits for producers in the developed countries undertaking liberalization. On the other hand, goods exported exclusively by developed countries are most likely to be liberalized. In so far as such liberalization expands within-developed-country trade, it is likely to divert supplies from developing countries. This will raise the price paid by the developing countries for these products or, equivalently, worsen their terms of trade. This benefits developed country producers. Therefore, the countries have an incentive to liberalize trade in products in which they are able to expand their mutual trade by diverting it from developing countries. The action will hurt the developing countries.

Most trade economists will appreciate the message underlying this conclusion: developing countries choose to stay out of the negotiating process at their own peril. Nevertheless, I suspect that the outcome in the real world is somewhat different: developing countries that are themselves keen to take advantage of the opportunities

offered by trade and chose to be open on a unilateral basis probably benefited from developed country trade liberalization via the Kennedy and Tokyo Rounds. It is inconceivable that South Korea and Taiwan did not benefit from the liberalization by developed countries in the 1960s and 1970s.

The Deardorff-Stern model obtains its strong conclusion by choosing a model in which it is possible to force liberalization from spilling over to the outside countries despite the Most Favored Nation (MFN) nature of liberalization. I suspect that in practice this is not possible. Liberalization within the GATT-WTO system must follow a tariff nomenclature that does not allow product categories to be defined according to the origin. This fact combined with the observation that in reality countries source most products from both developed and developing countries makes it nearly impossible to avoid spillover of developed country liberalization to developing countries.

We know from the recent work of Schott (2004) that even as we go down to the 10-digit products within the harmonized tariff system, we observe the United States continuing to import a very large number of products from both developed and developing countries.[1] Typically, the former send overwhelmingly high-unit-value varieties and the latter low-unit-value varieties of the same product. This pattern makes the exclusion of developing countries from developed country liberalization envisaged in the Stern-Deardorff model highly unlikely.

An early study by Michael Finger (1976) confirms the favorable trade effects of the Kennedy Round on the developing countries: it concluded that 'tariff cuts of each importer (EEC, United States, Japan) caused a significant increase of imports, from developing and from other developed countries.' A more recent study by Romalis (2007)

[1] Also see Mukerji and Panagariya (2009) in this context.

finds very strong growth effects of the opening up of the developed countries via the Kennedy Round on the developing countries.

Before I conclude this section, let me hasten to add that in one sense my points reinforces the underlying message of Deardorff and Stern: only countries that are themselves open will reap the benefits of liberalization by developed countries. Therefore, the qualifications to the Deardorff-Stern analysis I have put forward do not in any way undermine their key message: it pays to be open. And in so far as participation in multilateral negotiations leads to the opening up of one's own economy, such participation can only enhance the scope for benefiting from developed country liberalization.

4 Corporations and Globalization

Given the central focus on the role played by corporations in the process of globalization in Alan's writings, it is appropriate to end by asking whether he regards them as a positive or negative force on balance. The answer in Deardorff (2003, p. 657) is refreshingly unequivocal and worthy of reproduction in near entirety:

> "Perhaps more than most economists, I am personally predisposed to see corporations as beneficial to the society. It seems obvious to me that corporations have made possible a level of well-being throughout most of the world that far exceeds what could have been achieved without them. The invisible hand of the market only partly accounts for this, since large corporations clearly have far more power over markets than we assume in our competitive models. But as long as these large corporations are forced to compete with one another and also with small new entrants that may at any moment emerge – a level of competition that requires the

active vigilance and sometimes enforcement by government competition authorities – I have no doubt but that they do far more good than harm for the vast majority of the world's population. And indeed, within the markets in which they operate, corporations are much more vulnerable to public opinion and therefore powerless than is often thought."

The history of economic policies in India, which I have discussed in detail in my recent book (Panagariya 2008), lends a great deal of support to Alan's view. Motivated by fears of the concentration of wealth in the hands of corporations, India went on to tie their hands (and feet too!) in the 1960s and 1970s in ways that will be incomprehensible to Americans. The result was growth at a pace that was considerably below the country's potential. Eventual restoration of the freedom of corporations to operate in a business-friendly environment has led to dramatic improvements in the well being of many within a relatively short span of time with poverty at last declining significantly as well.

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COMPARATIVE ADVANTAGE, ECONOMIC GROWTH, AND THE GAINS FROM TRADE AND GLOBALIZATION:

A FESTSCHRIFT IN HONOR OF ALAN V. DEARDORFF

University of Michigan
Gerald R. Ford School of Public Policy/Department of Economics

Friday and Saturday, October 2-3, 2009
Rackham Amphitheater

Alan Deardorff's Contributions to Computational Analysis of International Trade

Thomas W. Hertel
Distinguished Professor and Executive Director
Center for Global Trade Analysis
Purdue University

1:15–2:15 PM, Friday, October 2, 2009
Panel Discussion: Computational Modeling and Trade Policy Analysis
Moderator: Drusilla Brown, Tufts University
Thomas W. Hertel, Purdue University
James R. Markusen, University of Colorado, Boulder
Will Martin, The World Bank

The general equilibrium analysis of gains from international trade is necessarily a high-dimensioned and complex undertaking. While the workhorse 2x2x2 model so elegantly developed by Ron Jones and others offers many insights, when it comes to the matter of offering policy advice, it is impossible to avoid moving to higher dimensions. Whether this involves disaggregating the "rest of world" to permit analysis of bilateral trade agreements, capturing differential tariff treatment of intermediate inputs employed in export industries, or disaggregating factors of production to discern the distributional impacts of trade policy reform, policy-oriented economists are inevitably called upon to move beyond the dimensions that are tractable in purely analytical models. This has spawned a growth industry in the supply of computational analyses for international trade policy.

