What is Macroeconomics?

Macroeconomics is the study of *aggregate economic fluctuations*. Key points of study are features like output, details of the labour market like unemployment and inflation.

Through studying it, we can examine how governments should respond to recessions why countries are rich or poor and how policy can interact with economic structures.

A major event leading to the development of macroeconomics as a field was the greate depression, which lead John Maynard Keynes to develop Keynesian theory, a fundamental part of macroeconomics, and covered in some detail in this course.

Major topics of this subject include

- Measurement and evaluation of economies
- Short or long run economic cycles
- Long term growth and development
- Effects and behaviour of the global economy

Measurement

Understanding the state of an economy relies upon accurate measurement of it, and this understanding is essential to effectively regulating and improving an economy. Theories with respect to measurement of economies are developed according to the study of data.

GDP

GDP or Gross Domestic Product is a measure of the output of an economy over time. The precise definition used in this course is that GDP is the *market value* of the *final goods* produced in a country during a given time period.

GDP is a useful measure of market activity, which can be used to document change in an economy, compare between economies, and evaluate the performance of an economy with respect to assorted variables. GDP is a kind of summary of the performance of an economy.

Richard Stone, one of the core forces behind the development of the concept of GDP was awarded the 1984 Nobel Prize in economics for his efforts.

Market Value

Market value is a way to describe the output of an economy across a wide range of different goods. The most common form of market value is the financial value of goods. While this measure is generally quite good, it ignores household production as well as grey or black market activities.

Because government production has no market price, it is usually valued at cost of production. This covers public goods such as education, defence and public health services.

Final Goods and Services

GDP calculations consider only end products, ignoring constituent goods. For example while the loaf of bread sold by a bakery is counted, the flour purchased by the bakery and the wheat used to produce that flower is not. This is done to avoid double counting the contributions of earlier stages.

In addition, resold goods are ignored. Second-hand houses or cars are ignored. Financial assets, such as shares are not a good or service, so they are also ignored.

GDP considers production in a region; goods produced by international businesses in Australia are counted toward Australian GDP while goods produced internationally by Australian businesses are not.

Measurement of GDP

There are three methods of calculating GDP. These are

- Income
- Expenditure
- Production

They should theoretically be equivalent, but practically vary by small margins due to differences in collection methodology and other real world inconveniences.

Income

Every time a good is purchased, money is transferred from a consumer to a producer. This money is transferred to the firm, which distributes it between the workers at the firm and the owners of the firm.

$$Y = wL + rK$$

Here, Y is the GDP, w is the labour income, L is the hours worked, r is the rental rate and K is the total capital. Rental rate describes the amount a production owner earns per unit capital invested into a business.

This method allows examination of the division between capital owners and labour providers (workers). Through this examination, one can observe that over time the share of wealth earned by workers has declined.

Expenditure

The expenditure method examines the amount spent by each group from among four sectors in the local economy. Each of these is a subtly different form of spending.

- Houshold sector, which accounts for everyday purchases.
- Business sector, which covers investment by businesses.
- Government sector, which includes government expenditure less transer payments like pension or unemployment benefits.
- Overseas sector, which totals net exports (exports less imports).

The equation for this sum is

$$Y = C + I + G + X - M$$

Where once again Y denotes GDP, X denotes exports, M is imports and the other symbols are the remaining three sectors.

This measure has the benefit of allowing the examination of consumption versus investment for instance.

Production

The production method uses a *value added approach*, examining the amount of value each producer in an economy. For example, considering a $3 loaf of bread.

- The bread may have been produced from $2 worth of flour. Therefore the baker add $1 in value.
- The flour may have been milled from $1 worth of wheat. Therefore the miller added $1 in value.
- The farmer, in producing the wheat created $1 worth of value.
- Thus, the total value added throughout production of the loaf of bread was $3.

This approach allows easy comparison between different industries in an economy, by considering how much value was added by each industry.

Equivalence

The three methods addressed are in essence equivalent. Value added must be equivalent to expenditure because someone had to pay for the goods. Because someone was payed for the goods, the money must have been distributed to the firm, and therefore received as income.

An essential caveat for this equivalence to be true is with respect to the treatment of unsold goods; if a car is produced by not sold, it must be valued as though it had been purchased in order for the different methods to agree on

GDP; otherwise the value added approach would consider the value added in the production of the car, while the expenditure approach would not see the purchase of the car and would therefore ignore its value, causing a discrepancy.

Circular Flow of Income

Another way to understand these different methods is through considering a cycle of income between consumers and producers.

- Households supply labour and capital to firms, who in exchange provide labour income and payments for capital.
- Firms supply finished goods to households, who in turn provide capital to firms by purchasing these goods.

Real GDP

Thus far, we have examined nominal GDP. While useful, this measure has some flaws.

- It isn't very effective for considering changes over time.
- It doesn't offer very good isolation of variables; changes in GDP could be due to change in quantity or price.

Real GDP attempts to remedy this by calculating change in quantity while disregarding changes in price. The most simple method to do this is to use a base year for the value of goods, and calculate the value of outputs in later years using the values of goods set in this base year. This method has the benefit of being fairly simple and intuitive, and effectively captures changes in economic activity over time, however, it can struggle to function well as more drastic changes occur in an economy. For example

- Changes in product preference altering the composition of an economy, causing valuations to be non-representative of output.
- Proportional changes in pricing between goods causing poor modelling using dated price data.

- Introduction of new goods which cannot be price using old data.

We can calculate GDP in this way by summing the quantity of each good produced in a year multiplied by the value of that good in the starting year. So for a year t and goods i:

$$\text{Real GDP} = \frac{\sum_i p_{i,0} q_{i,t}}{\sum_i p_{i,0} q_{i,0}}$$

Here $\sum_i$ indicates iteration across all goods i, for each of which a $p_{i,0}$ exists, which is the price of the good in year 0 and a $q_{i,t}$ exists, which is the quantity produced in year t. We divide through by the GDP of year 0 to create an *index value*, a ratio to the base year i.e. $1+$ the percentage change in market value, when valuing at year 0 pricing. Another way to consider this is as the cumulative product of these ratios across the years $\{0 \dots t\}$. If $t = 3$ for instance,

$$\text{Real GDP} = \frac{\sum_i p_{i,0} q_{i,3}}{\sum_i p_{i,0} q_{i,0}} = \frac{\sum_i p_{i,0} q_{i,1}}{\sum_i p_{i,0} q_{i,0}} \cdot \frac{\sum_i p_{i,0} q_{i,2}}{\sum_i p_{i,0} q_{i,1}} \cdot \frac{\sum_i p_{i,0} q_{i,3}}{\sum_i p_{i,0} q_{i,2}}$$

The modern approach to calculating real GDP uses *chain weighted prices* to compensate for the drift in accuracy caused by outdated pricing data. Rather than using $p_{i,0}$ for the entire calculation, this approach iteratively calculates the real GDP based on the previous years GDP according to

$$\frac{\sum_i p_{i,t-1} q_{i,t}}{\sum_i p_{i,t-1} q_{i,t-1}}$$

So for the example of $t = 3$, the full calculation would look like

$$\text{Real GDP} = \frac{\sum_i p_{i,0} q_{i,1}}{\sum_i p_{i,0} q_{i,0}} \cdot \frac{\sum_i p_{i,1} q_{i,2}}{\sum_i p_{i,1} q_{i,1}} \cdot \frac{\sum_i p_{i,2} q_{i,3}}{\sum_i p_{i,2} q_{i,2}}$$

This approach prevents outdated price data from skewing the GDP figure, while still maintaining the measure as relative to changes in production levels.

