Long run growth 4: A theory of TFP

Revised: October 23, 2012
Latest version available at http://www.fperri.net/TEACHING/20205.htm

In the previous class we established that TFP and TFP growth are prerequisites for returns to capital, factors accumulation and growth. In this class we briefly explore what are then the determinants of TFP.

The first order determinant of TFP is technological discoveries that make existing capital and labor more productive. For example think about the invention of the compass. Without the compass 10 sailors and a ship are capable of producing only a limited amount of shipping services as they will get lost very easily. When the compass is created the same 10 sailors and the same ship are going to be able to produce much more shipping services. More recently think of the invention of the Google search algorithm. Technological innovations are a very important driver of TFP growth in developed economies (like US). Figure 1 for example shows the some estimates contribution of information technology to labor productivity (note that labor productivity is different from total factor productivity) in the US. To give you a reference on the magnitude of those numbers the increase in labor productivity is larger than the one that the steam engine brought in UK during the industrial revolution.

How about in developing countries?

Developing countries should have an advantage over developed countries as they should be able to adopt more advanced technology from more advanced countries, without the need of reinventing it. Indeed in figure 2 below we see that countries that reached a certain income level (2000 1990US$) late in the current century were able to double their income at a much faster rate than countries that reached the same level the previous century. US for example reached the level in 1860 but it took more than 40 years to double that level as improvements in productivity were obtained only through technological discoveries. Taiwan instead was able to double the income from 2000 to 4000 in less than 10 years because it was able to increase productivity by adopting better technology that were already around.

Yet we have seen many examples of many developing countries where TFP (and returns to capital) is much lower than in developed countries and most importantly it fails to grow. Why does this happen? We will consider several possible explanations.