However, computational partial and general equilibrium (CPE and CGE) analyses of trade are often discounted by the academic community. Such models are referred to disparagingly as "black boxes", papers based on computational models are often discounted out of hand, and they are rarely published in the leading journals of international economics. Indeed, I expect that the majority of presenters in this symposium today would discourage their students from doing computational work during their graduate studies. It is a sad state of affairs when economic policy advisors are demanding more computational analysis even as the best and brightest in our community are supplying less of this very same product, leaving the bulk of computational work to be done by others – largely those outside of academia.

Fortunately, there are a few academic trade economists who have swum against this tide of intellectual purity, striving to link rigorous theory with computational analysis of important policy questions. Alan Deardorff is one of these few, and I am extremely honored to have the opportunity to celebrate his contributions to the computational analysis of trade policy.

The Planning-Feedback Approach to Computational Trade Modeling

In the two Deardorff-Stern (1986 and 1990) books documenting the first two decades of development of the Michigan trade model and some of its major applications, the authors describe "the curious and cumbersome process of informed trial and error by which we have used numerical models to grope toward an understanding of both theory and reality." They divide this process into two distinct parts, *the planning phase* and *the feedback phase*. Here, a quotation from the 1986 volume is in order:

> Only the first of these phases, which we shall call the planning phase, shows up clearly in the finished product. Yet it is the second phase, the feedback phase, that yields most of the insights that we shall discuss….. It is their interaction that we have found fascinating and informative over the years of working with the model, much more so than the ultimate numerical answers to the particular problems we set out to solve (Deardorff and Stern, 1986, p. 220).

In my own reading of Alan Deardorff's contributions to computational trade analysis, I have found these discoveries, motivated by the feedback process, to be especially intriguing and worthy of note by theorists and applied trade economists alike. I believe both groups could benefit from being "more like Alan" in their attention to this feedback phase of model development. Therefore, permit me to consider three such examples. (I'm sure there are more, but these are three salient illustrations that I was able to discern from a distance.)

The Factor Content of Trade: The first example of highly productive feedback from computational analysis of practical policy issues to theoretical trade insights is offered by Robert Staiger, a former Deardorff student, now on the faculty at Stanford University. (I took the liberty of contacting a number of Alan's former students while preparing this paper.) Staiger's work came to my attention because he appeared as an author on two papers in 1988: one, a computational paper in *The Review of Economics and Statistics*, and one a theoretical paper in

the *Journal of International Economics*. Both papers seek to answer the question whether we can infer something useful about the effects of trade on relative factor prices from our knowledge of the factor content of trade. Based on personal correspondence with Professor Staiger, the computational paper came first. Indeed, it was the presentation of an early version of this paper on the factor content of trade at an NBER conference which precipitated both publications.

According to Staiger, at the NBER workshop, Gene Grossman raised the question of whether one could make inferences about the impact of trade on factor prices from the factor content of trade. Staiger and Deardorff returned to Michigan and started with a blank sheet of paper and a simple theoretical model aimed a proving this link. This gave rise to the *JIE* paper in which Deardorff and Staiger establish a positive correlation between relative changes in the factor content of trade and proportional changes in factor prices. Indeed, under a more restrictive set of assumptions about production and utility functions, the factor content of trade provides an accurate measure of the relative effects of trade on *individual* factor returns. Meanwhile the *RESTAT* paper, which developed in parallel to the theory paper, brought these theoretical insights to bear in an analysis of the relative impact of Japanese and US tariffs on factor markets in those two countries (Staiger, Deardorff and Stern, 1988). Without the interplay between theory and computational analysis, these two papers would not have been published.

The Love of Variety: With the advent of the Spence-Dixit-Stiglitz CES, love of variety utility function, and its introduction in the trade context by Paul Krugman, this formulation of consumer demand has become pervasive in the trade literature. However, this specification also puts a great burden on the constant elasticity of substitution in that function, for it must determine both the price elasticity of demand – and hence the optimal markup – as well as consumers' love of variety (LoV) – and therefore the gains from product proliferation. While

initially introduced into consumer demand, Ethier suggested using this specification for modeling firms' derived demands, and the cost reductions from added variety became a key element of the gains from trade liberalization (Romer, 1994). Thus the incorporation of scale economies and the love of variety became a natural extension of the Michigan model (Brown, Deardorff and Stern, 1992a,b).

However there was a problem. When confronted with real world data, in which the vast majority of trade is in intermediate inputs, the standard CES love of variety cost function led to extreme model instability. Consider the case of a reduction in tariffs on intermediate inputs utilized in a domestic industry. In the absence of love of variety, this leads to a cost reduction and expansion of the industry, but this expansion is curtailed by rising factor prices and the model finds a new equilibrium at a higher level of output. However, product differentiation by firm and love of variety is added to this picture, the reduction in costs also leads to firm entry. When such entry occurs in input-supplying industries, this expanded product variety contributes to further cost reductions, additional entry and so on. For this reason CGE models with the CES LoV specification are prone to far greater specialization than observed in reality (Brown, Deardorff and Stern, 1995).

