Development Economics 855
Lecture Notes 4

Multiple Equilibria. Coordination Failure

Introduction

- remember, convergence idea (as in the Solow model) is not supported well by data, i.e. even if saving rate, population growth are the same we observe very different outcomes across countries
- idea: what if the economic outcome depends also on **history or expectations** – go further and endogenize things that the Solow model takes as exogenous
- examples: why investment rates in seemingly similar countries are persistently different, why given saving rate translates into very different growth rates?
- History and expectations: work through 2 main channels: **complementarities** (the more others do something the greater your incentive to do it) and **increasing returns** (the more you do something the better you become at it – your costs decline)
- In the above situations – there can exist **multiple stable equilibria** – self-fulfilling expectations may determine which one prevails (e.g. explain recessions)
- Typically in economics – unique globally stable equilibrium. Why? **negative feedback mechanisms –** a shock to the system unleashes forces that counteract the shock (e.g. usually sloped supply and demand, diminishing MP and Solow convergence)
- Leads to theories of underdevelopment as a **bad equilibrium in multiple equilibria setting**
- Downside: lose predictive power – just knowing the parameters of the economy can't say which equilibrium it will be in, need to know expectations, history, etc.; how do you coordinate way out of bad equilibrium? How do you change expectations?
- Upside: more optimistic policy implications – not necessarily the case that underdeveloped countries are stuck with "bad" parameters – can just be caught in a poverty trap

I. Increasing returns (you could read DE, sections 5.3.1-5.3.2 for more detailed discussion)

- the ability to realize the gains from IR depends on the **size of the available market**
- the market size however may itself depend on the ability to exploit IR to expand production and income
- thus an economy can be caught in a vicious or virtuous cycle in the presence of increasing returns – **multiple equilibria**.

Example – IR & Market Entry

- Example: auto manufacturing – local guy – can produce a car at lower average cost at any output level, market is however saturated (an incumbent is already present) – not profitable to start given that other producers are already there
- Under IR: If introduce new product – **suffer a loss until enough people switch**
- **If capital markets are perfect** – these temporary losses are not a problem – every bank would find it profitable to lend. However, they are usually not in developing countries – a problem
- IRS is crucial – if DRS – can start at arbitrarily small scale

II. Complementarities

- **idea:** (network) **externalities** cause the cost of implementing certain action to decrease as more and more people implement it
- examples: Windows, QWERTY keyboards (were efficient for typewriters, not necessarily computers)
- **lock-in effect**: if already many people use Windows maybe less worth to write software for Mac, Linux; this may prevent new better technologies, products to be used; **history would matter** (what was adopted first)
- what is crucial is the **complementarity** – if the cost of action increases in number of people doing it – no lock-in but instead congestion – no role for history
- **Effects of complementarities:**
    - There can be **multiple equilibria** (e.g. all use Mac vs. all use Windows)
    - The particular equilibrium that ends up occurring depends on **history** (e.g. IBM deciding to go with Microsoft in early 80s) – nothing is predicted by the theory

Coordination Failure

- because of the presence of complementarities it can happen that the economy get stuck in a **low-level equilibrium trap** while there exist a better equilibrium
- Rosenstein-Rodan – forwarded the idea that economic underdevelopment can be a result of **coordination failure** – some investments don't occur simply because other complementary investments are not made – two equilibria possible – one with all industries inactive and one with all active
- Both pessimistic or optimistic expectations can be **self-fulfilling;** examples – through demand – enhanced level of economic activity generates greater income which creates in turn additional demand to justify the activity
- Example: setting up factories in a region; suppose no entrepreneur is large enough to invest in more than one. Then there can be **2 equilibria**: if all entrepreneurs believe that others will invest – pays off to invest – **all invest** is equilibrium, if don't believe – **nobody investing** is also an equilibrium

- Which equilibrium will arise depends on **expectations** which are typically driven by history

Complementarities, Industry Linkages and Policy

- different industry **sectors are linked** together – one can facilitate/hamper development of another. The sectors complement each other (there are externalities) so there can be multiple equilibria again.
- if all sectors are in depressed state – hard to switch to growing state all of them at once
- example: steel industry – facilitates railroad industry, coal, etc. Both linkages through demand or supply are possible.
- Policy: suppose economy is in a depressed equilibrium, **what policies to use** to take it to a better equilibrium?
- Rosenstein-Rodan: idea of a **"big push"** – policy that simultaneously creates coordinated investment in many different sectors.
- **Problems with the big push**
  - May be "too expensive" – requires massive investment – country may not be able to do it
  - Requires to allocate investment in the right proportion of expenditure – too hard **information** requirements.
- Hirschman: instead of a big push (balanced growth) do deliberate **unbalanced growth –** to rely on the market to tilt the economy away from the bad equilibrium and converge to the good one naturally – idea of picking **leading sectors**

