Rosenberg on Technological Progress

Chapter 1: Technology in Historical Perspective

In this chapter, Rosenberg outlines his framework of what technological progress is and what it accomplishes. An important distinction to make when output growth occurs is whether the growth is resulting from using more inputs or from a change in technology. Rosenberg describes a hypothetical case of America in 1800 with the resource constraint relaxed. The economy could have grown (even under conditions of constant production technology) by simply pouring more inputs into production. However, when the resource constraint is enforced, Rosenberg concludes a Malthusian situation is inevitable. Eventually you cannot increase inputs but population grows - so output per capita declines until you hit a long run equilibrium (since tech is constant and cannot improve).

So technology is important because it allows economic growth even if resources are limited. This occurs in two ways: first, new machines allow you to get more output per input (embodied tech advances), and secondly you get improved organizational and distributional techniques (disembodied tech advances). Here the author makes the point about urbanization. Because many technologies contain scale economies, mass production is advantageous. But to mass produce, you need lots of inputs in one place, including labor. Also, mass production often requires fuel or raw materials, so it can be advantageous to locate near deposits. When these urban areas rise as population centers, they also provide the markets for such mass production since factories are likely to produce more than local demand. Rosenberg concludes that because all of these forces push us toward urbanization, industrial economies must devote significant resources to distribution of goods.

But it would be a mistake to see technological advances as simply being better ways to meet the same wants and needs. Invention introduces entirely new types of goods that can radically shift tastes and create new demands or eliminate old demands. For example, when radio and television were introduced, people changed the way they spent their leisure time. Indeed, the invention of labor and time saving devices for household chores simultaneously affects agents' demand for those devices (new demand) and also for leisure (since more spare time). New inventions create new employment opportunities (you can't have switchboard operators without switchboards), potentially allowing more people to enter the labor force who previously were not well suited to any jobs. Some goods are also fundamentally different from other goods, such as modern washing machines verses old wringing washing machines. "To the extent that technological change has provided us with an enlarged and qualitatively superior collection of goods and services than we formerly possessed, out conventional measure of economic growth - a rise in per capita national income - understates the resulting improvement in economic well being. . . An economic system should be judged by how it affects the lives of its citizens, and not by how well it maximizes money profits or measured output." (P.17)

Rosenberg's final point is that technology does not occur in a vacuum - technological advances appear as a solution to a problem faced by a society. The particular technologies developed by a society will be specific to the particular problems they face. Technological progress “does not occur in abstract but rather in very specific historical contexts.” (P.21) “Moreover, the kind of solution which any society can produce to the problems presented by its natural environment will turn on the level of knowledge and expertise which is available to it.” (P.22)

Chapter 2: The Economic Matrix

A key distinction to make is between invention and innovation. Invention has to do with making new discoveries in materials, procedures, or institutions that can make production more efficient. Innovation concerns the diffusion of an invention into an economy. “Inventions contributed to economic growth not as a function of the timing of their invention but rather as determined by their rate of adoption and diffusion.” (P.58) Technological change then, involves first being able to come up with the solution to the problem (invention) and then actually implementing that solution (innovation).

Invention without innovation has zero effect on economic performance, but innovation can occur using inventions from the outside. Therefore, technological change occurs only if a new invention is discovered by an economy. However, technological change occurs if and only if innovation occurs in an economy. The reason is that innovation could be using a discovery made by another economy and received through trade of information. “Therefore, much of the process of economic growth really centers upon the diffusion of new techniques.” (P.58)

Rosenberg asks “Why do some societies have a much greater apparent capacity to generate the appropriate inventions than do others? Why are some societies much more receptive to the introduction of inventions made elsewhere? These are very different questions, for the requirements for successful inventive activity may be very different from the requirements for the rapid adoption of an invention, once it has been made. Whereas the former question involves the supply of inventive talent, originality, and the ability to apply specialized knowledge to the solution of technical problems, the latter question is more likely to turn upon the supply of managerial abilities, highly motivated entrepreneurs, business acumen, and organizational effectiveness.” (P.31) Rosenberg goes on to make the point that the French were good at inventing but not innovating while the Japanese were bad inventors but great innovators.