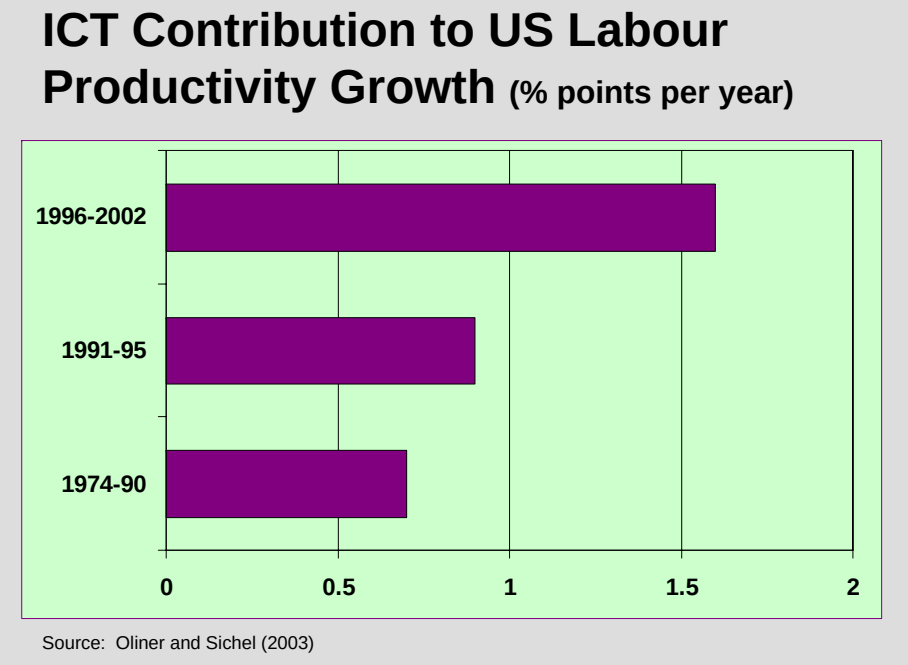

Figure 1: The contribution of information technology to US labor productivity

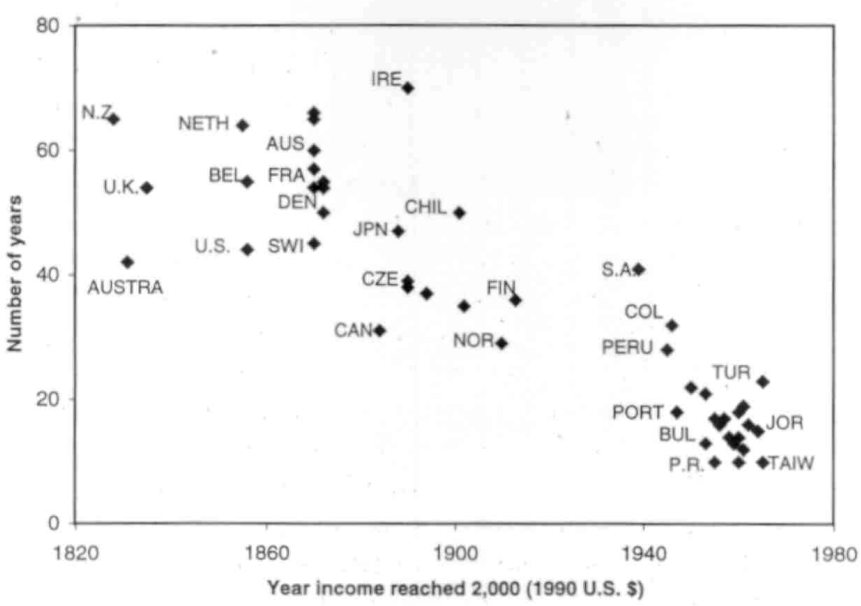

Figure 2: Years to double GDP

Lack of competition

Competition usually leads to the adoption of the lowest cost technology, i.e. the technology with the highest TFP. When there is no competition, either because gov-

ernment regulation or other causes, an inferior technology might be used.

India, for example, for a long time has been producing motorcycles, the leading piece of transportation equipment sold there, with a much older and less efficient technology than the one that was available in leading countries. Why? because the industry was a monopoly. Owners/workers of the industry had no incentive of adopting a better technology (they were making monopoly profits anyway) and had all the incentives of blocking the adoption of a better technology by competitors and of blocking imports as those things would have destroyed their profits and their jobs.

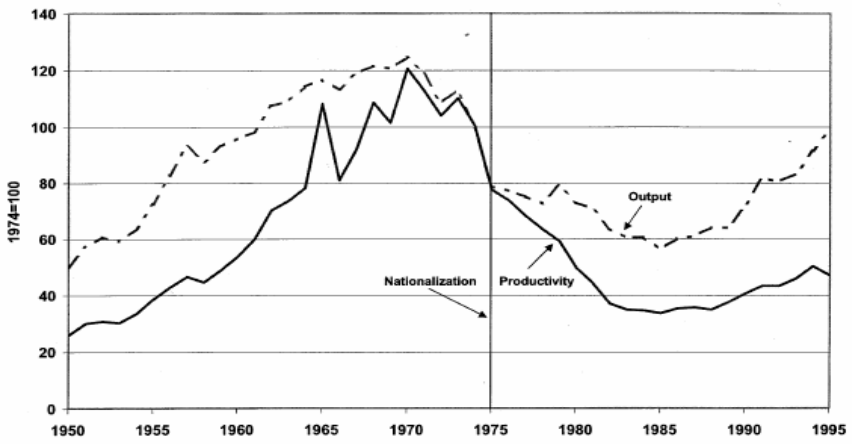

Figure 3: Privatization and Productivity in the Oil Industry in Venezuela

Many Latin American countries have experienced restriction in competition due to events like nationalizations or dictatorships and they have been associated to large changes in productivity (See figure 3). Even in the United States the coal industry in the post war period shows fluctuations in productivity (output per hour) that were not driven by technological innovations (the mining sector was already very mature) but by the decision of coal workers of adopting more efficient practices (when the price of coal was low and thus they were forced to produce high volumes to avoid shut down) or less efficient work practices (when the price of coal was high and they could increase profits by restricting production) (See figure 4).

