Macroeconomic Principles I

Part I Economics Tripos, Paper 2

Lecturer: C. Giannitsarou
2019, Michaelmas

Notes: Jinghao Men

The notes are organised mainly under my own framework of thinking and do not necessarily accurately reflect what the lecturer said or thought.

Measuring macroeconomic data
Introduction to macroeconomics and economic models, GDP measuring approaches, CPI, GDP and living standard differences across countries. [2]

The classical model of the long run
Neoclassical production function, marginal products, Cobb-Douglas production function, competitive firms, predictions of the model, components of the aggregate demand, goods market, loanable funds market, fiscal policy, saving and the interest rate. [2]

Economic growth
Standard of living, growth rate rules and importance; Solow-Swan growth model, steady state solution and prediction; effects of population growth, the Golden Rule and transition, absolute and conditional convergence, limitations and augmented Solow model, technological progress and policy. [4]

Labour market and the natural rate of unemployment
Labour force, participation rate, unemployment, natural rate, frictional unemployment, sectoral shifts, changing the natural rate, wage rigidity, structural unemployment, minimum wage, labour unions, efficiency wage, Eurosclerosis and European unemployment. [2]

Monetary system, the central bank and inflation
Money, central bank, monetary policy, reserve, deposit, fractional-reserve banking, balance sheet, money creation in the banking system, leverage and capital requirement, money supply, control of monetary base, refinance rate, CB independence, quantitative and credit easing, seignorage, quantity theory of money, interest rate, money demand, velocity, inflation, the Fisher effect, effects and costs of inflation, unexpected inflation, hyperinflation, deflation. [4]

Introduction to the short run macro and the great recession
Classical dichotomy, economic fluctuations, potential output, business cycles, recessions, Okun's law, AD-AS model, financial crisis, subprime debt, housing markets in the Great Recession, credit crunch, global economic influence, policy responses. [2]

Contents

0 Notations

For uniformity and elegance of presentation, the notations I use in this note might differ slightly from the notation used by the lecturer. In general, there are a few principles on these:

- Upper-case Latin letters ($A, B, C...$) will be used for variables that are directly measurable or defined *macroscopic* real and nominal quantities;
- Lower-case Latin letters ($a, b, c...$) will be used for variables that are *per capita* real and nominal quantities directly derived from macroscopic quantities (*e.g. per worker* income);
- Lower-case Greek letters ($\alpha, \beta, \gamma...$) will be used for else derived quantities including but not limited to rates, ratios and arbitrarily defined parameters, (*e.g. per annum* inflation rate, saving rate);
- Calligraphic M ($\mathcal{M}$) will be used to denote marginal products (MPK, MPL, MPC);
- Notations with an extra lower suffix indicates that the quantity is *w.r.t.* or based on conditions stated by the lower suffix;
- Endogenous variables assumed as fixed conditions in model (*aka.* exogenous) will be barred on top ($\bar{A}, \bar{B}, \bar{C}$). In short-run analyses the long-run trend (*i.e.* potential output) will also be barred;
- Steady-State solutions or values of variables will be denoted with an asterisk (*) on upper suffix. †See explanations below.
- Short-term fluctuations (*aka.* cyclical component) of output ($\hat{Y}$) is top-hatted, and the percentage deviation of output ($\tilde{Y}$) is topped with a tilde as shown.
- For simplicity, an abbreviated expression ∂_α is used in this note to replace $\frac{\partial}{\partial \alpha}$. Also, we use $f'(x)$ to replace $\frac{\mathrm{d}f}{\mathrm{d}x}$ or $\frac{\mathrm{d}}{\mathrm{d}x}f(x)$.

Note: differences of notations from the widely received notation used by the lecturer will be clearly stated in definitions of the quantities, and the latter will be always retained for your convenience.

