What is Endogenous Growth Theory?

A short presentation based on Paul Romer's work in the last decade (footnotes to come).

The word "endogenous" was originally a botanical term. An endogen is a plant that increases by the growth of new vascular and cellular tissue irregularly among that tissue already formed. Endogenous means originating on or growing within the side of something, as cells within the wall of the parent cell. Webster's current dictionary just says "originating or produced from within." That's a good metaphor for economic or technological growth -- exogenous growth is growing like rings on a tree -- definitely not how an economy grows, or innovations develop. It's a view of society as a giant organism within which innovations develop randomly and irregularly, not in any planned manner.

Endogenous growth theory simply means economic growth from within a system, usually a nation-state. There are a couple of reasons for the rise of endogenous growth models. The first one is the fact that the economies & output of industrialized countries is so much higher now than it was a century ago. Economics needed some kind of theory or model to account for that, and technological growth was a good explanation. As Romer states, "Output per hour worked in the US today is 10 times as valuable as output per hour worked 100 years ago." (1990, S71). Most of that is due to technological change; other reasons include the growth in human capital (ie. the development of an effective labour force -- itself arguably the product of new education technologies).

And endogenous growth theory offers hope to newly industrializing countries (NICs), and alternative ways to develop without becoming dependent on trade. Traditional theories of growth focus on trade as the engine of growth; endogenous growth theory focuses on education, on-the-job-training and development of new technologies for the world market.

Endogenous growth theory is a criticism of globalization. In the traditional neo-classical models, growth originates from trade. As Gill & Law find, "Liberal economists have interpreted the association as one where causation runs from freer trade to faster trade growth to faster economic growth." (p. 233, The Global Political Economy.) What this means is that the export-driven development will trickle down to all parts of the economy, and eventually, all countries will be at the same level.

The other part of neo-classical theory is the theory of comparative advantage, which is a false notion. That's the theory, from David Ricardo, that someone is best off, economically, to do whatever they're best at -- even if they're the worst at it. "According to Ricardo, when countries

specialise in the production of those goods in which they have a comparative advantage, and trade ensues, there is an absolute gain in welfare for both economies" (p. 235, Gill & Law). The problem with this is that in globalization, "capital is mobile foreign investment, so that the export sector of one nation may be owned by capitalists from another-and these foreign owners may repatriate most of their profits" (p.236, Gill & Law). This is exactly what happened in many developing countries-India's resources were depleted by England, for example. Basically, there are many problems with relying on trade, especially for developing countries.

The eventual problem is one that's been called dependencia -- the hierarchical and exploitative character of transnational firms in a global economy: growth may be achieved, but only at the cost of international, North-South and internal inequalities, combined with dependence on the financial headquarters of the world. (That's also from Gill & Law's book.)

What endogenous theory does is to show how countries can work within the process of globalization, to find complementary activities (like education and retraining) and regulatory frameworks which help them survive, and collect rents from the multinational corporations within their political and economic boundaries.

Romer's 1986 paper really started the entire theory rolling. In this paper, "Increasing Returns and Long Run Growth," he proposes a model where economic growth is driven by the accumulation of knowledge. This argument gets more refined and developed over the next 8 years. Catherine's given us a few papers to work with, and in the next section, I'll try to give an outline of what he says in each of his papers.

In his 1986 paper, he's arguing that knowledge is the basic form of capital. The differences between knowledge and physical capital:

1. The development of new knowledge comes with diminishing returns. Even though you pour money into research, you won't come out with identical products. Where you can buy a factory and that produces 10 widgets a day, you can't buy a team of researchers and get 10 developments a year. And the more money you pour into research, the less you may get back.

2. However, investment in knowledge leads to increasing returns in marginal products. If your team of researchers designs a prototype for the perfect widget, your factories can produce them, and you will sell thousands of them for the cost of the one development which put you ahead of the competition.

I've got a great example here, of a design problem which developed into a conceptual leap. Ralph Gomory, in "The Technology-Product Relationship" (Technology and the Wealth of Nations, p.389), discusses how IBM became

competitive with printers. When the first IBM home computers came out, IBM printers weren't competitive, and most consumers bought cheaper rival brands (mostly Epson). IBM's developers found that their printers had many more parts (about 120) than their competitors -- meaning that they were more complex to assemble. They worked towards a machine with only 60 parts, ended up with 62, and a machine that could be assembled in 3-4 minutes. The new IBM Proprinter went on to become the bestseller in its class in the US. (The remarkable thing was that this also cut the development time in half from previous projects.)