The key point is that the **adoption of the most efficient practices creates winners and losers**. Since, by definition of most efficient practices, the gains are larger than the losses, if there is competition the best practices will be adopted. But if competition is restricted efficiency is not guaranteed. And note that if institutions in a given country are such that restrictions in competition are possible, then probably competition will be restricted. This is because the benefits from competition are usually dispersed but the losses are heavily concentrated. This is a famous point made

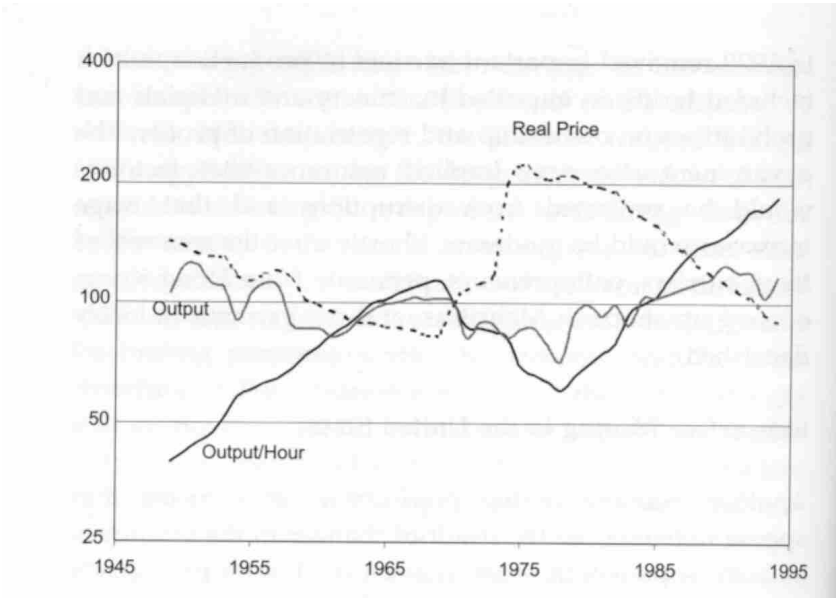

Figure 4: Productivity in the US Coal sector

by sociologist Mancur Olson. To see this more clearly suppose in the Netherlands there are 1 million bicycle riders. If bicycle were produced using efficient technology (under competition) producing a bike would cost 10 Euros (including remuneration for capital) and would be sold at 10 Euros. But suppose instead there is a bicycle monopolist which produces inefficient bikes at 11 Euros and sells them at 12 Euros. Suppose we moved to competition, the bikers as a whole would gain 2*1 million = 2 million Euros and the monopolist (which will be driven out of the market) would lose the profit of 1 million Euros. So for society as a whole competition is good. But note that the losses are all in the hand of the monopolist which will be happy to spend half of its profit to lobby against the introduction of competition. Bicyclists could try to counter-lobby but it is obviously very hard to get 1 million bikers together.

Diversion Policies

Individuals have incentives to adopt efficient methods of production, which require investment and time, if they can keep the benefits from those. If policies and institutions are biased toward diversion that is they facilitate the transfer of the rewards of production from the producer to someone else then the incentive of adopting better technologies and practices are strongly reduced. Taxes are one example of diversion, bribes, corruption and extortion is another. Diversion policies not only have the effect of reducing the efficiency of investments but also of stimulating less productive investment devoted to prevent diversion (Guns, protection guards and so on).

Example of diversion policies in developing countries are plentiful. As economists Shleifer and Vishny point out

"To invest in a Russian company, a foreigner must bribe every agency involved in foreign investment, including the foreign investment office, the relevant industrial ministry, the finance ministry, the executive branch of the local government, the legislative branch, the central bank, the state property bureau, and so on. The obvious result is that foreigners do not invest in Russia".

In southern Italy there is a similar situation with enterprises having to pay a fee to the Mafia whenever they want to start a new business. Many have documented that in countries such us Russia these costs can be huge and deter foreign as well as domestic investment. The Peruvian economist Hernando De Soto in his book, "The other path" shows that in Peru the costs of getting the permissions (including bribes) for starting up a small business are equivalent to thirty two times the monthly wage. This type of costs obviously reduce the efficiency of any domestic entrepreneurial project.