† Here *Steady-State* does **not** necessarily indicate the value of all quantities described in the whole system to be static, or say, completely independent of time, as the interdependency between some variables are not time-homogenous (*i.e.* include time-dependent terms). Instead, it is a state of equilibria, at which some variables (most frequently the variables our study is most interested in) possess the tendency to remains stationary, while other variables follow their asymptotic lines of time-dependency.

If the variables in an economic system are all considered as components of a vector parametrised by time in a functional space, then the steady-state would be the limit the vector converges to when time tends to infinity ($\lim_{t\to+\infty}$), in other words, it is analogous to a 'horizon' and cannot be reached in finite time, but can be approached infinitely close to. Therefore, we use the concept and solution of steady-state as a relatively precise prediction and approximation to long-term kinetics of economic systems to reduce the complexity of calculation compared to solving the whole time course in the evolution of the system, as transient responses can be neglected when our aim is to investigate the long-term performance or behaviour of the economic system.

1 Introduction

Motivation. Why do we study economics?

– For a more *efficient* and *reasonable* economy development, and eventually, a higher level of ***quality, sustainability*** and ***equality*** in the improvement of human life standard.

Macroeconomic Principles is the first introductory course on macroeconomics, mainly focusing on the assumptions, ideas and definitions of the fundamental concepts in macroeconomic systems and the interdependency between key economic variables and policies.

In this 16-lecture course, we will introduce briefly the underlying principles behind macroeconomics in the long run, and learn fundamental (and rather ideal), simplified mathematical models to undertake systematic macroeconomic analysis, mainly based the neoclassical economics.

This note is aimed to provide a clearer insight on the abstract issues and more rigorous understanding on the quantitative properties of basic macroeconomics on a Part I (*i.e.* college first year) level, and would be organised in a rather scientist, or, say, mathematician way of presentation. To understand the models and principles thoroughly, some preliminary knowledge of introductory level single- and multi-variable calculus are required.

So far, I have incessantly used the term *'Macroeconomics'* but never defined it clear. So what exactly is macroeconomics? What topics does it study, and to what problems can these studies provide an, even primitive understanding or solution? To find an answer to these questions, we shall now move on to the definition of macroeconomics and its approaches of measure.

1.1 Macroeconomics

Definition (Macroeconomics)**.** *Macroeconomics* is the study of the economy as a **whole**, on the behaviour of the **aggregate** economic phenomena in the short- and long-run in closed and open economies.

Macroeconomics Studies collections of people and firms, and how their interactions through markets determine the overall economic activity in a country or region.

Aim 1.1. There are 2 most fundamental questions that macroeconomics mainly solve:

Question 1.1. Why does the economy behave in a certain way?

Question 1.2. How should an economy behave, and what policies can government exert on the economy to make it behave in the way 'as it should be'?

These questions thereby determined several core topics of macroeconomic study:

– The economic growth, *i.e.* changes in economic activity over time;

– Government fiscal or monetary policies directing or stabilizing economy;

– Prices and inflation, the rate of price increase in an economy;

– Behaviour of the labour market and unemployment;

– Imbalance (mostly deficits) on government finance:

  Budget deficit: imbalance between government spending and tax revenue

  Trade deficit: international imbalance between import and export

– Economic inequalities across individuals and economies;

and so on.

1.2 Macroeconomic Models

If one observe it very carefully and imaginative, he or she would discover that the economy is extremely analogous to an individual living form–we are by all means very interested in studying its behaviour and the underlying principles of multiple scales behind it.

However, unlike in the field of biology where we might be able to conduct *in vivo* experiments on our object organism, the cost and risk to conduct 'Economic experiments' on the large-scale economy is too high and often against ethic for its huge influence and difficulty to perform.

Therefore, some methods must be established to facilitate economists to study about *their research object*, namely *economy*, in a simulative way mimicking the real economy, so that experiments can be carried on without affecting the actual world.

Among all forms of *in vitro* research methods (Yes–biologists also does this kind of experiments), the widest utilized tool is known as modelling, which would be our principal equipment of economics study.

