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Conclusion: A Wittgenstein's Ladder

Our long voyage of discovery is over and our bark has drooped her weary sails in port at last. Once more we take the road to Nemi. It is evening, and as we climb the long slope of the Appian Way up to the Alban Hills, we look back and see the sky aflame with sunset, its golden glory resting like the aureole of a dying saint over Rome and touching with a crest of fire the dome of St. Peter's. The sight once seen can never be forgotten, but we turn from it and pursue our way darkling along the mountain side, till we come to Nemi and look down on the lake in its deep hollow, now fast disappearing in the evening shadows. . . . But Nemi's woods are still green, and as the sunset fades above them in the west, there comes to us, borne on the swell of the wind, the sound of the church bells of Aricia ringing the Angelus. *Ave Maria!* Sweet and solemn they chime out from the distant town and die lingeringly away across the wide Campagnan marshes. *Le roi est mort, vive le roi! Ave Maria!*

—Sir James Frazer (1922), *Farewell to Nemi*

This chapter is a non-technical summary of what we have learned for the entire semester.

Modern macroeconomics has been featured heavily by micro-founded, dynamic, stochastic, general equilibrium models. The old thoughts can only be accepted after passing the micro tests, and the macro behavior has to be robust in the complex world — a changing world with many uncertainties, a system where everything determines everything.

We developed our course in a linear way, hammering our first nail in the wall — surely the simpliest case — a dynamic but deterministic, partial equilibrium Solow-Swan model, which is as fundamental for modern macroeconomics (and surprisingly similar) as the First Law of Thermodynamics for physics. Its central idea is quite simple: The increase in the capital stock of an economic system is equal to the amount of real resources added into the system, minus the amount lost as a result of consumption, depreciation, and so on [1] . With some reasonable neoclassical assumptions, i.e. constant return to scale, diminishing marginal product, and Inada conditions, the economy will finally end up in its steady state, or break-even point, such that the real production is exactly balanced by consumption, and the cost from maintaining the capital stock. Seemingly simple, it's still the only model which explains all the Kaldor facts in economic growth.

The partial equilibrium feature of Solow-Swan model is that the saving rate of the economy is exogenously given, or set by God. For all the candidate saving rates ranging from 0 to 1, people's consumption level is maximized by the one defined by the Golden Rule which makes the marginal output of the real production equal to the marginal cost of maintaining the capital stock. Then we make a step further, allowing the consumers to get the saving / consumption decisions on their own, i.e. the general equilibrium Ramsey-Cass-Koopmans model. The consequence of internalizing the saving / consumption decisions is not hard to imagine — consumers are impatient and prefer consuming earlier to accumulating the capital, therefore the augmented Golden Rule suggests a steady state with a lower level of capital stock.

Ramsey-Cass-Koopmans model brings a lot of technical challenges. One is dynamic optimization in the (continuous) infinite time horizon, which can be solved by the optimal control theory using present / current value Hamiltonians. The keys here are to distinguish the state variables from the control variables, and establish the proper law of motion describing the intertemporal evolution of the state variables. The other is to understand the economic dynamics encapsulated in a non-linear ordinary differential system, which can be made easy by being visualized in the phase diagrams. Further, the phase diagram is extremely helpful for economists to do a quick, qualitative analysis for the economic policy.

The original Ramsey problem was a typical benevolent central planners' problem, optimizing

[1] Free disposal should be allowed as well, as the case in microeconomic theory. But generally we assume that free disposal is stupid and nobody does that.

a representative consumer's welfare with the resources available in the economy. In the standard decentralized version, in which the households manage their asset holdings themselves and the labor / capital are paid with competitive prices, one can get the same results as the Moscow planners'. However, we shouldn't take such equivalence as a rule (of the fundamental welfare theorems, such that Pareto efficiency comes from the competitive market), and it's rather coincidential and easily disappears in more general settings (such as market with limited participation, an economy with distortionary tax, externalities, and so on).