Inflation

Inflation is important to consider in macroeconomics, because it has some important implications for the economy. High inflation imposes serious costs upon an economy. It provides information about the performance of an economy. It also has impacts on the behaviour of price indexes, such as in GDP. Several measures for measuring inflation exist, one of which is the Consumer Price Index or CPI.

Measurement of Inflation

The CPI measures the cost of purchasing a specific basket of goods and services relative to a base year. This entails collecting data on prices of goods over time, collecting data on household expenditure, to figure what a reasonable basket to measure is, and do this regularly; in Australia the CPI is measured quarterly. The measurement is performed as follows, similarly to the GDP calculation.

$$P_t = \sum_i p_{i,t} q_{i,0}$$

So the total price is given by the sum across the prices of the goods in year t in the quantities defined in the base year, 0. These goods i are drawn from a basket of I items with associated quantities defined in the base year. This can be converted to an index, known as the CPI by dividing by the price in the base year.

$$\frac{P_t}{P_0}(\times 100)$$

This values is often multiplied by 100 as a matter of preference. The CPI calculated this way can then be used to calculate the inflation rate through

$$100 \times \frac{\mathrm{CPI}_t - \mathrm{CPI}_{t-4}}{\mathrm{CPI}_{\mathrm{t}-4}}$$

Where t is the number of quarters since the base year (or base quarter). This calculation yields the annual inflation rate. The quarterly inflation rate can be found by simply using the previous quarter instead of the past year.

$$100 \times \frac{\mathrm{CPI}_t - \mathrm{CPI}_{t-1}}{\mathrm{CPI}_{\mathrm{t}-1}}$$

In general the quarterly rate is more relevant for short term considerations, as it is more volatile and vulnerable to random fluctuations. The approach of the CPI can be used to examine inflation in a specific good by simply looking at change in price of that good. An example is the education is growing more inflated while clothing is largely declining.

Inflation data is very useful for indexing certain government expenditures, like welfare payments. It can be used to compare the value of investments; whether its better to receive $\$x$ than $\$y$ in the future. Deflation is the term for negative inflation.

Inflation measurement suffers from bias as composition of goods changes over time, as cheaper goods are substituted for more expensive goods. This implies an exaggerated CPI. It can also be difficult to compare goods which advance significantly technically, such as computers.

Costs of Inflation

In general a low rate of inflation ($\leq 3\%$) is fairly harmless, but higher rates of inflation ($\geq 10\%$) can be quite damaging, causing issues including

- Noise in the price system, where the relative prices of goods change too rapidly for individuals are firms to properly evaluate different purchases.
- Brack creep in nominal tax systems such as in Australia, where inflation can cause incomes to rise to higher rates of taxation, resulting in lower take-home incomes for workers.
- Cash assets will depreciate rapidly under high inflation rates.
- It can be difficult to plan savings for purposes such as retirement.
- Menu costs; costs of updating pricing over time (such as in a restaurant menu).
- People might hold too little cash, creating inconveniences.

Prices and Real and Nominal GDP

Nominal and real GDP can be linked with a price index.

$$\text{Nominal GDP} = \text{Price Level} \times \text{Real GDP}$$

$$P_tY_t = P_t \times Y_t$$

This equation also holds for growth rates.

$$\text{growth}(P_tY_t) = \text{growth}(P_t) + \text{growth}(Y_t)$$

Here, price level is not the CPI but a slightly different measure known as the *GDP deflator*.

Interest Rates

In general, investment in a financial asset requires a turn on investment, an appreciation. This rate of return is generally described by an interest rate. This rate affects the decision to invest versus consume or save.

A nominal interest rate i implies that an investment of $\$1$ will yield a return of $\$(1+i)$. However, this nominal interest rate doesn't quite provide sufficient information. The real point of interest is not the quantity of wealth one possesses, but what one could do with that wealth, i.e. its *purchasing power*.

The *real interest rate* reflects the increase in consumption an investment returns. When receiving income, one has two choices; to save and consume later, or to consume immediately. If saving, it can be assumed that the savings are invested. There is a price level at time of receipt of P_0 and a price at later time of P_1. $\$1$ at time 0 purchases $\frac{1}{P_0}$ units of consumption bundle, while $\$(1+i)$ purchases $\frac{1+i}{P_1}$ units of consumption at a later date. Therefore, the real rate of interest is given by

$$1 + r = \frac{\frac{1+i}{P_1}}{\frac{1}{P_0}} = \frac{1+i}{1+\pi}$$

Where $\frac{P_1}{P_0} = 1 + \pi$ and π is the inflation rate. Therefore, only when the nominal interest rate is greater than the inflation rate is the investment good. This equation is known as the Fisher equation, and can be simplified to

$$r \approx i - \pi$$

Which is a good approximation, only as long as i and π are quite low, which will generally be the case in this course. An issue arises when using this as a decision making tool when we consider that we don't have perfect information about the future. For this, we introduce an expected real interest rate:

$$r^e = i - \pi^e$$

Where π^e is the expected rate of inflation.

Saving

Consumption and savings are two sides of the same coin; they represent the two ways one can use their capital. The relevance of this to macroeconomic theory is that consumption makes up the majority of GDP in a modern economy. Investment too contributes to GDP, often being a good indicator of movements in productivity over time. In general, savings and investment contribute to future productivity.

Saving is specifically described in macroeconomics as holding capital without using it. Investment is described distinctly to this. An individuals wealth is the sum of an individual's assets, both financial such as shares or savings and real, such as housing or resaleable goods. Saving increases an individuals wealth. If they are consuming more than their income, they are *dis-saving*. Wealth has a significant impact on economic decisions.

A distinction can be made between stock variables and flow variables. A stock variable describes a level, like a volume in a bath tub while a flow variable describes how much of something occurs per unit time (usually a quarter), parallel to the flow rate of water into a bath tub. Wealth is a stock variable. Rate of saving is a flow variable. GDP is also a flow variable.

A variety of incentives exist for saving.

- Lifecycle saving; people tend to borrow money when their income is low and to save money when their income is high. This results in a flatter consumption curve, maintaining a consistent quality of life despite changing income.
- Precautionary saving; people save for unexpected events.
- Bequest saving; people save for the next generation.

Several factors are indicative of saving in a group or time.

- Real interest rates; opportunity cost of saving. A lower real interest rate incentivises present consumption.
- Demographics. Age structure, etc are very important to savings levels.
- Feelings about future events. People who foresee instability may have more precautionary savings.

It is not only households that can save, firms and even the government can save for future events.

Savings and Investment

In a closed economy, there is no trade. This is a commonly used model to understand behaviours of an economy in a simpler setting. In this case,

$$Y = C + I + G$$

GDP is equal to consumption plus investment plus government expenditure. C and G are both considered consumption expenditure. This leaves I as the savings in the system, which can then be written as

$$Y - C - G = I = S$$

This essentially states that the lvel of production minus the level of consumption is equal to the level of savings, which in a closed economy must be equal to the level of investment. Savings can also be analysed in terms of public and private savings.

$$S = Y - C - G - T + T = (Y - C - T) + (T - G)$$

Here, T stands for total taxation. $Y - C - T$ is the total private saving in the economy and $T - G$ is the public saving in the economy, equivalent to the government surplus.