To study the behaviour and make predictions of the objects stated in the previous section, economists developed various models and testified them with actual measurements and observations. These models are then used to sketch other testable predictions or hypotheses on macroeconomics.

Definition (Economic Model)**.** An *Economic Model* is a system of mathematical equations and quantities representing a simplified hypothetical world following a set of definite assumptions, used to study economic phenomena *in vitro*.

A typical model normally contains these elements:

– Assumptions: hypothetical postulates and ideal conditions that the model is based on;

– Exogenous variable: a time-dependent input quantity determined ahead of time in the model;

– Endogenous variable: a time-dependent output quantity explained by the model;

– Parameter: a time-homogenous arbitrary input quantity in the model;

– Formulae defining the relationships between variables, parameters and time.

Via changes in these elements, economists can make observations of their effects (comparative statics), and make desired predictions on the effects of any policy or condition exerted on the economy. As models are rather simplified and approximate extrapolations to the economy based on some *not-necessarily-valid* assumptions, in all cases a non-vanishing error of some order exists.

However, well as expected, more delicate and closer-to-reality models exhibit less inaccuracies for the price of being more complicated and requiring more fine estimations on input, to achieve a higher level of precision.

Assumptions differ for models with different objects and timescales of study. Here is a rather crucial and fundamental example of a pair of opposite assumptions throughout macroeconomics.

Example 1.1 (Price Viscosity)**.** The behaviour of an economy partly depends on the viscosity of price, *i.e.* whether prices are flexible or sticky. For long-run and short-run models, the assumptions on price viscosity are adjusted to be contrary. Let's see what this difference demonstrates and how does this difference help in explaining different economic phenomena:

Assumption 1.1 (Market Clearing)**.** In the long-run, it is assumed that prices are flexible and adjust to equate supply and demand. This enables us to study the long-term trend of economy and its equilibrium, focusing on its steady-state behaviour.

Assumption 1.2 (Sticky Price)**.** In the short-run, it is assumed that some prices adjust only sluggishly in response to supply-demand imbalances. This enables us to study the short-term fluctuations of economy and effectively explains the unemployment and occasional sale-production imbalance, focusing on its transient responses.

1.3 Measuring the Economy

To acquire information on how the economy run, and how does the living standard of people develop, we need to make measurements on the activity of economy, and the cost of living. In macroeconomics, the most useful and straightforward indicator of these status is **GDP**, whose real, nominal, *per capita* and relative values and time-dependencies reflect the overall state and evolution of the economy as a whole.

Fact. National Accounting is the work of measuring the aggregate economy. In the United Kingdom, this work is done by the *Office of National Statistics* (ONS).

Now we shall sketch the definition and implications of GDP and the measure approaches to it.

1.3.1 Measuring the GDP

Definition (Gross Domestic Product)**.** The *Gross Domestic Product* (**GDP**) of an economy is the change of total value of wealth in a given time-period, defined by the total of either one of the following quantities in a definite period of time:

a) *Market value* of domestically-produced final goods and services;

b) *Expenditure* on domestically-produced final goods and services;

c) *Income* earned by domestically-located factors of production;

Based upon the assumption stated below:

Assumption 1.3. (Production = Expenditure = Income):

All productions in an economy are transacted in the market, and in every transaction the buyer's expenditure becomes the seller's income.

Thus the equivalence between the different approaches of definition are ensured. We shall now emphasize these approaches respectively more in-depth.

Notation 1.1. Now we shall denote GDP (total output of the economy) by Y.

Production Approach The GDP defined by the production approach is the value of final goods produced, *i.e.* sum of value added at all stages of production.

Remark. Here the value counted already includes the value of intermediate goods, therefore including the value of intermediate goods again would be double-counting.

Expenditure Approach A few definitions are required.