III. Policy Implications

- in the above context policies are to be viewed as a device for moving the economy out of one equilibrium into another
- a policy **need not be persistent** – precisely because the desired end-state is also an equilibrium – just need to push the economy to start "rolling" towards it. The policy may be removed immediately after old equilibrium is ruled out
- examples: can be an equilibrium optimal response to people to use slaves; bribe and be bribed, throw garbage on the street provided everybody **else is doing the same**. The very same people however will refrain from these things if no one else engages in them (e.g. immigrants). Thus a policy that makes one of these activities unlawful and is well enforced needs to be applied only some limited amount of time until people switch to the "good" equilibrium – social pressure will suffice later.
- **Policy implementation and timing must be smartly chosen** – e.g. compulsory **primary education** – its benefits are unclear in a society where labor power is needed for current output and where no one else is particularly educated. Thus a country may commit lots of resources to schools but children may not be sent to them by parents – may lead to worse outcome than the initial one.

3.2 Demand Complementarities

The model sketched below is based on "Industrialization and the Big Push" by Kevin Murphy, Andrei Shleifer and Robert Vishny, Journal of Political Economy, 1989 (pp. 1003-1026). The idea behind it comes from early work by Rosenstein-Rodan who proposed the following parable of a shoe factory. Think of a poor economy where there are no factories. Apart from agriculture, other consumer items are produced by village artisans using low productivity cottage industry technologies. Suppose one person decides to set up a big shoe factory using a modern factory technology which has some set up costs, so that it can earn profits only if sales exceed some minimum level. In the process of setting up this factory all the construction work, the wages and salaries paid to employees will generate a lot of demand in the village. But, and this is a key assumption, if the shoe factory is restricted to sell its shoes only within the village (i.e., there is no possibility of exports) then only a small fraction of all this extra income will come back to it in the form of sales. They will boost demand for other things, but since traditional technologies are used to produce them, it is unlikely that supply will expand. The end result will be losses for the shoe factory, and general inflation. If instead other industrialists simultaneously set up factories to produce food, clothing and every other consumer good, then they will expand each others market, as well as ensure that supply matches increases demand. In that case the village economy will become industrialized. MSV cite the work of Chenery and others that show among countries that grew relatively fast during 1950-70, domestic demand was the main source of demand among those that had large populations. The following model illustrates this idea.

3.2.1 The Model

Suppose consumers consume N goods and for simplicity they have a Cobb Douglas utility function of the form:

$$U = \frac{1}{N}\sum_{i=1}^{N} \log c_i.$$

This ensures that the share of expenditure on each good is $1/n$ of the consumer's income.[4]The model is static - there is no saving and so expenditure equals income.

[4]The first order condition for each good is

$$\frac{1}{Nc_i} = \lambda p_i$$

and hence substituting in the budget equation we get

$$\sum_{i=1}^{N} p_i c_i = N\frac{1}{N\lambda} = \frac{1}{\lambda}.$$

This must euqal income, Y and hence $\lambda = \frac{1}{Y}$ and so $p_i c_i = \frac{Y}{N}$ for each good.

Let L be the total amount of labor available in the economy. There are two sectors in the economy, traditional and modern. The traditional sector which is perfectly competitive uses a CRS technology that converts one unit of labor into one unit of any type of good:

$$Q_i = L_i.$$

This sector is (has to be) competitive and hence the price of each type of good is 1 and the wage rate must also be 1. The modern sector is characterized by increasing returns. Here a fixed cost of F in terms of labor must be incurred to install a machine which can then convert one unit of labor to $\alpha > 1$ units of output of each type of good :

$$Q_i = \alpha \left(L_i - F \right)$$

In the modern sector, each good is assumed to be produced by one monopolistic firm (of course one cannot have competition here - however, it is possible to have more than one firms). The profit function of a monopolist selling the i-th type of good is

$$\pi_i = p_i Q_i - \frac{1}{\alpha} Q_i - F$$

Recall that the pricing policy of a monopolist facing a constant marginal cost to set

$$Q_i \frac{dp_i}{dQ_i} + p_i = \frac{1}{\alpha}$$

or,

$$p_i = \frac{\frac{1}{\alpha}}{1 - \frac{1}{\varepsilon}}$$

where $\varepsilon = 1 / \left(\frac{Q_i}{p_i} \frac{dp_i}{dQ_i} \right)$ is the price elasticity of demand. However, with the given that the demand functions are unit elastic, this would suggest an arbitrarily high price. But the monopolist is prevented from charging a price of more than 1 by the presence of the competitive traditional sector.[5]

Total income in this economy is the sum of profit and labor income:

$$Y = \Pi + L$$

where Π is aggregate profits. When income is Y profit of a monopolist is

$$\pi = \left(1 - \frac{1}{\alpha} \right) \frac{Y}{N} - F = a \frac{Y}{N} - F$$

where $0 < a < 1$ is the difference between price and marginal cost, i.e., markup.