In other words, the development cost is high, but after that has been paid, the knowledge can be reproduced at very little cost. The other thing that was learned by the Proprinter developers was that more efficient production -- that is, not just making something that works, but making something that was quickly put together, and cheap to produce -- was highly profitable because consumers flocked to the cheaper product with equivalent quality. Knowledge production has many side-benefits.

3. And that leads to the last point that Romer makes, that investment in knowledge has a "natural externality" -- that is, knowledge can't be perfectly patented or kept secret. Once you know that something can be done, you can start trying to duplicate it. And new knowledge has a positive effect on the production possibilities of other firms.

(IBM developers took their competition's product apart and counted the number of parts, finding that the other printer had fewer parts. By working towards fewer parts, they weren't exactly reverse-engineering the competition's printer (although that must also have happened), they were also making their production process more efficient. As a side benefit, the knowledge that fewer parts to put together meant cheaper production, coupled with a highly profitable example, led other companies to streamline production, even if they weren't in the same fields.)

The Internet is a great example. It was developed by the US military to have no central controls, just in case the country needed to survive a nuclear attack. What it's become is a metaphor for the global village -- no centre, all connected.

But endogenous growth doesn't just happen. There are a few preconditions. As Romer writes in his 1990 paper, "Endogenous Technological Change," the model of endogenous growth has 4 basic inputs:

1. Capital -- measured in units of consumption goods

2. Labour -- skills available from a healthy human body

3. Human capital -- activities such as formal education and on-the-job training. This is person-specific; if the person who knows how to multiply dies, that skill is lost from the pool of human capital

4. An index of the level of the technology

The key in Romer's model is an adequate stock of human capital. He finds that "what is important for growth is integration not into an economy with a large number of people but rather into one with a large amount of human capital" (Romer, 1990, S98). This is important for countries to note, in setting up political and economic agendas. His conclusion is that, to promote growth, countries' economic policies should:

1. encourage investment in new research, as opposed to encouraging investment in physical capital accumulation.

or, if 1 is not possible, at least:

2. subsidize the accumulation of total human capital. (Problem with this one is that multi-nationals parachute in, and use the local human resources and human capital, but spirit their capital out of the country into safer tax havens, not investing the money back into the country, as we discussed in the second week. What countries need to do is to build regulatory frameworks to collect "rent" for the building of human capital from the multi-nationals.

In his 1990 paper, he finds two interesting implications.

1. That open trade may be supportive of growth and technological development. The example he gives is a study on US counties in the early 19th century. The ones which were close to navigable waterways had higher rates of patenting that those which were inland; as water transportation was introduced, the rate of patenting went up. (Of course this may have something to do with the fact that opening up the areas made them more attractive for creative people to work there, but this is also a metaphor for creative people in the global economy.)

2. That therefore, "a less developed economy with a very large population can still benefit from economic integration with the rest of the world" (p. s99). However, the "economy with the larger total stock of human capital will experience faster growth."

And then there's his 1994 paper, which is more an overview of the origins of endogenous growth. What I found interesting in this paper were the five facts which he presents as evidence about growth, and challenges for growth theorists.

1. There are many firms in a market economy.

2. Discoveries differ from other inputs in the sense that many people can use them at the same time. (Knowledge is a non-rival good -- this means that if you know how to add and I know how to add, we can both add at the same time. A calculator, on the other hand, is a rival good. We can't use the same one at the same time.)

3. It is possible to replicate physical activities. (Because knowledge is non-rival, many calculators can be made from the one principle of adding machines -- and lots of other electrical engineering, too, but that's another story.)

4. Technological advance comes from things that people do. (This one sounds funny, but it's based on the fact that things just don't happen because another year has gone by. That's more like the exogenous growth of a tree -- another year, another ring. What Romer is saying here is that technological advances come when people start experimenting or looking for market niches. The IBM Proprinter happened because a firm wanted to get competitive. The IBM happened because they needed another market. The IBM then failed because cheaper clones were developed by asian countries, with the same computing power for significantly cheaper costs.)

5. Many individuals and firms have market power and earn monopoly rents on discoveries. (This fifth one is the most interesting, and is also the link to Kwan's presentation on Schumpeter, who stressed the fact that monopoly power was a motivating force in the process of innovation. Intellectual property rights somewhat negate point #2, but only where they are in place and enforced. What some other theorists have implied is that it's probably a good thing for some countries to let the property rights slide for a few years, so that a country can catch up, and then put them in place to protect their developments. A similar thing happens with copyright in many developing countries.) (I can't find the reference to which theorists right now, but I can look for it if anyone's interested.)