This problem was first confronted by Drusilla Brown (personal communication) when working on the application of the Michigan model to an analysis of trade reforms in Tunisia. She was unable to get the model to solve and called Alan Deardorff to vent her frustrations. Alan responded by proposing a modification of the standard Spence-Dixit-Stiglitz, CES specification in which another parameter explicitly governing agents' LoV, is introduced. This parameter, let's call it β, is bounded between zero and one and produces both the Krugman-style trade model ($\beta = 1$) and the Armington model (no love of variety) ($\beta = 0$) as special cases. When Drusilla asked

Alan for a suggestion on the value to assign this parameter, he suggested 0.5. (As we will see momentarily, this turns out to be a remarkably prescient choice!) This indeed solved Brown's convergence problem, and she was able to complete the project successfully. Meanwhile this new LoV parameter became embedded in the Michigan model.[1]

A few years later, I was attempting a large scale, disaggregated application of the CES-LoV model within the GTAP modeling framework at Purdue University, and ran0 across the same problem of model instability. After scratching my head for awhile, I contacted Drusilla to inquire about her experience, whereupon she related to me Alan's suggested model revision. It worked like a charm! Of course, this left open the question of what the appropriate value of the LoV parameter might be, which brings us to the remarkable conclusion of this tale of the "feedback" phase of model development.

In 2003, Adina Ardelean, a student of David Hummels (another Deardorff/Michigan connection in this story), took my graduate class in computational trade modeling at Purdue University. Her work on CGE analysis of trade policy in this course got her interested in Deardorff's modified LoV specification and she developed this into her doctoral dissertation. In addition to working out the theoretical properties of this model, she came up with an innovative approach to estimating the LoV parameter (Ardelean, 2009). I recommend this paper to you. For the purposes at hand, suffice it to say that Adina's global trade-weighted mean estimate of the LoV parameter is 0.54 (with a standard deviation of 0.13) -- remarkably close to Alan's initial intuitive estimate of $\beta = 0.5$. I find this to be an excellent example of the feedback phase in which computational analysis is iterated with theoretical (and econometric) work to produce an improved model of the way international trade really works.

[1] It should be noted that Benassy (1996) published a paper about the same time, exploring the implications of deviations from the CES-LoV specification for the optimal number of varieties in an economy. It appears that these developments were fully independent discoveries.

Protection and Real Wages: One of the oldest questions in international trade pertains to the impact of trade liberalization on real wages. The Stolper-Samuelson Theorem represents a milestone in this literature, stating that a tariff cut would decrease the real wage of a country's scarce factor of production. In the 1990's, the question of the likely wage impacts of trade policy reform loomed large in the NAFTA debate – a policy debate in which the Michigan Model played an important role. In the context of this debate, it was assumed that real wages in the US – a labor scarce country – would likely fall in the face of tariff cuts. However, the Michigan Model results for NAFTA produced the opposite result: real wages rose (Brown, Deardorff and Stern, 1992a,b). In a subsequent paper, Brown, Deardorff and Stern (1993) explain how this phenomenon can arise. In so doing, they extend the Stopler-Samuelson Theorem to an environment with scale economies, imperfect competition and product differentiation. In this context, increased scale of production, reduced markups and varietal gains can all work against the traditional Stopler-Samuelson effect, giving rise to an outcome where real wages of the scarce factor of production rise with tariff reductions.

This last example nicely illustrates a further discussion of the feedback phase of model development from Deardorff and Stern (1986):

> What typically happened when we solved the model was that we found something unexpected in the results. Sometimes the results were just nonsense and we had to go back and find out why. More often the results were plausible overall but contained one or two features that we did not expect in terms of either direction or size of the effect. (E.g., the real wage impacts of NAFTA.) The feedback phase of model construction consists of examining the assumptions of the model carefully until such surprises can be explained, and then either modifying the model or modifying our ideas of what to expect so that the results are no longer surprising. Either way, something can be learned in the process (p. 221).

Other Important Contributions

While there is not sufficient space to develop all of Alan Deardorff's contributions to CGE analysis of trade policy (and I need to leave some material for my fellow panelists), I would like to highlight a few more things which are important and notable about the Deardorff-Stern work. Their focus on short run labor market impacts provided policy makers with highly relevant information about the likely impacts of trade reform on employment by industry. They also were ahead of their time in seeking to come to grips with non-tariff barriers as well as trade in services, both of which have now (two decades later) moved front and center in the global trade policy landscape.

As his career progressed, the focus of Alan Deardorff's computational work shifted increasingly to developing country impacts of trade policy. Of special note is his long term collaboration with Rajesh Chadha and Sanjib Pohit, as well as Robert Stern, on the CGE analysis of domestic policy reforms in India. The ensuing model, documented in Chadha et al. (1998) represented an innovative approach to CGE modeling of an economy with significant elements of state monopoly and administered pricing.

As a direct result of his willingness to engage with policy makers in the messy world of computational trade policy analysis, Alan Deardorff has also become a much sought after advisor on issues relating to the multilateral trading system, undertaking numerous projects with the US government, the United Nations agencies, the World Bank, and others.