[5] Notice that we could assume the existence of a price premium like a wage premium, and so long as it was less than the amount of the wage premium our analysis goes through.

When n of the N sectors use the modern technology aggregate profits are

$$\Pi(n) = n\left(a\frac{Y}{N} - F\right)$$

Hence aggregate income as a function of sectors industrializing is the sum of three terms - profit income in the modern sector, labor income in the modern sector and labor income in the traditional sector:

$$\begin{aligned} Y(n) &= n\left(a\frac{Y}{N} - F\right) + \left[L - (N-n)\frac{Y}{N}\right] + (N-n)\frac{Y}{N} \\ &= n\left(a\frac{Y}{N} - F\right) + L \end{aligned}$$

Solving for $Y(n)$ and $\pi(n)$ we get

$$\begin{aligned} Y(n) &= \frac{L - nF}{1 - \frac{n}{N}a} \\ \pi(n) &= \frac{\frac{a}{N}L - F}{1 - \frac{n}{N}a}. \end{aligned}$$

Notice that

$$\begin{aligned} \frac{dY(n)}{dn} &= \frac{-F\left(1 - \frac{n}{N}a\right) + \frac{a}{N}(L - nF)}{\left(1 - \frac{n}{N}a\right)^2}. \\ &= \frac{\frac{a}{N}L - F}{\left(1 - \frac{n}{N}a\right)^2} \\ &= \frac{\pi(n)}{1 - \frac{n}{N}a}. \end{aligned}$$

Hence national income is increasing in the number of firms using the modern technology, so long as they make positive profits. This has two interpretations. First, shareholders earning profits from industrialization in the n-th sector spend their extra incomes on other sectors, leading to a chain of increased demand. The larger is n the greater is the multiplier effect. Second, since the price of labor is 1, the profit in the last firm is the net labor saved due to cost reduction. The numerator is the increase in labor availability in the whole economy as a result of investment in the last firm. The free labor moves in all sectors, IRS and CRS. The effect on total output is higher the greater is the fraction of sectors that use IRS because labor has a higher marginal product in these sectors. The denominator $1 - \frac{n}{N}a = (1-n) + \frac{1}{\alpha}n$ is the average marginal *cost* of labor in the economy and is clearly decreasing in n.

We assume that in any given sector the modern technology is more productive than the traditional technology if it gets an equal share of total labor resources:

Assumption 1

$$\alpha\left(\frac{L}{N}- \ F\right)>\frac{L}{N}.$$

Notice that if by Assumption 1

$$\frac{\alpha-1}{\alpha}L- \ NF>0$$

or,

$$a\frac{L}{N}- \ F>0.$$

Then

$$\pi(N)=\frac{\frac{a}{N}L- \ F}{1-a}>\pi(1)=\frac{\frac{a}{N}L- \ F}{1-\frac{1}{N}a}>0.$$

Suppose all sectors are using the traditional technology. Is there an incentive for a firm in the modern sector to use the modern technology? What the above condition says is yes if $\pi(1)>0$. But then $\pi(N)>0$ and so all firms industrialize. However, if setting up the IRS technology requires an added fixed cost in terms of money, another component of fixed cost, say in terms of disutility d of managing this technology. Then it is possible to have

$$\pi(1)-d<0<\pi(N)-d.$$

If profits are the only source of demand spillovers, then multiple equilibria cannot exist. If starting with a situation where no one is investing, it is profitable for one firm to invest, it generates positive demand spillover on other firms, inducing them to invest as well.

3.2.2 The Model with a Wage Premium

Let the wage rate in the modern sector be $w=1+v>1$ which reflects a wage premium relative to the traditional sector. Later in the course we will see how this can result in many different ways, but for now treat it as the cost of commuting to the city from the village.

Now when income is Y profit of a monopolist is

$$\pi=\left(1-\frac{1+v}{\alpha}\right)\frac{Y}{N}-(1+v)F=b\frac{Y}{N}-(1+v)F$$

where $b\equiv 1-\frac{1+v}{\alpha}\in(0,1)$ is the difference between price and marginal cost, i.e., markup.