Another important framework for modelling economic dynamics is the (Diamond's) overlapping generation model, which gives a perfect example of dynamic Pareto inefficiency in a competitive market because of limited participation. The limited participation makes it impossible for intergenerational trading [2], so people rely on early savings when they get old. The saving technology may be inferior, and this gives a chance for fiscal (like the "pension" policy in Problem 6 of Problem Set 2) or monetary (like introducing money as a media of value transfer as in Problem 7 of Problem Set 2) policy to correct the inefficiency and make everyone better off.

So far we know that Ramsey-Cass-Koopmans model internalizes consumers' saving / consumption decisions and the optimal consumption path is thus pinned down, which means that the path for capital accumulation is rather "passive" , i.e. the capital stock grows out of the "residuals" of the output after consumption. However, a second thought suggests that in the micro level the capital process should be equally important as the consumption — the firms have to take some substantial adjustment costs when they are updating their capitals, so the current price of adding one additional unit of capital exceeds one. Further, in a competitive market this price should also include all the future profit the firm can generate from this additional piece of capital, which is exactly captured by the Lagrange multiplier of the current value Hamiltonian — the Tobin's q.

Now we have to confront with the complex reality. The world is full of uncertainties. Since generally we can never be sure about this year's corn harvest or our banks' financial health, in contrast to the standard yet deterministic Ramsey-Cass-Koopmans economy, the consumers with risk aversion will see different values for the assets of different risk levels. The principle of asset pricing can be easily revealed from the simpliest two-period consumption-based model, and rather intuitive: The asset can be priced by its expected return (i.e. its "certainty equivalence"), plus the bonus which induces you to take the risk (i.e. the "risk premium"). Further, the latter is the covariance between the marginal utility and the actual return. — How if the covariance is negative? Well, a negative covariance means that you get a high return when you are full (low marginal utility from consumption), and this is a bad feature of the asset so that you ask for a bonus — a rebate in the asset's price.

Here ends the first pillar of the course — the "growth" part, and comes the second one — the "money" part. Well, since we have learned so much about dynamic optimal decision, it

[2] Note that here we have neither bequest nor intergenerational altruism. — "When I was kidnapped, my parents snapped into action immediately. They rented out my room." Woody Allen once said. — And things will change if these two are allowed.

shouldn't be hard to add one more variable for money and get things done. And if we admit that money is something valuable, we should be able to price it in whatever complex world.

Sounds easy? Unfortunately we cannot even persuade ourselves to accept money in the first place. Adding money in the Ramsey-Cass-Koopmans economy is an inferior idea — People would invest anything valuable in capital holdings (which generate a real interest return, and the return is positive as long as the world is not too risky) rather than holding the fiat money — paper that generates zero return. Therefore, we have to build the bridge towards monetary economics first by motivating the need of money — micro-founded while macro plausible ways to justify the role of money in transaction, seignoirage, or merely making people happy.

Although money plays different roles in different object functions or budget constraints, e.g. money-in-the-utility or cash-in-advance, and the timings of the consumer's decisions differ substantially (every flow budget constraint should be supported by a long story), standard deterministic monetary models yield similar insights. First, the real steady state allocation doesn't depend on the nominal variables, so as long as the price is flexible, the nominal shocks (such as money supply) don't have any real impact, i.e. money is neutral [3]. Second, since the opportunity cost is the only barrier to holding money, the optimal policy implied by these models is to minimize such cost, i.e. setting zero nominal interest rate as the Friedman Rule suggests. Third, technically one needs essentiality condition for money (which is more strict than neoclassical Inada conditions) to ensure a unique equilibrium and rule out the hyperinflation bubbles.

These features are rather depressive, — saying that monetary policy plays virtually no role other than making people happier from holding more money — and experimenting the deflationary Friedman Rule would be a nightmare in the real world. So if we admit that monetary policy indeed makes a lot more sense for the macro economy, we have to add imperfections into the model.

The first imperfection is introduced via monopolistic competition. Rather than competing with one single consumption good as in the standard Ramsey model, the firms now differentiate their products to meet the different "tastes" of consumers. Since these differentiated goods are not perfect substitutes, each firm gets some "local" monopoly on its product, allowing them to add a markup in the prices and hence earn strictly positive profits. In equilibrium, the commodity price is higher than its efficient level, i.e. the marginal cost, and the wage rate is lower than the marginal product of labor, making the employment rate (the natural rate) lower than its efficient level.