In the case of the United States, the elements required for both inventing and innovating were present during the 19^{th} Century. The author argues that the population of immigrants self selected themselves into an industrious group because most Americans came seeking better jobs and financial gain. Rosenberg presents some statistics (P.38) that showed formal schooling rates in America for white males was probably the highest among all nations. Formal education plus some degree of equality of opportunity among white males (allowing the nation to tap the best, no matter what station they are born to) and industriousness probably made the US population a natural fit for inventive and innovative activity.

At the middle of the chapter, Rosenberg studies the role of demand-pull and supply-cost effects on the incentive to invent and innovate. The framework he uses here is one of expected returns versus expected costs. The “inventor” weighs the costs in resources and time he expects to use in making a new discovery. Because it is unclear how easy or difficult it will be or even how valuable the discovery will be, the “inventor” takes an expectation on what he believes will have the greatest impact on efficiency subject to his expected costs of experimentation/research. This is the supply-cost side - the most desired discovery will be the one that lowers production costs the most and is the easiest to find and implement.

However, the value of a discovery also depends on what that discovery is used for. Suppose a great efficiency enhancing discovery could be made in the production of accordions. If nobody wants accordions, then what is the discovery worth? Suppose a great efficiency enhancing discovery could be made in the production of televisions (and everyone wants a television). Since the market value of a product is subject to consumers’ willingness to pay, the value of a discovery is linked to what people want to buy. Rosenberg invokes Schmookler’s study on rail capital goods to make this point. (P.40) When rail capital goods were in high demand, they commanded a high price. So being able to manufacture rail capital goods cheaply was of high value (you could make a profit on every rail capital good you sold). Expected profitability in the sector the discovery will be used in translates directly into expected value of the discovery itself.

The only way to capitalize an invention into profit is if somebody wants that invention. The only reason someone wants the invention is if they can innovate with it and make a profit manufacturing something. So logically you want to try to discover an invention that can first be used by manufacturers in high demand sector, and secondly can be applied cheaply. Even if an invention is in a high demand industry, firms will not use it if it’s too costly to implement. Thus, you have to tailor your research pursuits to the tastes and resource base of the particular economy you are operating in. Rosenberg uses the United States’ labor scarce and wood/land abundant situation with plain tastes to talk about why the US developed so many inventions that “wasted” wood (P.29) but saved labor.

Changes in the resource base (reflected in factor price changes) and tastes in consumers will cause the optimal direction of research to change. When you decide what to engineer and research, you are really trying to guess which discovery path will produce the biggest cost savings in the most profitable product line. Technological change ultimately is a result of people having the right incentives to discover and then implement new methods and products. The particular inventions and innovations an economy comes up with depends on the particular tastes and resource allocation of that economy.

Inside the Black Box

Chapter 1: The historiography of technical progress

Technical progress “constitutes certain kinds of knowledge that make it possible to produce (1) a greater volume of output or (2) a qualitatively superior output from a given amount of resources.” (P.3) This is the same reasoning as above where technological change has value because it provides more efficient production methods and also provides new products. Rosenberg particularly emphasizes how important the value from having new and improved goods to consume is.