Definition (Consumption, Investment, Government spending and Net exports)**.**

– *Consumption* := all durable and non-durable goods and services bought by households;

– *Investment* := spending on capital as the factor of production, or equivalently, spending on goods bought for future use. This includes *gross fixed investment* (business and residential) and inventory investment, *i.e.* the change in the value of all firms' inventories;

– *Government spending* := govt. spending on goods and services, excluding transfer payments;

– *Net exports* := the value of total exports minus the value of total imports.

Notation 1.2. We denote the total consumption, investment, government spending, export, import and net exports by C, I, G, EX, IM and NX respectively. By definition, $NX = EX - IM$.

Now we can finally define GDP (output) using the expenditure approach mathematically:

$$\boxed{Y = C + I + G + NX}$$

Also known as the *National Income Accounting Identity.*

Income Approach Measures the sum of all income earned in the economy, consisting of shares to *labour* and *capital*.

Capital reflects inputs into production other than labour not used up in the production process, which are increased by firms through investment.

Depreciation is defined as the deterioration of capital due to wear and tear, and links GDP with NDP (*Net Domestic Product*) via this identity:

$$\text{GDP - depreciation} = \text{NDP}$$

A fact worthy of notice is that, the *labour's share* of GDP has remained **roughly constant** over time, with a fraction of approximately $\frac{2}{3}$.

Limitations of GDP

There are multiple components or new elements in economy that GDP does **not** include, *e.g.:*

- Home production;
- Goods or services not transacted in markets or in underground/black markets;
- Used good transactions;
- Government transfer payments and housing services;
- Intangible assets, and the effect of globalisation;
- Digital, sharing and gig economy......

The economic *inequality*, changes in *environmental resources* and *well-being* of an economy's people are also **not** taken into account by measurements of GDP.

1.3.2 Comparative GDP Measurements

Measuring GDP over time Again, starting with a few definitions:

Definition (Real and Nominal GDP, GDP Deflator and Inflation Rate)**.**

- *Nominal GDP* := GDP measured using the current price;
- *Real GDP* := GDP measured in terms of actual quantities;
- *GDP Deflator* := $\frac{\text{NominalGDP}}{\text{RealGDP}}$ *w.r.t.* a certain timepoint;
- *Inflation Rate* := the rate at with prices change over time.

Notation 1.3. We denote the general price level as P, and the inflation rate as π, defined by

$$\boxed{\pi = \frac{\Delta P}{P}}$$

Where ΔP is the change of price level over the certain period of time.

Both real GDP and price level change over time, reflected by multiple arbitrary indexes, *e.g.*

- The *Laspeyres* index, calculating changes in real GDP using the initial year prices;
- The *Paasche* index, calculating changes in real GDP using the final year prices;
- The *Fischer* index which is average of *Laspeyres* and *Paasche* index, *etc.*

Similarly, the price level in inflation can be indicated by multiple measures as well, *e.g.*

- GDP Deflator;
- *Consumer Price Index* (CPI) measuring the prices of a typical basket of goods;
- *Harmonized Index of Consumer Prices* (HICP) measuring the overall level of prices for countries in the EU;
- *Retail Price Index* (RPI), a CPI type of inflation measure including housing costs, *etc.*

Remark. In contrast to the GDP deflator, the CPI measures only value of *consumption* good prices. It **does not** measure the prices of capital goods, but **do** measure prices of imported consumer goods. In addition, the *basket of goods* of CPI are fixed but changes every year for the deflator.

Measuring GDP across countries

To compare the economic performance and living standards between economies, measurements of GDP across countries serve as an important tool. However, as statisticians in each country use local prices when measuring nominal GDP, we must facilitate the *currency exchange rate* to normalize the original economic data we obtained and calibrate the calculations based on them.

This process normally needs the following 2 steps:

1) GDPs are first expressed in a common currency[†] via adjusting by the exchange rate;
2) The value of nominal GDP are then multiplied by the ratio of price levels in the countries.

The final number obtained is thereby adjusted for price differences across distinct economies, and can then be referred to in comparisons of objects we are interested in, such as general economic performance, consumer life standard, aggregate productivity *etc.* across multiple countries.