Investment

Capital stock is the stock of durable goods, such as machinery that exist at a point in time and can be used as part of the production process. *Investment* describes new expenditure on durable goods that increase the capital stock. This includes inventory investment such as the production of goods to be sold in future periods. Notably, purchasing financial goods such as shares is not investment in a macroeconomic sense.

$$K_{t+1} = (1 - \delta)K_t + I_t$$

The above equation describes the relationship between capital and investment for a future period. The total capital for the next period is given by the capital of the present period multiplied by 1 minus the depreciation rate δ, plus the capital investment undertaken in the period.

A variety of factors inform the decisions of a firm to invest. A framework for this requires several standard assumptions. The first is that capital is costly to acquire; that firms must pay an interest rate plus a depreciation cost for using capital. However, a trade off exists as increased capital stock increases output according to

$$y = F(k)$$

It is assumed that an increase in k entails an increase in y i.e. $F'(k) > 0$. It is also assumed that dimishing returns apply to this function, i.e. $F''(k) < 0$. Finally, it is assumed that output is sold at a fixed price. To maximise profit in this instance, the following equation can be used

$$\Pi(k) = pF(k) - (r + \delta)k$$

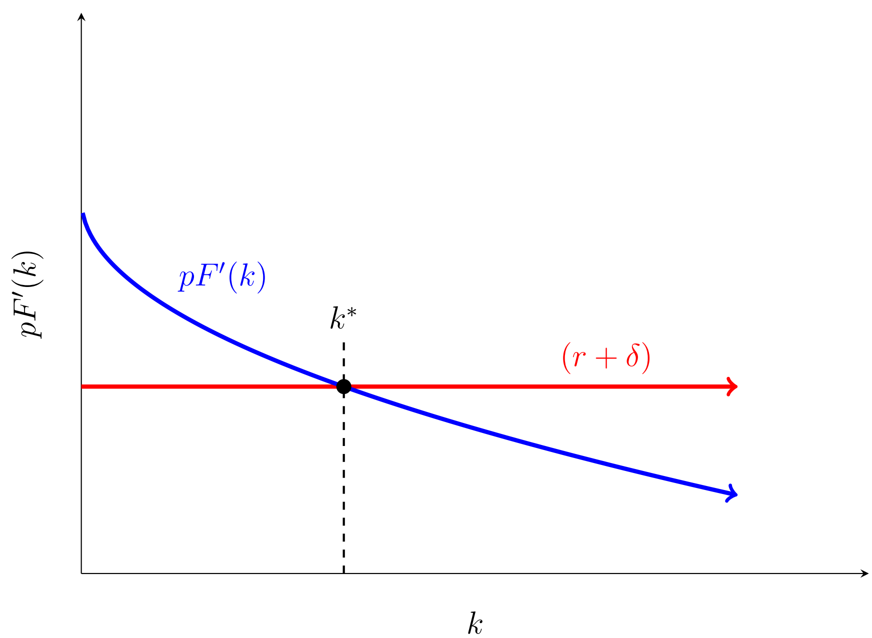
Here, $pF(k) = y$, r describes the interest payed on capital and Π describes the total profit for this level of k. To maximise this, we set the derivative equal to 0 i.e.

$$pF'(k) - (r + \delta) = 0$$

Here, the first term is the marginal revenue of capital while the second term is the marginal cost of capital. Examining this, we can identify the key determinants of investment decisions.

- The marginal product of capital; a higher marginal product encourages greater capital investment.

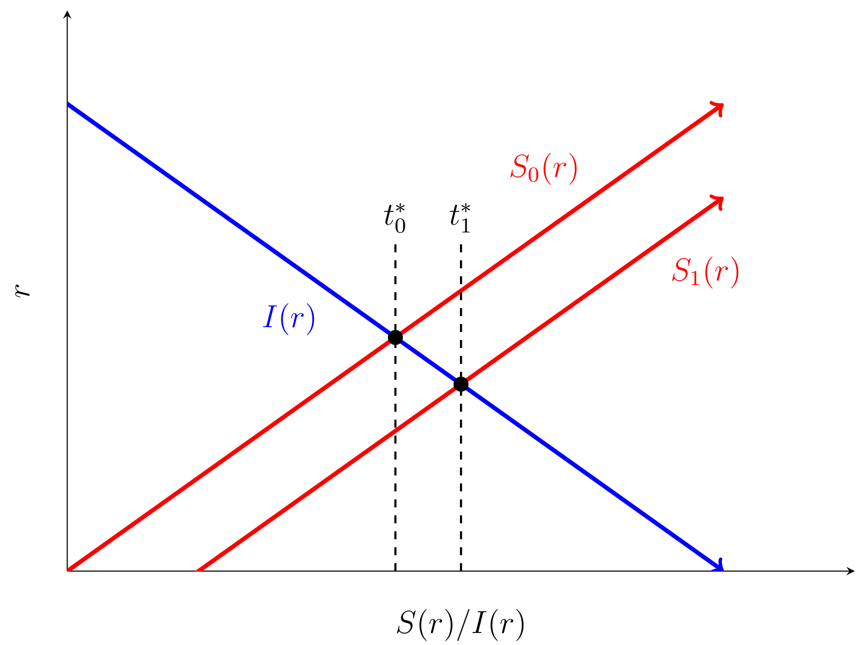
- The output price as compared to the capital price; a higher output price encourages higher capital investment.
- The real interest rate; a higher interest rate encourages lower capital investment.
- The rate of depreciation; a higher rate of depreciation also encourages lower capital investment.



In the above plot, a function for marginal revenue of capital is plotted against another for marginal cost of capital. Their intersection is the optimal level of capital, k^*. A profit-maximising firm will invest an optimal quantity i^* to increase their level of capital to k^* at each unit time.

Market for Loanable Funds

In all economies, there are some agents that wish to save and others that wish to invest. Interest rate is the price that adjusts to equate this market. With higher interest rates, individual saving is more incentivised, and firm investment is disincentivised.



The interest rate is determined by the relative attractiveness of saving S and investment I. For example, in the above plot we see that a shock incentivising savings, such as an increase in uncertainty about the future, has the effect of reducing the real interest rate. The real interest rate in many modern economies, including Australia, is around $0 - 1\%$

The Labour Market

The labour market is an extremely important factor in the success of an economy. It performs the essential task of allocating workers efficiently to important or valuable tasks. In addition, unemployment is a strong contributor to long term unhappiness and personal dissatisfaction.

When measuring a labour market, we need to measure both wages, as an indication of price, and unemployment as a measure of quantity.

Wages are often measured through surveys of workers, asking for wages, hours worked, etc. This yields an hourly wage, the *nominal* wage of the worker, which can be evaluated in terms of purchasing power to find the *real wage*.

Measurement of employment rates is more complex. They are generally also measured by survey. This process operates as follows.

- An assessment of working age groups is performed, and a representative sample selected.
- These people are asked whether they are employed, and then whether they are searching for work. People who aren't employed or searching for work are classified as "out of the labour force".
- Labour force is the sum of employed and unemployed people, the total working age group in the population.