When n of the N sectors use the modern technology aggregate profits are

$$\Pi(n)= \ n\left(b\frac{Y}{N}-(1+v)F\right)$$

Hence aggregate income as a function of sectors industrializing is

$$\begin{aligned}
Y(n) &= n\left(b\frac{Y}{N}-(1+v)F\right)+(N-n)\frac{Y}{N}+(1+v)\left[L-(N-n)\frac{Y}{N}\right] \\
Y(n) &= \frac{(1+v)(L-nF)}{(1+v)-\frac{n}{N}(v+b)}.
\end{aligned}$$

Notice that $1+v>v+b$ as $b<1$ and $v+b>\frac{n}{N}(v+b)$ for $n<N$ and so $(1+v)-\frac{n}{N}(v+b)>0$ for $n<N$. For $n=N$, it is equal to $1-b>0$. Hence

$$\begin{aligned}
\pi(n) &= \frac{b}{N}\frac{(1+v)(L-nF)}{(1+v)-\frac{n}{N}(v+b)}-F(1+v) \\
&= (1+v)\frac{\frac{b}{N}(L-nF)-F(1+v)+\frac{n}{N}(v+b)F}{(1+v)-\frac{n}{N}(v+b)} \\
&= (1+v)\frac{\frac{b}{N}L-F}{(1+v)-\frac{n}{N}(v+b)}-(1+v)\frac{vF\left(1-\frac{n}{N}\right)}{(1+v)-\frac{n}{N}(v+b)}
\end{aligned}$$

Notice that the second term is increasing in n. Now when $n=1$

$$\pi(1)=(1+v)\frac{\frac{b}{N}L-F}{(1+v)-\frac{1}{N}(v+b)}-(1+v)\frac{v\left(1-\frac{1}{N}\right)F}{(1+v)-\frac{1}{N}(v+b)}$$

and when $n=N$

$$\pi(N)=(1+v)\frac{\frac{b}{N}L-F}{1-b}.$$

Hence it is possible now to have

$$\begin{aligned}
\pi(1) &< 0 \\
\pi(N) &> 0
\end{aligned}$$

or,

$$\begin{aligned}
v\left(1-\frac{1}{N}\right)F &> \frac{b}{N}L-F \\
\frac{b}{N}L-F &> 0.
\end{aligned}$$

Simplifying and combining the two conditions above we get the following condition for the existence of multiple equilibria :

$$v(N-1)+N>b\frac{L}{F}>N.$$

Notice that this is more likely to happen the larger in N (so the worse in the coordination problem) - in particular, if $N = 1$ then there is no coordination problem and naturally, this condition is not satisfied. Second, the larger is v the greater is going to be the problem. In particular, if $v = 0$ we are back to the previous case and there is no multiple equilibria.

It is important to note that welfare goes up in the full industrialization equilibrium.. Since prices do not change workers are equally better off as wage earners in the second equilibrium. Since they have higher total incomes for the same prices (from the distributed profits), they are better off.

To have $v > 0$ is the key here. By setting up a factory and paying higher wages to workers a firm generates demand for other firms even though it may lose money itself. Hence its profits is no longer the only measure of its contribution to aggregate demand as in the previous model because the extra wage it pays is not captured in the profits. Another way the same effect could be captured is firms have to contribute towards building infrastructure. Suppose there is no wage premium, but to operate the modern technology some roads need to be built which cost G. If a firm moves alone then it will make it easier for others to move, although it could be making losses. In that case no firm would want to move all alone. But if all firms coordinate and split the cost of the infrastructure, then it will be profitable for all of them to move.

3.3 Some Comments on the Literature

We have discussed several models that lead to multiple equilibria. But this does not, by any stretch, exhaust the literature. There are many alternative, and interesting stories of multiple equilibrium. You will see some in the classes (Basu-Van, 1998, Ghatak-Morelli-Sjostrom, 2002). Ray (1998) mentions some more stories in Ch. 5 of this book. Some authors have thought hard about the predictive content of multiple equilibria models. Is it true that they suggest anything can happen? If you are interested you can look up Kiminori Matsuyama's "Explaining Diversity: Symmetry-Breaking in Complementarity Games," American Economic Review, 92 (May 2002): 241-246 and Russell Cooper's "Estimation and Identification of Structural Parameters in the Presence of Multiple Equilibria" N.B.E.R. Working Paper 8941, May 2002. A provocative recent study by Donald Davis and David Weinstein ("A Search for Multiple Equilibria in Urban Industrial Structure", N.B.E.R. Working Paper 10252, January 2004 argue that the bombing of Japanese cities are industries in World War 2 provides a good test of multiple equilibria theory. One implication of this theory is, a big shock can throw the system from one stable equilibrium to the other. They claim that in the aftermath of these immense shocks, a city not only typically recovered its population and its share of aggregate manufacturing, they also built the same industries they had before. As they themselves acknowledge, while thought provoking, this does not settle the issue. After all, even if buildings were destroyed, the land and ownership claims to it remained the same after the bombing. A labour force specialized to particular industries may have largely survived (even in Hiroshima 80% of the population survived). Infrastructure also remained largely unaffected. Therefore the pattern of economic activity prior to the bombing might have acted as a focal point for reconstruction.