Future Directions for Computational Analysis of International Trade

Alan Deardorff was a pioneer in the computational analysis of international trade. As was the case with other pioneers in this field, he had to be a jack of all trades. In addition to writing

down the theory of the model, he also wrote the FORTRAN code necessary for its numerical implementation. Implementation of the Michigan Model required him to develop clever techniques for partitioning the numerical model and solution strategies that permitted him to solve models that were exceptionally large, by the standards of the time. He and Bob Stern were also required to develop globally consistent data sets, and had to worry about obtaining sensible parameters for their model. In short, this was a lot of ground to cover before actually getting to the point where results could be generated. Fortunately for those coming later to this field, there have been some important institutional advances which have lowered the entry barriers to this field, while simultaneously enhancing the credibility of such work in policy circles.

More specifically, the advent of the publicly available, regularly updated Global Trade Analysis Project (GTAP) data base has removed one of the biggest barriers to CGE analysis of trade policy. And as the community of CGE modelers has grown, so too has the software industry servicing the computational needs of this group. The GAMS and GEMPACK software packages have greatly enhanced the efficiency of computational modelers, while also making it much easier to replicate the work of others. Indeed, as the CGE (and CPE) analysis of trade policies moves forward, the availability of libraries of alternative models and policy analyses will prove increasingly important. The only way to overcome the black-box critique of these models is to permit others to readily replicate, critique and extend published work. I encourage everyone serving as a reviewer on a CGE or CPE journal submission to require such submissions to be accompanied by an archive permitting the reviewer and/or future readers to easily replicate all of the findings in the paper. Without such replication, computational studies will remain little more than one-off exercises with limited potential for longer term, scientific impact.

As with the efforts by Deardorff and Stern to bring to bear elements of the Krugman model of international trade within their computational framework, future research in this field must be on the lookout for promising new theoretical innovations. Prime among such innovations currently available are the Melitz-style models of producer heterogeneity (Melitz, 2003; the appearance of Marc Melitz at this point provides yet another Deardorff/Michigan connection in this story). Early attempts to incorporate heterogeneous firms into a global CGE model (e.g., Zhai, 2008) suggest that this captures an element of trade policy reform long held by practitioners to be important – namely the impact on industry total factor productivity. CGE models with heterogeneous producers also open the way for incorporation of additional empirical characteristics of specific industries which are amenable to measurement – namely the distribution of firm-level productivities in a given industry. Indeed, some CGE analyses suggest that these productivity distribution parameters may be more important than the time-worn elasticities of substitution in trade which have hitherto governed the overall size of trade gains.

The revolution in empirical trade which has occurred over the past two decades also offers a great opportunity for computational analysis. This econometric work, coupled with systematic sensitivity analysis with respect to the estimated parameter distributions, gives CGE modelers the opportunity for the first time to put serious confidence intervals on their findings (e.g., Hertel, Hummels, et al., 2007). And recent estimates of the relative importance of the extensive and intensive margins of trade expansion (Hummels and Klenow, 2005) have proven critical for calibrating new CGE models of international trade (Zhai, 2008). There is also scope for statistically testing competing models of international trade for specific industries (Villoria, 2009). Despite all the noise to the contrary, econometricians studying international trade and computational modelers are natural partners. The latter are typically addressing critical policy

issues, but are challenged as to the validity of their models. Meanwhile the former are often congratulated on the quality of their estimates, but they are faced at the end of the day with the question: Who cares? Greater cross-fertilization between these two groups can yield significant gains from trade.

In closing, I would like to call attention to the increasing role for trade economists in the debate over global environmental policy. The national impacts of climate change will hinge critically on the capability of a smoothly functioning global trading system to even out the differential regional impacts of climate change. Meanwhile, the policies aimed at mitigating climate change are likely tosignificantly alter the global pattern of comparative advantage, thereby creating new pressures for protectionism, as well as new potential gains from trade. In some cases, national environmental policies – specifically U.S. renewable fuel mandates -- are being written in such a way that their impacts through the global trading system must also be taken into account. Even more so than for trade policy, the world of global environmental policy relies heavily on computational models. Indeed the Intergovernmental Panel on Climate Change maintains a library of results from 22 Global Circulation Models (the CMIP3 project) upon which scientists regularly draw to publish scholarly works. If trade economists wish to have an impact on these important deliberations, they, will have to “get their hands dirty” in the world of computational modeling. As Alan Deardorff has shown over the past three decades, there is great scope for trade theorists, working in conjunction with computational modelers, to contribute – both to the policy dialogue, as well as to the further development of economic theory.

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The Third Way: Applied General-Equilibrium Modeling as a Complement to Analytical Theory and Econometrics

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1. The third way

Congratulations to Alan Deardorff on a long and distinguished research career that has shown great breadth as well as depth. It is a pleasure to be here and participate in these events. I am honored to be invited given that I have never worked with Alan and that our research interests have been rather different. Yet in spite of the latter, I have great admiration for the things Alan has done and accomplished.