It is important to notice the category of people who are out of the labour force. For example, after the GFC, the unemployment rate in the United states repaired fairly rapidly, but the group of workers out of the labour force took much longer to re-enter the market. The rate of working age people who participate in the labour market is the *participation rate*.

This high rate of non-participance can paint a more attractive picture of unemployment statistics. Participation rate is given by

$$\frac{\text{labour force}}{\text{population}}$$

Perfectly Competitive Model

A perfectly competitive model of the labour market is used to understand it. This model assumes that there is a very large number of workers as supply, and a very large number of firms demanding workers, therefore no individual workers or firms have market power. In addition, it assumes perfect information in the labour market; a fact which is a serious idealisation.

In this setting, firms are seeking labourers to produce output. Thus demand for labour is pinned to demand for output. Workers seek employment to earn income to increase their welfare.

Here, a firm i has a production function f that takes inputs labour l and capital k, which is a assumed to be fixed in the short term, and produces an output quantity y. All terms could be subscripted as e.g. $y_{i,t}$, indicating this is for firm i in period t, but this has been omitted for clarity.

$$y = f(k, l)$$

The output function is assumed to be increasing with respect to both labour and capital, and also to have diminishing returns. A profit maximising firm will seek to maximise the profit, given by

$$\Pi = pf(k, l) - wl - rk$$

Here, Π is the total profit, for firm i in time period t, p is the price payed for its goods, w is the cost of wages for a single worker l and r is the rent payed on each unit of capital k. This assumes a depreciation rate $\delta = 0$. If we assume that wages, rents and capital are fixed, then profit maximisation is undertaken through

$$\frac{d\Pi}{dl} = p\frac{df(k, l)}{dl} - w = 0$$

i.e. the marginal product of labour is set equal to 0. This can be rearranged to

$$\frac{df(k, l)}{dl} = \frac{w}{p}$$

So we set the marginal product of labour equal to the real wage (which is nominal wage divided by price level). This makes sense when we consider that while the workers productivity is greater than the cost of paying the worker, the firm should continue to hire workers, while when the marginal product is less than the real wage, the firm should reduce employment to increase profit.

The incentive of a worker to take on labour is the wage. The standard assumption is that an increase in wages results in increased attractiveness of labour, i.e. a rise in wages causes a positive supply shock. Demographic changes can also affect supply. An example of this is the increasing participation of women in the labour force over the course of the twentieth century. Wealthier individuals are also somewhat less incentivised to work.

Age structure of a labour force also has a significant impact on labour supply.

While this idealised perfect market is useful, it has flaws. For example, it can't explain unemployment. In addition, it ignores the presence of real world regulation, like minimum wages, union influences, market power or imperfect information.

Types of Unemployment

Several types of unemployment exist.

- Frictional unemployment is the unemployment from people who have left one job and are finding another.
- Structural unemployment is the unemployment caused by a group of workers who lack skills which align with market demand.
- Cyclical unemployment is caused by the behaviour of the overall economy, recession or boom, etc.

The natural rate of unemployment is the sum of the frictional and structural unemployment, while regulation is more able to address cyclical unemployment. It can be difficult to survey and gather data on which type of unemployment individuals are under, which makes addressing different causes more of a regulation challenge.

Modelling Economies

The Business Cycle

In modern economies, output tends to fluctuate with time, peaking at somewhat regular intervals. A trough is the counterpart of a peak, a time of lower economic activity. A period after a peak leading up to a trough is described as a contraction or bust, with the following period leading to the peak described as an expansion or boom. A period with two consecutive quarters of falling nominal GDP is known as a recession.

There is a strong link between employment and growth in output. Lower rates of unemployment imply a higher growth in output.

Potential output is defined to be the amount of output an economy can produce when using resources at normal rates. This value is denoted as Y^* and bears a couple of a associated assumptions. It assumes that people are working a "normal" number of hours, and that the amount of capital involved remains largely constant. Output can be greater than or less than the natural rate implied by this value. If one were to use more capital or work workers harder, the output could be increased above potential.

Output gap is the percentage difference between actual and potential output. This gap is defined as

$$100 \times \left(\frac{Y - Y^*}{Y^*}\right)$$

When this gap is positive, is is expansionary, while if it is negative it is contractionary. In this course, we assume that the relationship observed between employment level and output growth holds true.

Okun's Law

Okun's law addresses the behaviour of the economy with respect to employment levels. The natural rate of unemployment, denoted u^* is the sum of frictional and structural unemployment, while the cyclical unemployment is given by

$$u - u^*$$

Where u is the total unemployment in the economy. Okun's law is an expression which asserts that this value is proportional to the output gap.

$$100 \times \left(\frac{Y - Y^*}{Y^*}\right) = -\beta \times (u - u^*)$$

This implies that a positive output gap entails some people who would naturally be unemployed are not, while if the output gap is negative, there is a level of unemployment which is higher than the natural rate.

A model expressed in this way could have changes in output due to movements in potential output or movements in output gap. It is somewhat difficult to measure an economy in this way because it is difficult to assess the natural rate of unemployment and output, so they need to be estimated in some way.

Keynesian Modelling

A macroeconomic model is a mathematical description of the behaviour of an economy. This model is generally founded upon some intuition about the behaviour of agents within this economy. Models provide a useful simplification of an economy.

Success criteria for macroeconomic models vary. They might be useful for forecasting, providing insight into an economy or generally improving understanding of the behaviour of the world, perhaps for the purpose of developing relevant and effect policies.

Variables

Within a macroeconomic model, we draw a distinction between two types of variables.

- Exogenous variables; external variables which are often taken as fixed within a model, such as the behaviour of a global economy.
- Endogenous variables; internal variables which are determined by the model, such as output of an economy.

Variables might moved between the two classes depending on time period or other factors.

In this course, we largely examine comparative statics; looking at what changes a change in an exogenous variable effects. An example of this might be examining the effects of different monetary policies or the performance of a world economy on a local economy.

A variety of assumptions inform models, such as assumptions about saving behaviour or profit maximisation as a goal of firms. These assumptions, when tempered by the model, suggest implications which can be considered the outputs of the model.

Specifically addressing Keynesian modelling, assumptions are made about household spending, investment of firms and government spending. We would like this model to offer insight into the effect of economic shocks on an economy, and the implications of these shocks for output. It would also be good to understand how different elements of an economy interact with each other.

Different theories draw different reasons for business cycles. Keynesian theory blames market failure for business cycles, while some other theories blame fluctuations in productivity rather than market failure.

Keynes

Keynes was an economist who developed his namesake theory during the Great Depression, finding that classical theories struggled to explain the behaviour of the economy at the time. In particular, standard theories struggled to explain prolonged severe unemployment.

Keynes' submission was that the government should attempt to increase spending to stimulate a deflationary and underactive economy. Some economists attribute the relatively minor effect of the GFC as compared to the Great Depression to application of macroeconomic theory.

Keynes' model had some key assumptions. He assumed that prices are static in the short term, and that expenditure plans are realised, with the exclusion of investments by firms.

His model introduced the idea that expenditure or demand is the key variable in terms of output. He also emphasised the importance of expectations and certainty for decision making. His findings had important implications, suggesting that government policy can help stabilise the economy.