Monopolistic competition brings inefficiency into the economy, hence leaves some room for public intervention. However, monopolistic competition alone isn't sufficient to eliminate the neutrality of money and create a role for monetary policy, because the economy may stay at its natural rate level without responding to any nominal shocks as long as the price is still flexible. Therefore, we need to introduce the second imperfection, the stickiness in price

[3] What's more, the real steady state allocation doesn't depend on the inflation rate as well, i.e. money is superneutral, too.

adjustments, into the economy.

The reluctance in price adjustment may arise from the monopolistic competition itself as a result of the aggregate demand externalities. Under a pressure of price adjustment (say, there's a positive aggregate demand shock and the pressure is upside), whether your firm sets a new, higher price depends on whether you get a higher profit than your rivals. Although under the new price your firm may get a higher profit margin from each piece of the product, setting such high price generates a positive aggregate demand externality on the other firms (who haven't yet set the new price) as well, making your market share shrink. In the end, this may not bring you a higher profit — knowing this, no firm would ever try the new price, and the aggregate demand externality brings failure of coordinative price adjustments as long as the exogenous demand shocks are small. Such failure is strengthened and made more robust by adding some menu costs in tuning the prices, and surprisingly only some tiny such costs will be well sufficient to deter most of price adjustments.

Now given that the economy's natural rate is below efficiency and the price is sticky (making money non-neutral), a monetary expansion will indeed boost the real demand and push the economy closer towards efficiency — a typical Phillips curve story. This is precisely captured by the Calvo-Yun framework, in which the nominal rigidity comes from a quantitative staggering Calvo pricing and a micro-founded Phillips curve is defined. The details can be found in Professor Illing's lecture notes, CHAPTER 2.5. Unfortunately, we weren't able to have the luxury to discuss that in the class.

But using monetary policy to fix the inefficiencies is just one part of the story. At the same time many economists, Barro, Gordon and Prescott being the most notable ones, doubt whether such policies can be implemented at all. The policy maker, caring about aggregate employment and inflation rate, tries to minimize the social loss by implementing certain monetary rules. The private sector, who doesn't care about the aggregate employment, wants to minimize the error in predicting the inflation. Keeping in mind that generating a surprising inflation helps boost employment as the Phillips curve suggests [4] , the discretionary policy maker can never resist the temptation of generating surprising inflations. Knowing this, the private sector will raise its inflation expectation to avoid being fooled. The equilibrium thus ends up with a prisoners' dilemma — a Nash inflation bias with no improvement in employment, which is Pareto inferior.

The failure here comes from the fact that the policy maker attempts to catch two rabbits at the same time, — using one monetary instrument to deal with two evils, — which makes her promise incredible. One way to make committing to a (socially optimal) solution plausible is to delegate the policy to a conservative (independent) central banker, whose social loss function has a heavier weight on inflation. Central bankers' longer tenure with the "trigger strategy" (fierce response from the private sectore, once the central banker breaches her promise) may also help: The longer tenure allows the monetary game to be repeated many

[4] It's the old Phillips curve in Barro-Gordon model. The Barro-Gordon problem with micro-founded Phillips curve is presented in Professor Illing's lecture notes, CHAPTER 2.5.

many times, making the cooperative solution more likely to hold; and even a truly bad guy may find it profitable to conceal his nature in the early stage.

But even if we are successful in implementing the policies, the problem ahead is still huge: Are we able to find the optimal monetary rule (deterministic, system-stabilizing, implementable, simple, with the lower bound of zero interest rate respected)? And how can we implement the optimal policy through the instruments, such as money supply, nominal interest rate, and so on, in the monetary rule? What are the roles for finance and financial crises? These questions are among the frontiers of macroeconomic studies, and need more ambitious researchers to worry about.

The final exam is scheduled on February 17th, Thursday, 16:30 — 18:30, Room B 101, Main Building. Good luck!