[†]The common currency we use in macroeconomic studies is usually U.S. Dollar($).

2 Classical Model of the Long Run

In this chapter, we will first introduce the simplest (and in some sense, most ancient) classical economic model of the long run, with its assumptions, model equations, interpretations and accordance with empirical figures analysed. Then, the factors involved in the **demand side** and the **market** through which an equilibrium is established are illustrated further, together with *comparative statics* about how the variables involved influence the model in a whole.

2.1 Classical Model of Production

The classical model of production is based on a general production function $Y = F(K, L)$, in which Y is the output, L and K are mutually independent, denoting for Labour and Capital respectively. Note that we inherently assumed that $Y, K, L \in \mathbb{R}_{>0}$.

2.2 Assumptions

The classical model of production is highly hypothetical and simplified, based on multiple ideal assumptions which are not necessarily true in the real world; however, it gives very important insights. These can be classified into assumptions on the general economy, on the production function, and on firms involved in the economy.

2.2.1 Assumptions On Economy

(i) The economy is single and closed;

(ii) Only one good is consumed, or equivalently, produced;

(iii) Markets always clear (*i.e.* consumption equals production at every time point), and prices are flexible.

2.2.2 Assumptions On Production Function

First we have to make some important definitions.

Definition (Marginal Product)**.** *Marginal Product* of a factor of production is the amount of extra output produced when input of the factor increases by unit amount.

Here we denote the marginal product of labour (**MPL**) by $\mathcal{M}_L$ and marginal product of capital (**MPK**) by $\mathcal{M}_K$ for convenience; then it is obvious to see that:

$$\mathcal{M}_L = \frac{\partial F}{\partial L}|_K =: \partial_L F \text{ and } \mathcal{M}_K = \frac{\partial F}{\partial K}|_L =: \partial_K F$$

Definition (Return to Scale)**.**
A production function $F(K, L)$ has *constant returns to scale* property if:

$$\forall \lambda \in \mathbb{R}_{>0}, F(\lambda K, \lambda L) = \lambda F(K, L) \equiv \lambda Y$$

And has the *increasing* or *decreasing returns to scale* property if:

$$\forall \lambda \in \mathbb{R}_{>1}, F(\lambda K, \lambda L) > \text{ or } < \lambda F(K, L) \equiv \lambda Y$$

The returns-to-scale property determines the effect of simultaneously multiplying workers and equipments on production. In different forms of industry, this property could be different; however, in our assumption, this property is determined for simplicity:

(i) Production has **Constant Returns to Scale** (CRS) property;

(ii) Production function is with *Diminishing Marginal Returns* (DMR):

$$\partial_\alpha \mathcal{M}_\alpha = \partial_\alpha \partial_\alpha F := \frac{\partial^2 F}{\partial \alpha^2} < 0 \text{ for } \alpha \in \{K, L\}.$$

i.e. the production function is *concave*, and when only *one* factor of input is increased (and others kept constant), its marginal product decreases, to ensure existence of a equilibrium solution to the model (this result is used *w/o* proof).

A very important and symbolic production function is the **Cobb-Douglas** production function, which we would use throughout this course.

Definition. (Cobb-Douglas production function)
A production function is *Cobb-Douglas* if it adopts the form

$$\boxed{Y \equiv F(K, L) = AK^\alpha L^{1-\alpha}, \alpha \in (0, 1)}$$

With α being an arbitrary parameter equal to the *capital's share*, and $A \in \mathbb{R}_{>0}$ denoting general productivity which, is kept as an exogenous constant in the classical model.

Theorem 2.1. A *Cobb-Douglas* production function follows the *CRS* and *DMR* property criteria.

Proof. We can prove this by doing a little algebra and calculus as below.