Assumptions of the Model

Aggregate expenditure is the total expenditure in the economy, effectively equivalent to GDP.

$$AE = C + I + G + X - M$$

In this course, it is assumed that all imports are for consumption. In addition C^d is defiend as the consumption demand for domestic output. This tells us that the total consumption is given by $C^d + M$.

$$C = C^d + M$$

$$AE = C^d + I + G + X$$

It is assumed that if they so desire, any group may purchase goods. Firms can always invest to the level they desire. They need to make expenditure decisions as to their capital investment, and their desired change in inventory. While we assume they can invest as much as they like, we assume they cannot perfectly control the inventory investment. If we take I^P as planned investment, the actualy investment I may be more or less than this amount dependent on sales figures. Using this value, we can introduce planned aggregate expenditure as

$$PAE = C^d + I^P + G + X$$

Consumption

To model consumption in a Keynesian model, we use a Keynesian consumption function.

$$C^d = \bar{C} + c(Y - T)$$

Here, c is a coefficient known as the marginal propensity to consume, in the range $(0, 1)$. $\bar{C}$ is the necessary consumption expenditure, the subsistence expenditure. Y is the nominal income and T the taxation on that income. This modelling assumes that an increase in take home pay implies an increase in consumption.

Government

It is assumed that government spending is exogenous; that it is simply an input to the model. This is useful because it can be used to model policy decisions.

A simple taxation function is used of the form

$$T = \bar{T} + tY$$

Here, $\bar{T}$ is a taxation lump sum while tY is a term with a coefficient t known as the marginal rate of tax on income multiplied by the total income Y.

Exports are taken to be exogenous, dependent on global demand on which Australia has little impact.

Investment

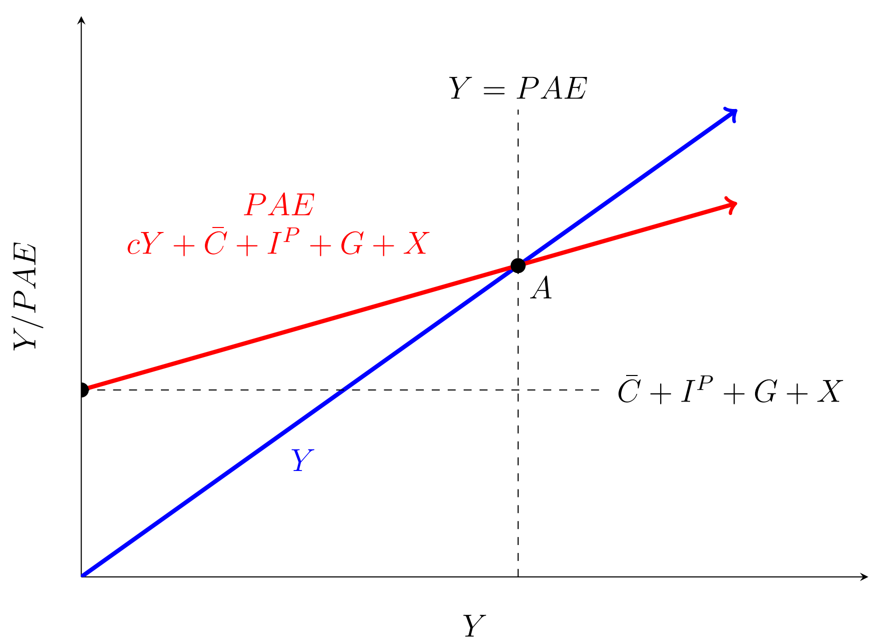
Planned investment is taken to be exogenous, with the level of capital investment they would like to achieve a constant to a firm. Firms want to maintain some static level of inventory, independent of their income. In reality investment depends upon the real interest rate, and the “animal spirit” of the investor; what they believe about the value of investments moving into the future (bull, bear, etc).

Equilibrium

In a Keynesian model, we take $Y = PAE$ i.e. output is equal to planned aggregate investment to be an equilibrium condition. Therefore, because the only way PAE can exceed or fail to meet Y, as all other values are given, is through deviations of I from I^P, $I > I^P$ implies $Y > PAE$, so in a situation where the aggregate expenditure is lower than the gross output, firms must have produced excess inventory and so will reduce product. Conversely,

$$Y < PAE \Rightarrow I < I^P$$

i.e. when production is less than aggregate expenditure firms must have run down their inventories, and will seek to increase production to refill them. When trying to find the equilibrium, it is useful to observe that most of the inputs to the model are considered exogenous. These are $\bar{C}$, I^P, G and X. The only moving part in the model is cY, the expenditure of consumers.



In the case that $Y < PAE$, this tells us that $I^P > I$, which implies that an increase in I^P will occur, while if $Y > PAE$, $I^P < I$, which implies a decrease in I^P will occur. The above plot assumes $T = 0$. We can described the same system algebraically.

$$Y = \bar{C} + cY + I^P + G + X \Rightarrow (1-c)Y = \bar{C} + I^P + G + X$$

$$Y = \frac{\bar{C} + I^P + G + X}{1-c}$$

Several simplified versions of this model exist.

- A two sector economy looks at only household and firm spending. $Y = C + I$.
- A three sector economy introduces the government. $Y = C + I + G$.
- Finally a four sector economy includes exports less imports to round out the production formula. $Y = C + I + G + X - M$.

Because we know that output must be equivalent to income, we can state that

$$Y = C^d + S + T + M$$

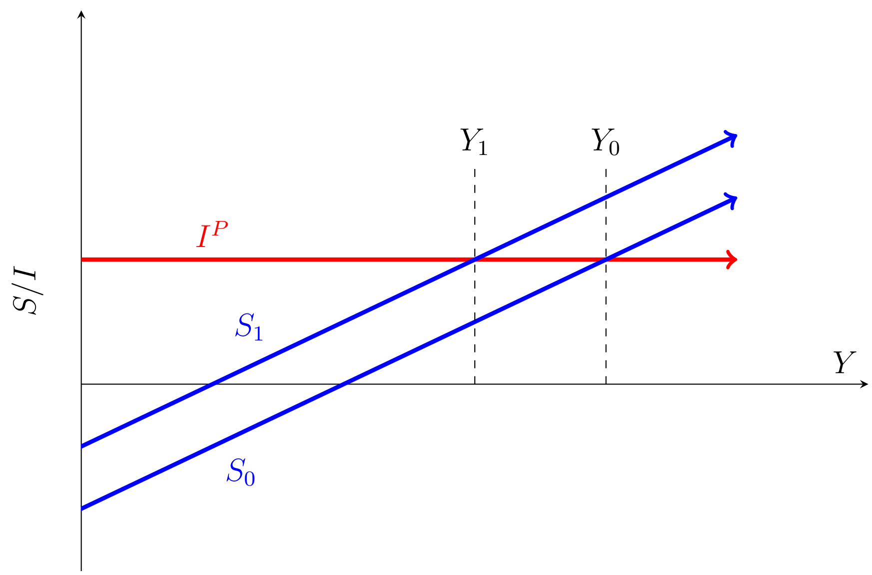
i.e. total output is equal to household consumption plus savings plus taxation plus imports. If we plug this in to a previous equation, we find that

$$S + T + M = I^P + G + X$$

The left side of this equation is described as leakages; referring to income which is not used for local consumption, while the right hand side is referred to as planned injections; the total exogenous expenditure in the system. For a two sector system, this implies that

$$S = I^P$$

$$\Rightarrow S = Y - C = (1-c)Y - \bar{C}$$



Here, S_0 has a higher $\bar{C}$ value than S_1, and therefore has a lower rate of saving. Because we know that $S = I^P$, we know that the intercept of this saving function with the exogenous firm investment must be at the output level of the economy, and we can therefore see that a higher rate of saving implies a lower total output. However the amount of saving undertaken at each point is the same.