I have been asked to offer some thoughts on Alan's work on applied general-equilibrium modeling and indeed this is an area where our interests have a different focus. Alan and the Michigan group used the computer and computational tools for policy simulations, working through the horrible task of calibrating these models to real data. I have used simulations more as an extension of my theoretical tool kit, attacking problems that have too many dimensions, too many non-linearities, or too many inequality constraints to be tractable with our traditional analytical techniques. To be honest, my knowledge of the difficulties involved in data work and calibration programs was in good measure why I did not go the same route. But that indeed makes the Michigan group's accomplishments much appreciated by myself.

The basic theme of my comments is that applied-general-equilibrium (AGE) modeling represents a "third way" of doing economics, complementing the more traditional methods of analytical theory and econometrics. Most of us at this conference were schooled only in the latter two methodologies and, worryingly, that limitation generally persists to this day. This is in spite of the fact that analytical theory, "pencil and paper" theory if you like, and econometrics have limitations that prevent us from analyzing or even asking certain important questions. I shall argue a bit later that in fact some traditional theorists and econometricians have been hostile to calibrated modeling and simulations and make that clear to their graduate students. I have never understood this point of view, and see simulation modeling as an excellent complement to our other techniques.

I am going to offer some praise and support for simulation modeling in the comments that follow, and also offer some criticism of the critics. When I do this, please keep in mind that this is not really my field at all: I don't want to be dismissed as merely touting my own research agenda. Most of my thirty-seven year career has been as a pencil-and-paper theorist, and more recently I have also been a co-author with competent econometricians. My own publications constructing and using calibrated models with real data amount to three papers.

2. Limitations of traditional analytical theory

As I just noted, I have spent the bulk of my career doing analytical theory; I continue to work primarily in this direction and place great value on the discipline of this approach and on the value of its insights. But I believe that this approach has sharp boundaries and limitations, and that the computer is an excellent research tool to push back these boundaries.

A first limitation of the analytical approach to theory is that it generally offers no quantitative estimates; e.g., with respect to comparative statics experiments. I remember

learning in graduate school about the optimal tariff. Well, it turns out it is not an optimal tariff *number*, it is an optimal tariff *formula*. It is a very complicated general-equilibrium effect even in the very simple 2x2x2 Heckscher-Ohlin model, where it involves elasticities of substitution in both production sectors and in consumption, country sizes and so forth. No one has a clue what its *numerica*l magnitude might be, and analytical theory cannot even solve for it in terms of underlying numerical magnitudes of structural parameters.

A second example is gains from trade liberalization. Analytical theory gives us a gains-from-trade theorem for moving from autarky to free (or restricted) trade, but little else, and even in the case of autarky to free trade there is of course no quantitative estimate of what the size of gains might be. In realistic cases of second best liberalization scenarios, trade theory has virtually nothing to say. But gains from trade is in fact a crucial question that policy makers need estimates about. I have long observed a tendency for trade economists to invariably assure policy makers and journalists that trade liberalization is always and everywhere a good thing. In fact, our theory says no such thing.

To put this on a more general level, analytical methods have no ability to analyze complex comparative statics, generally not even with respect to qualitative properties except in extremely special cases. There are several different problems, often coming together in bundles. The first is dimensionality: large numbers of equations and unknowns often defy analytical methods. The second difficulty is that the equations are typically non-linear in our theories and thirdly, there is often complex simultaneity (meaning no simple recursive structure for example).

The next difficulty is that in most reasonable general-equilibrium situations the "true" model is actually a set of non-linear inequalities instead of equations. The actual model we would like to solve includes the possibility of many corner solutions and slack activities. These models are termed non-linear complementarity problems in mathematical programming terminology: each non-linear inequality has an associated or complementary non-negative variable. The classic simple supply and demand problem has in fact three possible equilibria in two unknowns, price and quantity. (1) there is an interior equilibrium with both variables positive, (2) supply can lie entirely above demand so the equilibrium quantity is zero (production is unprofitable), and (3) supply can lie entirely to the right of demand so that the price is zero (it is a free good). Traditional methods have difficulty even with this very simple case.

The traditional way around this is to simplify the problem down to the point in which it is analytically tractable. In my probably unpopular view, this often leads to extremely unrealistic assumptions that "throw the baby out with the bathwater." The interesting features of the problem are assumed away! I have heard or read many presentations in which I find a very odd assumption or two. When I then try to figure out the reason for this oddity, I often as not find that without the offending assumption the entire paper falls apart, meaning that the results don't hold or that the model can no longer be solved analytically.

Let me give three quick examples of over-used constructions in trade theory, chosen for analytical convenience despite generally counter-empirical predictions. (1) the 2x2x2

Heckscher-Ohlin model, generally inconsistent with stylized facts about political economy. (2) the large-group monopolistic-competition model, inconsistent with growing firm size and falling markups as the world economy grows and liberalizes. (3) quasi-linear preference and the reliance on an "outside" good so common in the industrial-organization approach to trade theory, inconsistent with the high income-elasticities of demand for the goods in question.

There is nothing wrong with starting in these places, the sin is in finishing there. As I will propose later, start with a simple analytical case for insight and then simulate the model you really believe in. One of my favorite quotes along these lines is the following:

> "Many branches of both pure and applied mathematics are in great need of computing instruments to break the present stalemate created by the failure of the purely analytical approach to nonlinear problems."
>
> --- John Von Neumann, 1945

Yup, 1945, and yet there is still considerable resistance in our field to this very basic observation and truth 64 years later.