The degree of diversion is strictly related to economic stability. If (as in the case of many African countries) there is a continual switch of powers between ethnic groups and the dominant ethnic group expropriates the losing group, the incentive to invest and develop efficient productive techniques are very low. Well defined property rights, investor's protection are form of policies and institutions that discourage diversion and they have been found to be associated with high TFP and TFP growth. The big question then is why some countries enforce anti-diversion policies while others don't. Economists Acemoglu and Robinson attempt to answer this more ambitious question in their book (Why Nations Fail), and conclude that some countries, sometimes due to luck, were able to put institutions which were accountable and implemented good policies, while in others an elite came into powere and impleneted policies that favored her staying in power, at the cost of leaving the general population in poverty.

Flexibility and efficient allocation of resources

Productivity most of the time is about finding the right matches for the existing talents of a nation. Finding the right matches, especially in times when things change fast, requires lots of flexibility both in labor markets and financial markets.

Labor Markets

Suppose a firm starts to use a new technology but it is not quite sure of type of worker they need to operate the technology. The firm needs to experiment with several workers and once it finds the right one it can exploit the full potential of the technology. If

the labor market is heavily regulated (inflexible) then such experimentation strategy is not possible for the firm and the technology is left unexploited. Many have argued that the inflexible European labor markets and Latin American labor markets are an important cause of the relatively poor productivity performance of these countries in recent years (For example in the US there is no mandated severance pay, in Europe, on average, there is one equivalent to 1 month pay and in Latin America is equivalent to 3 months pay).

Financial markets

Suppose now that there is a variety of entrepreneurs out there each with a project, each project indexed by a productivity A_i. If an an entrepreneur invests k units in the project she gets The entrepreneur does not in general have the money to start their project but there is a total amount of saving S available to the country. The role of the financial markets is to allocate S to the most efficient projects that is to the project that has the higher A_i. If, for a variety of reasons, bad investments are selected this will directly affect efficiency because a lot of resources will be allocated to low productivity projects and that will lower the productivity of the economy. It will also affect output indirectly because the poor allocation of resources will imply low return for savings and therefore will reduce the amount of savings to be invested.

Also efficient financial markets can enable individuals to take more risk which in turn can increase growth in TFP. Consider the following example: in an economy there is a large number of individuals each can either work in a risky activity, which pays off \$10 with a probability of 50% or 0 with a probability of 50%, or in a safe activity which pays \$1 for sure. If there are no financial markets individuals most likely choose the safe activity as they cannot afford the risk of getting 0 consumption in the event the risky technology fails. So the average productivity of the economy will be 1. If financial markets work, individuals could undertake the risky activity and in case their project fails they can share their risk with other agents. In particular suppose that agents undertake the risky activity, issue a stock that they sell to a financial intermediary for \$4. Agents will make \$4 for sure and the financial intermediary pooling all stocks together will make \$5 -\$4 =\$1, so average productivity of the economy will be \$5 as opposed to \$1.

Efficiency of financial markets is not an easy thing to measure but consider this statistic: in 1990 50% of the top 10 banks on Latin America were Government owned, In Europe the number is 40% while in the US is 0. Some authors (see for example Hsieh and Klenow have attempted to measure efficiency of financial markets directly, by measuring differences in marginal product of capital across firms in China and India, and compare these differences with the same differences in the United States. In a perfectly efficient world marginal product of capital across firms should be equalized

(see the box), while when financial markets are inefficient one would expect to observe large differences in the marginal product per capital.

Efficiency and the Marginal Product of Capital

Consider N firms each indexed by productivity A_i and suppose that each firm can produce output with the technology $A_i k_i^\alpha$ where k_i is the capital allocated to firm i. How does the efficient allocation of capital across firms look like? A key condition is that the marginal products of each two firms should be equalized; if not overall output and productivity can be increased by reallocating capital from the low to the high marginal product firm. Notice that for firms i and j the condition amounts to

$$A_i k_i^{\alpha-1} = A_j k_j^{\alpha-1}$$

which also implies that

$$\frac{k_i}{k_j} = \left(\frac{A_i}{A_j}\right)^{\frac{1}{1-\alpha}}$$

which shows that a hallmark of efficiency is that high TFP firms should be larger.

Hsieh and Klenow conclude that better allocation of resources across firms could lead to increase in productivity as large as 60% in India and 50% in China. Using similar arguments Song, Storesletten and Zilibotti show that a large fraction of the spectacular growth in China. In particular they argue that the reallocation of resources from large and not productive firms to small and highly productive firms has increased TFP and enabled growth in China.