This is known as the *paradox of thrift*; it is an observation that when increased saving is desireable, the real world result is that no real increase to saving occurs and therefore output falls. This is to some degree likely a result of the simplicity of the model; it doesn't consider supply side factors or changing prices.

The Multiplier

Returning once again to our two sector economy, we have the equation

$$Y = \bar{C} + cY + I^P$$

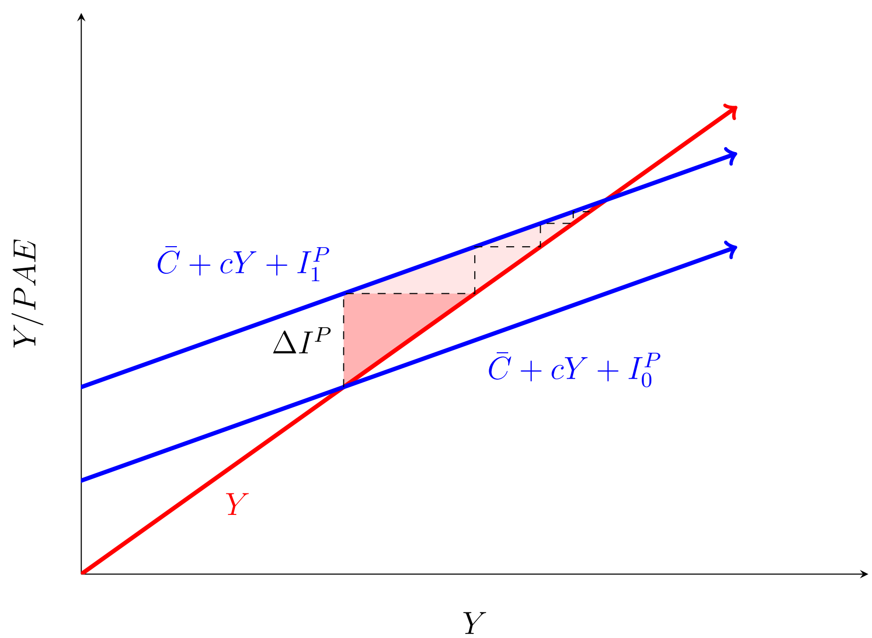
Which implies that Y can be calculated as

$$Y = \frac{\bar{C} + I^P}{1 - c}$$

$$\frac{\mathrm{d}Y}{\mathrm{d}I^P} = \frac{1}{1-c}$$

This implies that an increase in $\bar{C}$ or I^P leads to an increase in output. More generally it is taken that a change in an exogenous expenditure in an economy results in an increase in income, results in an increase in consumption, results in a significant increase in total output. The fact of this increase being larger than the initial change in expenditure is known as the multiplier. This applies both ways; a reduction is exogenous expenditure is worse than it would suggest at face value.

The magnitude of this multiplier is given by the derivative of Y with respect to I^P shown below the equation; because $0 < c < 1$ this value is greater than 1 and acts as a multiplier for the increased investment.



This plot showcases the multiplier effect in response to a change in planned investment ΔI^P from I_0^P to I_1^P. The dark red shaded area is the initial effect of the increased investment, while the light red shaded area is the multiplier benefit from the increase. Each "step" represents the effect of a calculation cycle of increased income implying increased consumption implying increased output.

This model can be extended to include all of the components of an economy, yielding the equation that

$$Y = \frac{\bar{C} + I^P + G + X - cT}{1 - c(1-t)}$$

$$\frac{\mathrm{d}Y}{\mathrm{d}I^P} = \frac{1}{1 - c(1-t)}$$

It should be noted that this applies equivalently to all terms in the numerator; not just I^P but also $\bar{C}$, G, etc. Thus, the multiplier is affected by the marginal taxation rate. The taxed income doesn't go towards an increase in output. The taxation rate can be thought of as a dampener on the multiplier.

An increase in c implies an increase in the multiplier, while an increase in t implies a fall in the multiplier.

Fiscal Policy

Fiscal policy can be simplified down to the size of aggregate government spending, in addition to the quantity of tax and transfer payments made. In this subject, we generally look at the impact of these different quantities on the output of an economy.

Fiscal policy as a concept is often dated back to Keynes contributions, as he argued that market failures were the cause of many economic fluctuations, and that government spending could be modified to address then. Since then a shift toward monetary policy has occured, though the GFC started the pendulum back somewhat toward the other direction.

In simple terms, in an ideal world output is equivalent to potential output. In the case that output is below this value, an increase in government spending can increase planned aggregate expenditure and therefore total output per $Y = PAE$.

Some economists argue that this is oversimplified; it has unnacounted for impacts on the supply side of a market, and it ignores the time lag involved with government spending.

Austerity

After the Global Financial Crisis, Australia had a somewhat different response to some other parts of the world. Where Australia increased welfare payments and government spending to attempt to mitigate a recession, the United Kingdom adopted a contractionary footing and attempted to reduce government spending and transfers.

As a result of this policy, Australia suffered only a single quarter of negative growths while the United Kingdom entered a significant recession. Various perspectives on the correct response to economic downturn do however exist. This is in part because it is very difficult to isolate variables in these systems. It is also very difficult to experiment in macroeconomics; systems on the scale of nations are somewhat difficult to obtain.

The general concept of Keynesian fiscal policy is that rather than maintaining a roughly constant rate of government spending, throughout peaks and troughs of the business cycle, a government should spend less during booms and spend less during busts.

A concept in fiscal policy is that of *automatic stabilisers*. An example of this is taxation policy, particularly progressive taxation policy. These are schemes which will "automatically" modulate government spending according to the state of the economy; for the taxation example, people earning more pay more tax, essentially reducing government spending.

Debt and Fiscal Policy

Debt is import to fiscal policy as it is one of the two ways money can be raised for government spending. Governments can either raise tax rates or sell bonds to borrow money. Often raising taxation has the issue of disincentivising labour, an often undesireable outcome. To quantify debt, we use this model for the debt taken on by a government in time period t

$$B_t - B_{t-1} = G_t + Q_t r B_{t-1} - T_t$$

Here, B_t is the government debt at the end of the period, G_t is total government expenditure (again, in the period), Q_t is transfer payments like welfare, r is the real rate of interest, B_{t-1} is the total government debt in the previous period and T_t is total government revenue (generally taxation) in the period.

COVID Response

The Australian governments response to COVID has largely come in the form of JobKeeper and JobSeeker, which serve to maintain business relationships and therefore maintain employment, in addition to offer unemployment insurance; effectively a safety net for the unemployed. This policy should allow the economy to recover more rapidly after the pandemic.

While large quantities of debt have been taken on by the government, the real interest rate is currently fairly low. In addition, Australia had a relatively low debt rate prior to the pandemic, and so doesn't suffer overmuch by comparison when taking on additional debt.

Financial Markets and Intermediation

When an individual saves money, that money must go somewhere while it is stored. This money is usually loaned out to people looking to go into debt. For a saver, it is ideal that the interest rate they earn on these funds is as high as possible, while for the person taking out a loan to invest this interest rate would ideally be a minimum.