The 1991 paper with Rivera-Batiz is probably the most useful for this discussion, however. In this paper, they set up a controlled and simplified thought experiment to test trade and technological development between two countries, which together make up the "global" market. They set up three scenarios, with different levels of trade restrictions and intellectual property rights. (It's sort of reminiscent of the prisoners' dilemma):

Innovating companies have 3 options:

1. designing a new good and earning monopoly rents in the world market

2. copying a good from abroad that is not allowed to enter the domestic market, and earning monopoly rents from the domestic market alone. (This assumes that duopoly is not possible in the other market because the other government won't allow the copied good into the country.)

3. copying a good that is already being sold in the domestic market and playing a duopoly game.

A country would want to limit imports of foreign goods because locally produced goods allows them to keep the money from their companies in their country -- not flowing to a foreign country. This can be done through import restrictions & tariffs, or by selectively weaken intellectual property rights so that foreign rights are undermined and domestic rights are preserved (p.989).

However, if the barriers are too high, and new inventions can't cross the national lines, then the incentive to innovate decreases, and worldwide technological progress slows down. Basically, they find that any barriers on trade slows down worldwide technological growth. Also, as they put it, copying is a tax on the revenues that a copy makes, and reduces the amount of human capital that could be used more productively (ie. innovating).

On the other hand, if companies in both countries A and B innovate, there are greater spinoff benefits (knowledge spillovers) for both countries, and greater overall economic development for the global economy.

What countries have to do is find growth through balancing innovation and copying; tariffs and free trade; incentives to R&D and trade barriers to discourage external goods. (And that's what endogenous growth is all about.)

There are some interesting researchers doing work on how to encourage endogenous technological growth. A lot of this work is remarkably post-Fordist in character. I'll just outline one paper for you. It's called "The New Age of Capitalism: Innovation-mediated production" by Richard Florida and Martin Kenney. In this paper, they describe a system of mass production which uses decentralized decision making, and uses the knowledge and intelligence of all employees, making daily learning important.

Here's a great quote from a steel factory worker, quoted in the paper, which is just like the Saturn ad we were talking about last week:

"Before we came to work in the morning, we used to check our minds at the factory gate. Now we are the source of innovation" (p.638).

Florida & Kenney identify 5 major dimensions in innovation-mediated

production (note: this is all terribly reminiscent of Jackie's presentation on post-Fordism):

1. A shift in the main source of value creation from physical skill or manual labour to intellectual capabilities or mental labour

2. the increasing importance of social or collective intelligence as opposed to individual knowledge and skill

3. an acceleration of the pace of technological innovation

4. the increasing importance of continuous improvement at the point of production

5. the blurring of the lines between the R&D laboratory and the factory.

Basically, what they're describing is the model of production in a post-Fordist era. In order to stay competitive in an era of constant change, companies have to use all the resources available. They describe a steel factory where production time was cut down from 12 days to one hour, and the quality of the steel produced was improved tenfold -- primarily because of a drastic change in production methods, changes in workers' attitudes to work, and a constant improvement policy.

There's also a utopian stream of thought with these new developments. That workers are able to use their minds as well as their brawn is good, but the authors also offer hope for developing countries -- in the model of Romer's work. Because this new model of development gets workers involved in production, increases your human capital, and develops more innovation.

As they write, innovation-mediated production is good for developing countries because "this new model of development does not require huge investments in technology. Even if a country or firm has limited resources to invest in formal R&D, shopfloor workers comprise a crucial source of innovation and improvement. Thus, every nation and every firm have assets for innovation, which can be unleashed if their human resources are cultivated and managed properly. ... A key factor in future development strategy will be the ability of these nations to adopt key aspects of innovation-mediated production and develop both the manufacturing and human infrastructures required to support it" (p.650). This, of course, ties in really well to Romer's thesis, that countries need to be in control of their own development, so that they can function in the new information economy.

Endogenous growth theory is a "bootstrap" method -- a way for countries to pull themselves into the information economy using their available resources, and not allowing themselves to be exploited by multinational

corporations, as globalization is doing now.

[Image]

This was a presentation for CMNS 840, Fall 1994. Hopefully I've stayed faithful to Paul Romer's work, and written a fairly easy-to-understand paper out of my original presentation notes.

- Gladys We

[Image]

Send e-mail to Gladys We (we@sfu.ca).

Go back to the Information Highway home page.

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