Many have argued that one reason for the poor economic performance of Japan in the 2000s (the so called Japan's lost decade) has been the very poor performance of its financial intermediaries and their inability of channeling resources to more productive businesses. And many are arguing that the reason of the poor performance of US and other developed countries in recent times lies in a broken financial system, as a consequence of the 2007-2008 financial crisis.

An interesting branch of economics, Microfinance studies the importance of financial markets in less developed and less formal economies. Some recent studies show that even very samll loans extended to rural households to finance, for example, the purchase of a cow or of fertilizer, can have an important impact on growth and TFP growth.

Also the efficiency of financial markets is clearly linked to the strength of anti-diversion policies (see above). Since financial markets usually involve inter-temporal exchange (i.e. I give you money today in exchange for a promise), it is important that participants in financial markets trust that the that promises will be enforced, if they are not financial markets just won't work.

Unmeasured human capital

One factor that will show up as TFP but really is not is unmeasured human capital i.e. quality of workers. For example consider two workers which are both college graduate working with the same computer: worker 1 produces 100 dollars worth of output, worker 2 produces 1000 dollars worth of output. Obviously the production process of worker 2 has higher TFP but maybe one reason is that worker 1 received a better quality of education in college. How do we measure quality of education? one standard measure of education is achievement in tests scores. Figure 5 below shows that for a number of countries indeed higher test scores are associated with higher growth of output (and hence of TFP).

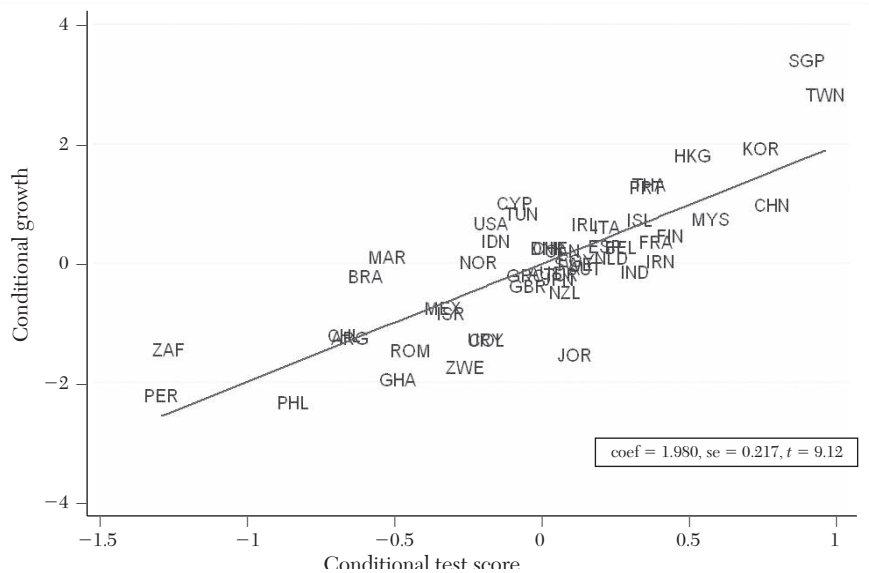

Figure 5: GDP GROWTH AND TEST SCORES

What to do then?

If efficiency and productivity are the key to economic prosperity, what are the policies best geared to promote this efficiency? This is a very hard question and answering it is well beyond the scope of this course.

One simple lesson is that economic outcomes can only by changed if we first understand the incentives that lead to the actions that caused the bad outcomes and who gains from maintaining the status-quo. Once this is understood we can think about mechanisms or plans that change the incentives of people and that can lead to better outcomes. This procedure might take a long time as it might involve

- The design and the creation of new or better institutions (better financial markets)
- A change in culture (i.e. in the beliefs that people have about the others and about the environment)
- Very unpopular political decisions which hurt the interests of groups in power

but it is probably the only way to go: indiscriminate and non conditional aid are usually ineffective and, although they might offer some relief in the short run, they might make things worse in the long run, by increasing the power of the group (or groups) that prevent general economic development in the first place.

Concepts you should know

1. TFP
2. Diversion policies
3. Role of financial markets in promoting efficiency