This is a somewhat different relationship to a normal purchase; it suffers from information asymmetry, where a saver has little information as to the trustworthiness of someone they are loaning to. In addition, a significant portion of debt demand is in the form of extremely large sums for very large projects, while much of saving is done by small (household) groups. Financial intermediation exists to facilitate this.

Financial Intermediaries

Financial intermediaries are primarily banks, but can also include credit unions. Banks accept deposits from savers, paying them a low interest rate on their savings while lending them out at a higher interest rate to investors. The spread between these two interest rates is the bank's cut and is the source of its profits. Generally the more transactions a bank undertakes the more profitiable it is, but this does come with some risk.

The specialisation of the bank is in evaluating risk, and in pooling savings of small individual savers. This can minimise the risk of a single project, as well as funding large projects and making risk management more efficient.

Financial Markets

Another financial intermediary is in financial markets. These include

- Bond markets where large business sell bonds at a given price with a commitment to pay back a larger some at some fixed future date.
- Stock markets where firms offer a share of firm profit in exchange for an upfront sum. These are generally more risky than bonds, but offer a higher rate of return.

When working in these markets, legislation requires that businesses must provide a *prospectus* which provides information about a business. These markets play an important role in allowing savers to diversify their saving portfolios.

Conceptually, these markets will tend to finance the most profitable projects as these are the ones that will tend to be invested into. This has the added benefit of maximising rate of return for savers.

This system can be severely damaged during market crashes like that 1929 market crash in the US, or during the GFC. Here, issues with banks and other intermediaries can cause failures in this transfer of wealth, leading to a contraction in investment and consumption and thus overall market contraction.

Money

Money fulfills a few important roles in society

- It stores and transfers purchasing power over time. It should therefore be long lasting and durable.

- It is also a unit of account; a measure of the economic value of a good.
- It is a medium of exchange, it allows people to exchange a common good for other goods, avoiding the inefficiences of a barter economy.

Thus money includes currency, but also bank deposits, the two of which are combined to make $M1$, or for $M3$ including private non-bank deposits. *Broad money* describes $M3$ as well as borrowings from the private sector, minus holdings of currency and deposits of non-bank depository corporations.

Banks have a special role in a macroeconomy in that they create money. They do this under a system of *fractional reserve banking*. Under this system, banks take deposits from the public, keeping a certain percentage of these deposits on hand, but lending out the majority. These loan funds end up being re-deposited elsewhere and the process repeats. This essentially results in a multiplier to the quantity of money in circulation.

This means that if every customer wants to withdraw their savings simultaneously, the bank would be unable to make good on the deposits. The ability of the banks to create money is controlled by the amount they are required to keep on reserve. A bank will generally want to have as many loans as possible.

Quantity Theory of Money

The quantity theory of money states

$$MV = Py$$

Here, M is the money supply, V is *velocity*, a measure of the amount of transactions that can be financed from a given amount of money in some time period. P is the price level and y is the real output of the economy. V is affected by the structural features of an economy, such as the ease of the payment mechanisms. If V and y are fixed in the short run, there is a direct relation between M and P.

This is often a desireable outcome, however it can be difficult to control velocity.

The Reserve Bank

The Reserve Bank of Australia is the central bank, an institution which controls monetary policy for the nation. It has severy important functions

- It controls the level of the nominal interest rate
- Historically it has controlled the level of money supply
- Some central banks directly control the exchange rate
- It also regulates payment systems and financial stability

The goals of a central bank are generally to maintain stability of the currency (i.e. low inflation), to try and keep employment levels high (i.e. close to the natural rate of unemployment).

The way the central bank manages the interest rate is by trying to target the interest rate in overnight unsecured interbank market. Transactions in this space occur through the Exchange Settlement Accounts of banks, which are used to settle balances incurred between banks by customers of these banks each evening. The accounts must remain positive, but holding large somes in them is prohibitive due to the foregone interest this entails. Because the central bank controls money supply in this arena, it has control over this interest rate.

This interest rate tends to control the other interest rates in the economy. The interest rate for this market is known as the cash rate, and it has a very significant impact on other loan types. This is largely due to arbitrage, the process of market factors altering prices through competition.

Today, the central banks main goal is *inflation targeting* where the bank tries to set an inflation rate over the business cycle. It is felt that this is a better metric than money supply because it is more explicit and thus offers better evaluation. It is also thought to be good for stability; with a set target people can have well defined expectations for the inflation of their money.

Over the course of this subject, we assume that the central bank can control real interest rates. In reality, the market for loanable funds means this isn't quite too; while the central bank can more or less set the nominal interest rate, they have less control over the real interest rate.

Consumption and Interest Rates

$$C^d = \bar{C} + c(Y - T)$$

This is the basic model for Keynesian consumption, while the more complex version, accounting for saving, takes the form

$$C^d = \bar{C} + c(Y - T) - \gamma_c r$$

Where γ_c is, a coefficient relating consumption to the real interest rate, r. Also in this situation, we consider that investment of firms has an opportunity cost of lost interest. Thus

$$I^P = \bar{I} - \gamma_I r$$

Thus firms have some maximum investment $\bar{I}$, reduced by the amount saved according to $\gamma_I r$. A low interest rate would therefore encourage increased consumption. However often γ_I and γ_c are very small.

In a three sector economy, our model now looks like

$$PAE = C^d + I^P + G = \bar{C} + c(Y - T) - \gamma_c r + \bar{I} - \gamma_I r + G$$

In this model, an increase in r implies a drop in PAE, the magnitude of which is dependent on the γ terms.

Behaviour of the Reserve Bank

The behaviour of the reserve bank can be quantified through the equation

$$r_t = \bar{r} + \alpha_y \left(\frac{Y - Y^*}{Y^*} \right) + \alpha_\pi \pi$$

Here, r_t is the real interest rate targeted by the reserve bank, $\bar{r}$ is a constant, α_y is a constant greater than 0 which relates interest rates to the output gap (i.e. the fractional Y term), α_π is another constant greater than 0 which defines how interest rates respond to inflation.

The RBA wants to try and keep output near potential, to ensure stability of unemployment. If $Y > Y^*$, an increase in r occurs due to the positive α_y term, tending to reduce PAE, while if output is below potential, the term is negative resulting in a drop in r, and an increase in PAE.

For the $\alpha_\pi \pi$ term, if π is high, and increase in r occurs, resulting in a fall in output and a reduction in inflation pressures. When π drops, so too does r resulting in an increase in demand and thus inflation. This will tend to react aggressively; generally a change in π is reflected by a larger change in r.

This description is approximate; the reserve bank still has plent of leeway for human intuition. Interestingly, 0 is not a lower bound for the interest rate. Economists tend to think that a slightly negative interest rate is acceptable due to the utility inherent in storage of wealth in a bank.

Aggregate Demand and Supply

The Keynesian model makes the assumption that prices in an economy are fixed in the short run. The model of aggregate supply and demand allows us to consider situations with high inflation or other price changing factors. Aggregate demand and supply is essential to understanding evens like the GFC.

Aggregate Demand

The model of aggregate demand assumes that

- Household consumption is given by $C^d = \bar{C} + c(Y - T) - \gamma_c r$
- Firm investment is given by $I^P = \bar{I} - \gamma_I r$
- Government, export and import spending is exogenous
- The monetary policy of the system is defined by the policy reaction function.
- Prices are set by the aggregate of firms in the economy.

