Innovation and the World Economy:

Thoughts on Measurement, Theory, and Policy

Samuel Kortum

University of Minnesota

Dr. Marburger's Challenge (2005, AAAS)

- *It is well to keep in mind how primitive the framework is that we use to evaluate policies and assess strength in science and technology.*

- *... the nascent field of the social science of science policy needs to grow up, and quickly, to provide a basis for understanding the enormously complex dynamic of today's global, technology-based society.*

- *Are we funding all the R&D we need to defend ourselves, improve and sustain our quality of life, and compete with other nations ...?*

- *I do not know of any reliable way to answer this question short of developing a massive econometric model for the world's economies and workforces, and exercising it with various scenarios.*

Wake-Up Call

- He's basically right. But will our "nascent field" ... "grow up" by developing a "massive econometric model"?

- More promising steps to maturity:
  - Better measurement and establishment of basic facts (why I'm excited about this conference).
  - Careful estimation of key parameters, employing a variety of techniques.
  - Development of an endogenous growth model that sews together the disparate evidence and allows us to conduct policy experiments.

Flash Back

- R&D Rountable at the NBER, 1999 (EINT, 2004). Zvi Griliches wanted us to think forward 20 years:
  - *I proposed that the goal be to build up a quantitative general-equilibrium model of innovation and growth.*
  - *This model would be tightly linked to evidence from micro-econometric strudies of R&D and technological change*.
  - *It would speak to the firm-level evidence, but would also aggregate up to the economy-wide level, perhaps with an international dimension.*
  - *It could be used to supply Alan Greenspan with a sensible number or to give advice to those formulating R&D policy.*

Are We Making Progress?

- I got a tepid reception in 1999, but I'm returning to the same theme 7 years later!

- One can get discouraged in this endeavor by the small ratio of things measured to things we can make theories about.

- As we assemble better and better data, however, this agenda starts to seem more realistic.

The Quantitative Methodology

- Traditional approach: regress outcomes, such as productivity growth, on inputs, such as R&D investment.

- Can add more explanatory variables such as foreign R&D, but this approach always masks the key issue of why firms invest in R&D.

- For conducting policy experiments, the central tool should be a quantitative general-equilibrium endogenous growth model.

- Ed Prescott's Nobel lecture (JPE, 2006) gives an inspiring account of the development of the quantitative general equilibrium approach and its use in macroeconomics.

Why a General-Equilibrium Approach?

- Advantages:
  - Incorporates optimizing behavior, e.g. accounts for R&D investment.
  - Equilibrium by definition, e.g. what if firms all try to hire scientists?
  - Uses consistent theory to fill in what's not estimated econometrically.
  - Allows individuals and firms to reoptimize to a change in policy.
- Disadvantage: certain elements are not tested.

Basic Models

- Endogenous growth models (Romer, Aghion and Howitt, Grossman and Helpman) are a good starting point.
  - Very clear about the non-rival nature of technology, and the implications for market structure.
  - A bit stylized, but R&D investment gets determined within the model.
  - Still some rough edges: is population growth crucial for long-run technological advance?
- Progress in bridging the gap between these aggregate models and micro-level evidence (with Tor Jakob Klette).

Incorporating the International Economy

- Endogenous growth models should embody international trade and international technology diffusion.

- International technology diffusion is particularly important, even in ancient times, as Jared Diamond describes so nicely.

- Without international trade, technology diffusion is a win-win proposition (ignoring wars).

- See Klenow and Rodriguez-Clare chapter on externalities (Handbook of Economic Growth) for a review of progress in this area.

Measuring Technology Diffusion I

- Challenge: its inherently invisible.

- Why do we think there is international technology diffusion?
  - By a process of elimination, we infer that technology drives growth.
  - We see that different countries make very different investments in R&D, particularly in absolute terms.
  - Yet productivity in the small (low R&D) countries does not fall farther and farther behind.

Measuring Technology Diffusion II

- Why don't we think international technology diffusion is instantaneous?
  - By a process of elimination, we infer that technology explains productivity differences.
  - Yet, these productivity differences across countries persist.
  - Why doesn't every country know how to build a nuclear bomb?

- An econometric test of H_0: *Technology does not move outside national borders* or H_0: *Technology moves freely across countries* seems like a waste of time.

Quantifying International Technology Diffusion

- Progress in indirect measures of international technology diffusion:
  - International patent databases, by EPO and OECD.
  - Patent citation databases (Jaffe and Trajtenberg).
  - Firm level data and international trade by product and destination (Bernard and Jensen, Kramarz).
  - Linking of firm-level data on R&D and R&D of multinationals (reading for this conference).
  - ....

Opportunities

- We're entering a golden age in terms of access to data, thanks to the hard work and foresight of people in this room.

- Also have a rich set of economic models and the computational power to use them.

- We can evaluate models and pin down parameters using individual micro observations, macro observations across countries, or a combination of the two via distributions of micro outcomes.

- It is time to put some of these riches to work to provide deeper answers to policy questions in the area of science and technology.