3. Disconnect between AGE modeling and econometrics

I have virtually no expertise in this area and thus I will try to be brief and not discredit myself. My view is that calibrated AGE modeling (calibrators) and econometrics (estimators) have different objectives, and critical comments made by one camp or the other are sometimes irrelevant and missing the point. Estimators doing trade are interested in estimating the parameters involved in important relationships suggested by theory. To continue my Heckscher-Ohlin example, an estimator may restrict the parameter space by imposing the HO assumptions that countries have identical technologies, identical, homothetic preferences, and no domestic distortions and then estimate the contribution of endowment differences across countries to trade. Results give an "average" response of trade to endowment changes. There are positive degrees of freedom, standard errors, and measures of how good the HO model fits the data

Calibrators are interested in the counter-factuals and have no reason to believe the HO model is "true": countries surely have different technologies, tastes, endowments, and domestic distortions. Their assumption is that the observed data (once made micro-consistent) represent an equilibrium, and the (endogenous) parameter space is expanded until the data fits the model exactly. So, for example, countries are allowed to have Hicks-neutral differences in technology which "soak up" the error terms in the estimator's equations. There are no standard errors or degrees of freedom by assumption. Obviously, estimators point to the lack of standard errors and degrees of freedom with enthusiasm, and I think calibrators are well aware of these issues. But I surely don't want to get into this debate here.

As in the case of analytical methods, it seems to me that traditional econometrics has difficulties in assessing complex general-equilibrium counter-factuals. One of the areas where this is most obvious and most worrying is in providing quantitative ex ante estimates of the gains

from complex regional trade agreements. A few years ago, I heard a prominent empirical trade economist give an excellent survey on all of the recent empirical work on international trade issues. When he finished, a questioner asked "what about gains from trade." The answer was that econometricians don't do that, and that it is the province of applied general-equilibrium modelers. But as mentioned above, this is surely one of the crucial things that policy makers want to know about before going into complex and lengthy negotiations. In the case of NAFTA negotiations, econometric findings based on past multi-lateral liberalization (and at which time Mexico was a very small economy) were not very useful or appropriate in assessing this counter-factual.

To be more constructive, I think applied general-equilibrium models are useful for complementing both theory and empirical branches of economic science. Models calibrated to real data for use in policy simulations pick up where econometrics leaves off, and econometrics has a crucial role in estimating elasticities and other parameters that go into the models. I have never seen a conflict here and have had a hard time understanding the negative attitude of some traditionalists.

Simulation of theory models with too many dimensions, two many non-linearities and/or too many inequalities to permit analytical solutions is surely a very worthwhile practice. Again, I am in no way criticizing the use of analytical models simple enough to solve; that would, after all, be trashing my own career. I just don't want to stop there as I have indicated above. In short, I strongly believe that simulation modeling is a complement to traditional theory and empirical methods, and we should embrace that complementarity in our own work and in our graduate teaching.

4. Acknowledgment of early contributors to the development of simulation modeling

Going back starting a couple of decades ago, the Stroh's - Labatt's region, as we use to call it, was a world leader in the development of applied general-equilibrium modeling. Over on the Michgan (Stroh's) side we had the Michigan model with Brown, Deardorff and Stern. Over on the Ontario side (Labatt's), we had John Whalley and assistants and graduate students that the rest of us at UWO referred to as "Whalley World," and we had Richard Harris at Queen's.

Not doing this type of large-scale calibrated modeling, I really am in no position to comment in details about the many developments that are credited to the Michigan group, but I know they were path-breaking and hope that my colleagues in this session will comment in more detail. I do believe that the Michigan group, along with Richard Harris, were pioneers at incorporating industrial-organization features into AGE models. Based on being a colleague of John Whalley for fifteen years, I can tell you that I have immense respect for what these early modelers went through in the late 1970s and 1980. Many a day we saw John with bags under his eyes having spent most of the night in the computer center where he would book out the VAX for six or so hours at a time in order to do a couple of runs of a 167 sector model.

I am certain that Alan and the Michigan group did the same and I have great admiration

for that sort of dedication. I suspect that Alan was the theory guru of the group, but collectively they took on a difficult task: bad data, bad computers and bad to non-existent software. Again, I don't know the details of the Michigan model, but most of these early modelers wrote their own computer code, generally in fortran. I actually started sitting in on John Whalley's course for a few weeks before I quit after trying to code up an algorithm in fortran. I got lost somewhere between Newton steps and Lemke pivots. This is nuts I thought.

5. Nattering nabobs of negativity[1]

Over the years, I have heard a lot of criticism and negativity from both theorists and econometricians about calibrated simulation modeling; beware, your graduate students talk. I suppose that what bothers me most is that these individuals generally had essentially nothing else to offer on the important counter-factual questions such as the income and distributional consequences of NAFTA as I just indicated. Why the nattering?

Perhaps the most puzzling objection to me is the analytical theorist's "black box" criticism used to dismiss simulation modeling and, once you dismiss it, there is of course no need to actually learn anything about it. The black-box criticism essentially says that we do not know what is going on inside the computer program and thus we can dismiss and ignore it. In fact, I have generally felt that GE modeling is quite transparent (given lots of dimensions): the structure of the models (equation and unknowns) are clear, the functional forms are described in detail, the choice of exogenous versus calibrated parameters are clear, and the solution algorithm is understood.