(i) **CRS**. The proof is straightforward:

$$F(\lambda K, \lambda L) = A(\lambda K)^\alpha (\lambda L)^{1-\alpha} = A\lambda^\alpha K^\alpha \lambda^{1-\alpha} L^{1-\alpha} = \lambda AK^\alpha L^{1-\alpha} = \lambda F(K, L) \equiv \lambda Y$$

(ii) **DMR**. First differentiate *w.r.t.* K:

$$\partial_K F = \alpha AK^{\alpha-1} L^{1-\alpha}$$
$$\partial_K \partial_K F = \alpha(\alpha - 1)AK^{\alpha-2} L^{1-\alpha}$$

By $\alpha \in (0, 1)$, we know that $1 - \alpha \in (0, 1)$ and thereby $\alpha(\alpha - 1) < 0$; note that $A, K, L > 0$, therefore $\partial_K \partial_K F < 0$, K satisfies the DMR condition. Proof for L is similar, or wlog. by directly swapping K and L or α and $1 - \alpha$, as that they are arbitrary and $(1 - \alpha) \in (0, 1)$.

□

2.2.3 Assumptions On Firms

Assumption. Firms are perfectly competitive, *i.e.* small price takers which maximize profits under given prices by choosing the amount of capital and labour to demand.

However, we must first define what *profit* really is:

Definition (Profit)**.** $Profit = Revenue - Cost$ is the net gain from production, denoted by $\Pi(K, L)$. In the classical model of production, it is given by:

$$\boxed{\Pi(K, L) = PF(K, L) - RK - WL}$$

$P, R, W \in \mathbb{R}_{>0}$ are the price (of product), wage (of workers) and rent rate (of capital) respectively.

Proposition 2.2. The function $\Pi(K, L)$ is concave. ($\frac{\partial^2 \Pi}{\partial \alpha^2} < 0$ for $\alpha \in \{K, L\}$.)

Proof. Note that $P > 0$ and F is concave, while RK and WL terms don't contribute to second derivatives. The proof is trivial. □

This means that Π has **unique** stationary point and it is a **maximum**, and we only have to focus on the *first order conditions* (FOC) in its maximization. In other words, we only have to care about the amount of a factor of production a firm hires when the extra revenue from increased production equals extra costs.

$$\text{FOC}(K)\text{: } \partial_K \Pi = P\partial_K F - R = 0$$
$$\text{FOC}(L)\text{: } \partial_L \Pi = P\partial_L F - W = 0$$

Note that by definition $\partial_K F =: \mathcal{M}_K$ and $\partial_L F =: \mathcal{M}_L$, we can rewrite those conditions out to yield $\mathcal{M}_K = \frac{R}{P}$ and $\mathcal{M}_L = \frac{W}{P}$. Given a production function $F(K, L)$, we can now solve everything out.

2.3 Solution to the Model

In Progress.

2.4 Interpretations and Empirical Accordance

2.5 Aggregate Demand

2.6 Comparative Statics

3 Growth and Solow Model

under construction

4 Labour and Unemployment

under construction

5 Monetary System and Inflation

under construction

6 Economic Fluctuations and Recession

under construction

7 References

- **Giannitsarou, C. (2019)**. Part I Macroeconomic Principles Lecture Notes. *Economics Tripos, University of Cambridge.*
- **Jones, C. (2017)**. Macroeconomics, International edition, 4th ed.
- **Mankiw, N.G. & Taylor, M.P. (2014)**. Macroeconomics, European Edition, 2nd ed.
- **Romer, D. (1996)**. Advanced Macroeconomics.
- **Barro, R.J. & Sala-i-Martin, X. (2003)**. Economic Growth, 2nd ed.
- **Cobb, C.W. & Douglas P.H. (1928)**. A theory of production. *American Economic Review.* **18**:139-165.
- **Solow, R.M. (1956)**. A contribution to the theory of economic growth. *Quarterly Journal of Economics.* **70**(1):65-94.
- **Swan, T.W. (1956)**. Economic growth and capital accumulation. *Economic Record.* **32**(2):334-361.