The author goes through a brief survey of theory in the mid 20th Century, including Kuznets' and Schumpeter's emphasis on the value of new products. Schumpeter's big contribution to studying technical change was his "great emphasis upon technical progress as constituting major breaks, giant discontinuities with or disruptions of the past." (P.5) Schumpeterian innovation is a discontinuous shift of the production function representing a radically new way of making something or a totally new good. According to Schumpeter: "Add as many mail-coaches as you please, you will never get a railroad by doing so." (P.6)

Opposite of Schumpeter, Marx and Usher thought of technical progress as a continuous incremental process. "Usher called attention not only to the elements of continuity but also to the cumulative significance, in the inventive process, of large numbers of changes, each one of small magnitude." (P.6) Reminiscent of Kuhn, "Usher's concern with the emergence of novelty in history led him to pay careful attention to the factors that conditioned or set the stage for a particular inventive breakthrough." (P.6) Rosenberg then goes into a big discussion of institutional factors that contribute to why the West had technical progress but not anyone else (lots about religion and some about property and contract law).

One thing that Rosenberg returns to at this point is how innovation and not invention is the big deal. It doesn't matter if an invention is discovered if nobody uses it. But even if you don't invent something, you can still innovate with it. He quotes Hall at length to make the point that the West wasn't so good at inventing, but was really good at borrowing from others and innovating with their discoveries (China, Islam, India). Because you can always borrow inventions from others, "a top-quality scientific establishment and a high degree of scientific originality have been neither a necessary nor a sufficient condition for technological dynamism." (P.14) Does science create new inventions or do inventions lead to scientific discoveries? The causality is unclear.

Hicks made the argument that you want to direct your research at "the" optimal discovery path, but this was challenged. Salter and others said firms will take whatever cost saving inventions they can get "and that there is no reason why attention should focus upon invention possibilities with any particular factor-saving bias." (P.15) Habakkuk, Temin and David try to unify these ideas by saying that firms will take into account how difficult/costly they expect a discovery path to be. And since one discovery will lead to the next, a la Usher's cumulative progress, decisions now may lock you into a particular discovery path. Ruttan-Hayami developed an idea where there's a "dicovery possibilities frontier" that marks all the terminal points you can end up at, following all your possible discovery paths. What you should be able to do is pick a point you want to go to and find a David path to get there. If you know what your relative resource scarcities are, you have a good idea of where you want to end up. So you make your initial choices in such a way as to get onto the David path that gets you to the "right" terminal point. So all of the incidental inventions along the way may not have any particular bias toward any factor as Salter said, but you will end up at what Hicks thought was the best place.

The author then takes another look at the importance of innovation. His big point is that it doesn't matter when the thing was invented, only when people started to actually use it. So one way to measure the impact of technical progress is to measure how widespread the use of a particular invention is. But this can be misleading because any of the tiny Salter incremental discoveries may be the one to finally push the cumulative value of the discovery path over the hump from "too costly" to "slightly profitable." "Thus, very large technological improvements may be made in an innovation during its "prenatal" period without any substantial repercussions." (The cumulative value isn't big enough yet) "Conversely, even small further technological improvements made after the innovation has reached a threshold level may lead to rapid, large-scale productivity consequences." (P.27) Earlier in the paper, the author mentions a study by Enos which "found that the cost reductions achieved by the later improvements in the major innovations were far greater than the cost reductions associated with their initial introduction." (P.8) This is similar to the Tratjenberg finding about the value of technological progress in CAT scanners.

According to Salter, the firms will make use of any edge they can get. Even if an invention is only slightly better, you might find everyone using it. "As a result, its ubiquitousness may superficially suggest something grossly misleading about the extent of its economic importance." (P.27) Therefore, we have to take into account not only how diffused the invention is, but also the magnitude (how much better the invention is than the old technology). Rosenberg invokes Fogel's opportunity cost rail versus canal instead of rail versus wagon reasoning to make this point. Rosenberg's thinking is along the same lines as Fogel: no individual discovery is indispensable. If a particular invention wasn't made, something else would have come along instead - provided the institutions and society was one that was predisposed to inventing and innovating.

Therefore, the features of a particular economy that we want to study are whether or not the agents in the economy have the incentives, knowledge, and energy to invent and innovate. As long as they have some knowledge and resources to work with (greater than zero), industrious people will somehow find a way to invent and innovate their way past the problems their particular situation presents them with.