A strong and convincing feature of applied general-equilibrium models that I think should calm the critics is the "replication check." If we begin with a micro-consistent data set, then the program must be able to reproduce the input data as an equilibrium. Not until the model passes the replication check will any respectable modeler proceed to actually use the model. No way, no exceptions. After the replication check, modelers often give their models questions to which we know the answer and make sure that the right answer comes back as a further version of the replication check. I certainly do that in my theory simulations. For example, if I make two countries identical, I better get a symmetric solution or I know something is wrong. While I do not write the fortran or C code myself, I certainly do understand exactly what Newton steps and Lemke pivots are and how they work.

I don't think that econometricians typically use the black-box argument, they have other objections as noted above. Nevertheless, I cannot resist speculating that they have little or no knowledge of how their canned programs work. Most never write the code for their estimations and don't have an idea how the code works. I have been told in discussing this with applied

[1]The title of this section is from an infamous speech by then US Vice President Spiro T. Agnew in 1970. The speech and phrase was however written by speech writer William Safire, not Spiro.

econometricians that there are well-known examples of tests where the same data are submitted to different econometrics packages or attempts are made to replicate published papers and the results can come back different. To the best of my knowledge, there is no equivalent of the replication check in econometrics, and thus many errors are harder to find than they are in AGE modeling.

I regret that there is not a seat at the table for applied general-equilibrium modeling in most graduate programs. At this time, the AGE crowd is fairly disjoint from mainstream economics but everyone should understand that it is now a very large crowd indeed. The Global Trade Analysis Project (GTAP), the home professional society for modelers, now has 7769 registered members representing 157 different countries. Governments take this seriously, many corporations or industry groups take this seriously (e.g., the electric power industry is a big client of private-sector consulting companies doing GE modeling).

6. Ways forward?

To the extent I could make an appeal to fellow theorists, I would simply ask that they recognize the limitations of analytical theory. If you have to make assumptions that throw out the interesting part of the question or if the results are extremely fragile to the assumptions you choose, then there is a problem. Once again, I am a strong supporter of the traditional methods of analytical theory and continue to do much of my work in this vein. I am simply suggesting that we do not stop there. What I have often done is to make a model-of-the-model: a simplified analytical version of the problem I really want to work on. An example of a model-of-the-model is a partial-equilibrium version of a question which can be solved analytically, and surely the author and reader gain some insights from such an exercise. Then I attack the real GE model via general-equilibrium simulations.

I just don't have enough expertise to comment much on trying to find common ground between econometrics and calibrated modeling. Clearly, there is great need for econometrics in estimating parameters that go into applied general-equilibrium models. Engineering data are valuable as well as has been demonstrated in energy modeling; for example, how unprofitable is wind or solar energy at today's prices? Technologies that are not currently in use, like inactive trade links, pose a particular challenge to econometrics.

I do know that there are a number of current papers that could be interpreted as pointing in the direction that suggests there is far more overlap between structural econometrics and calibrated general-equilibrium modeling than is currently realized. In a number of recent papers, authors are estimating the structural response parameters (e.g., elasticities) by running regressions subject to the full GE simulation model. The regressions cannot be inconsistent with the GE, and the parameter estimates are those that minimize the sum of squared errors in the econometric objective. This class of problems is called a mathematical program with equilibrium constraints (MPEC). That is, optimize something subject to the general equilibrium defined by the constraint set, typically a complementarity problem of inequalities with complementary non-negative variables (e.g., zero-profit conditions for activities, market-clearing conditions for

commodities and factors, and so forth).

Traditionally, MPECs have been used to find an optimal set of policy instruments (optimal tax policy), but this numeric method is now being used to estimate structural parameters. This method allows us the opportunity to move the benchmark replication up to the second order. This is found in Balistreri and Hillberry (2007, 2008). Working separately Su and Judd (2008) advance the MPEC as a general method for direct structural estimation. Again, it is beyond my competence to evaluate this idea in detail, but I hope that it proves to be a fruitful avenue for getting the estimators and calibrators to work together.

7. Conclusions

I want to conclude by saying well done to Alan and others in the Michigan group, Brown and Stern in particular.[2] I would go on about Alan's many important contributions in analytical theory which I know more about, but I was asked to comment more narrowly on the simulation work which I have now said several times I know less about. I want to thank Brown, Stern, and Deardorff for persisting in the face of huge technical problems and limitations as well as in the face of the intellectual resistance I discussed earlier. I am sure that Von Neumann would be proud of you, though apparently he was not the great human being that everyone knows Alan is.

Thanks for the invitation and my very best wishes.

[2]Alan Fox and others should surely be included.

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Computational Modeling and Trade Policy Analysis: Some Key Contributions of Alan Deardorff

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Computational Modeling and Trade Policy Analysis: Some Key Contributions of Alan Deardorff

It's a pleasure to have the opportunity to comment on Alan's work on computational modeling and trade policy analysis. Alan came to this field from highbrow economic theory, where he made particularly important contributions on esoteric theoretical issues such as cones of diversification. From this background, he and his collaborators made major practical contributions to helping build support for some of the most important and far reaching agreements—including the Tokyo Round of the GATT; the Uruguay Round of the GATT/WTO, and the North American Free Trade Agreement. Alan's applied studies took into account many of the mind-numbing details of these agreements, and incorporated new developments—such as services—where the data were poor and even the theoretical basis for analysis needed to be developed from scratch. This contribution by a leading theorist to influential analyses of applied policies is very unusual, and deserves high praise.

Some of the key themes and interests in Alan's long and productive career have been:

1. Highbrow economic theory
2. Computational analysis of trade negotiations
3. Trade in services
4. Trade and labor, and
5. Globalization and intellectual property.

In this note, I'll focus on Alan's contributions to the computational analysis of trade negotiations.

Alan was, along with Bob Stern, a pioneer in the use of quantitative economic models for the analysis of trade negotiations. Beginning in 1973-4, they developed the Michigan model of global production, consumption and trade and employed it in pioneering analyses of the implications of the Tokyo Round (Deardorf and Stern 1979). This study, produced as a report to the Committee on Finance for the United States Senate, calculates the reductions in average tariffs implied by the tariff-cutting formula (the famous Swiss formula) and the exceptions from this formula allowed during the negotiating process. It then proceeds to calculate the impacts on economic welfare, exchange rates, outputs, sectoral employment and other key economic variables.

The Michigan model used simpler, linear solution methods than many other models, with the advantage that this allowed solution of larger models, and hence more detailed information on the sectoral impacts of reforms—information of great interest to many policy makers. In an era where modelers needed to be jacks-of-all-trades, this model was originally solved using Fortran code written from scratch by Alan. In an era before the large scale collection and harmonization of input-output, trade and protection data under the GTAP project (Hertel 1997), Alan and Bob

found it necessary to make the striking assumption that the structure of numerous developing countries could be approximated using the available input-output table for Brazil.

A key element of the Michigan Model project was careful documentation of the model, and its applications, in volumes such as Deardorff and Stern (1986). Alan and Bob sought, and sometimes obtained unsolicited, comments and advice on their model and its results. A key feature of their work—and a model for subsequent scholars—was the way they built careful responses to these comments into subsequent versions of their models.

The Michigan model was part of the pioneering wave of models that showed the importance of taking general equilibrium effects into account when evaluating trade agreements. Taking into account cross-price effects, input-market linkages, and market access implications is particularly important when considering the effects of thousands of simultaneous tariff changes. Yet most of the studies of the Tokyo Round used much simpler techniques that omitted these important linkages. A key feature of this modeling effort was the attention paid by Alan and Bob to surveying the econometric literature--and estimating directly where necessary—the key parameters on which the reliability of their results depended.

The Michigan Model was regularly updated and developed through the 1980s as new software became available, and theoretical developments provided new opportunities for enhancement. Pioneering work with Drusilla Brown resulted in a new model the Brown-Deardorff-Stern model that included key insights from the "new" trade theory, particularly the welfare implications of the new trade theory where consumers have a preference for variety. Because it included preference for variety only amongst manufactures, this model emphasized the importance of liberalizing manufactures, relative to agriculture, and was particularly suited to the analysis of liberalization of services trade.

Another key area of interest for Alan has been the liberalization of trade in services. When this was first incorporated into international agreements, economists had to rush to catch up. At first, the best that could be done was to classify—a process which generated the classification into four modes of supply which lives to this day in the General Agreement on Trade in Services. However, Brown, Deardorff, Fox and Stern (1996) quickly moved to fill the analytical gap, providing measures of the consequences of liberalizing trade in services. To do this, they relied heavily on the measures of the extent of liberalization of services trade developed by Alan and Bob's former student, Bernard Hoekman (Hoekman 1996).

Alan's long and distinguished career and his important contributions to policy analysis provide some important lessons for those seeking a brilliant career in analysis and policy. A first lesson is the importance of keeping policy work well grounded in—at least motivated and guided by—economic theory. A second is the importance of ensuring that the relevant measures of economic

distortions are estimated using sound conceptual and empirical measures. A third is to carefully examine the features of any agreements under analysis—as the devil can be thoroughly embedded in the details. A fourth is surely the desirability of having a great seminar series like the Michigan research seminar in international economics. A fifth is to have great graduate students like the many presenting in this seminar. A sixth lesson is surely the desirability of seeking feedback and criticism, and taking it on board in subsequent phases of project work. A final, and most important, lesson is surely the importance of being a delightful, humorous and slightly eccentric colleague and friend to all.

Of course, our hypothetical scholar also has the opportunity to stand on the shoulders of Alan and his cohort. Anyone seeking to follow Alan in using computable general equilibrium analysis has many advantages. Perhaps foremost is the development of the GTAP database (Hertel 1997) that frees the researcher from the need to become a master of the intricacies of input-output databases, and their concordance with databases on trade and protection. Another advantage is the availability of software suites such as GAMS and GEMPACK specifically designed for solving large scale models. Protection databases such as MAcMAPs have also advanced in leaps and bounds, allowing us to capture the intricacies of preferential trade regimes. And new aggregation schemes (Bach and Martin 2001; Anderson 2009) allow us to avoid the errors inherent in using crude trade-weighted averages. A key challenge of the moment is to include the insights of the new-new trade theory (Melitz 2003) where the implications of heterogeneity in firms and other actors are taken into account, and extensive-margin adjustments to the range of products traded (Hummels and Klenow 2005) are taken into account.

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