The model has implications for the level of output of the economy, as well as the level of inflation implied by the model. It therefore has implications for the real interest rate as well as consumption.

The aggregate demand curve exists with one axis showing output and another showing inflation. It maps the set of points where $PAE = Y$, points in Keynesian equilibrium; no unwanted change to inventory occurs.

The plot will take the form of a downward curve. A high level of inflation implies a low level of output, a fact largely due to the effects of monetary policy from the reserve bank. The reserve bank will respond to high inflation by attempting to lower output, resulting in a lower level of output at higher levels of inflation.

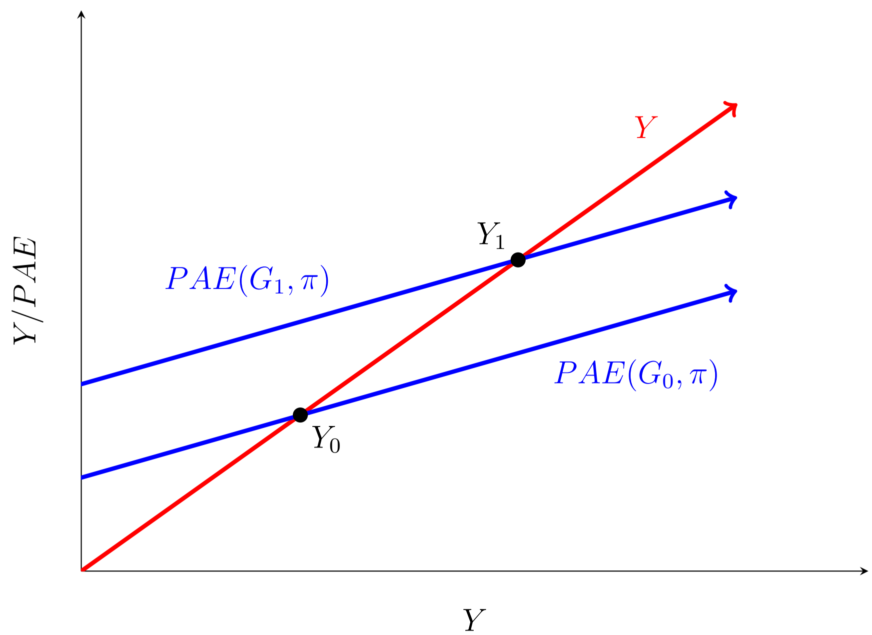
On an individual level, it is intuitive that inflation coincides with erosion of wealth, reducing people's ability to consume. In addition, generally those that are wealthy are able to make intelligent investment decisions that protect them from inflation, while the poor are less able to do this. This, combined with the fact that the consumption of wealthier people tends to be less tied to increases in their wealth explains a fall in output.

Shocks to the Aggregate Demand Curve

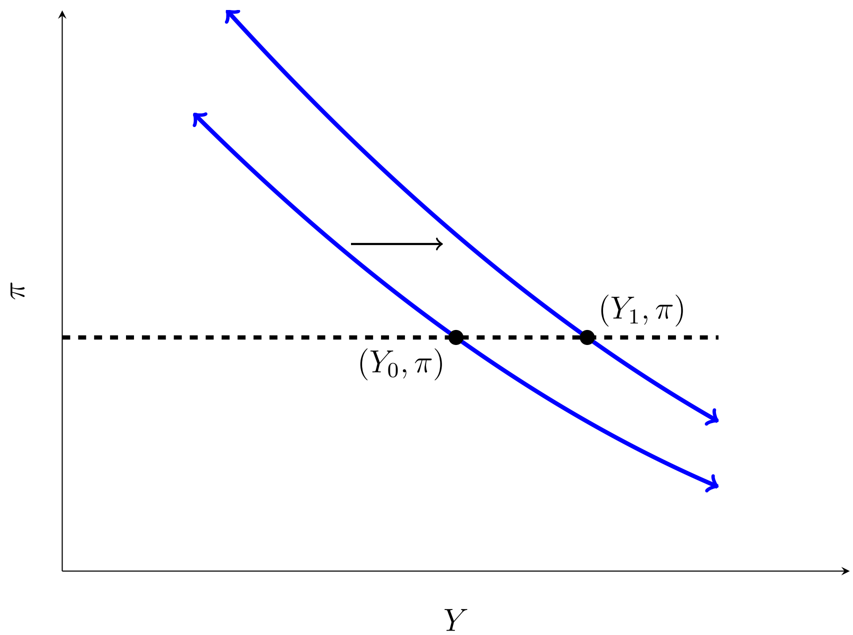
Causes of shifts to the aggregate demand curve include

- Shifts to the planned aggregate expenditure curve, excluding those caused by inflation. These include changes in household behaviour, firm behaviour or exogenouse variables. Changes inflation cause a move along the same curve.
- Exogenouse changes to the policy reaction function of the central bank. If the relationship between the real interest rate and inflation changes, so too will the aggregate demand curve.

We can examine the effect of a change in exogenous expenditure through a case study.



Here, government expenditure has increased from a level G_0 to a level G_1, causing an increase of output from level Y_0 to Y_1. This all occurs at a constant inflation rate π. The below plot shows the impact of this change in PAE in the aggregate demand curve.



We can see that because the inflation rate π has remained constant while the level of output increases, the curve has moved to the right, to a higher level of output. Generally a rise in PAE implies a shift outward of aggregate demand while a fall in PAE implies a shift inward.

Another way the curve can be affected is through changes in the policy reaction function of the central bank. This can be considered by thinking about what the new function entails for saving and expenditure behaviours. For example a decrease in real interest rate implies an increase in PAE implying a rightward shift of the demand curve.

Aggregate Supply

The aggregate supply curve maps out a set of points (Y, π) where firms production decisions are consistent with price changes. The prices set by firms are determined by costs of production, particularly labour costs. They are also influenced by demand for their products.

In general, inflation will tend to behave as though it has inertia; it will be slow to change naturally.

The primary determinant of production costs is the cost of labour.

$$Y = wL + rK$$

Tells us that total output is made up of wages paid for labour and interest paid on capital, with $55 - 60\%$ of this made up by the labour term. These wages are generally negotiated between businesses and workers, and tend to be inflexible in the short term.

The *real wage* describes the distribution of gains from trade between workers and employers. If we assume that the two can agree on a fair real wage (which assumes that workers will have some insight into the future, considering inflation, etc for calculation of nominal wage.). This implies that high inflation needs high nominal wage increases to compensate, while low inflation implies low nominal wage increases.

This forms a kind of self-fulfilling prophecy; an expectation of high prices results in higher wages and higher costs of production implying high prices. Thus the expectation of inflation in some way dictates the rate of inflation.

But what determines this expectation? Considering inflation inertia, one would expect the present rate of inflation to reflect future inflation. Thus if inflation inertia is the main factor, we can calculate inflation through

$$\pi_t^e = \pi_{t-1}$$

$$\pi_t = \pi_t^e + \epsilon_t$$

$$\pi_t = \pi_{t-1} + \epsilon_t$$

Here, π_t^e is the expected rate of inflation during time period t, set equal to the rate of inflation in period $t-1$. We then set π_t equal to this value plus some exogenous constant ϵ_t, which represents external shocks to the system.

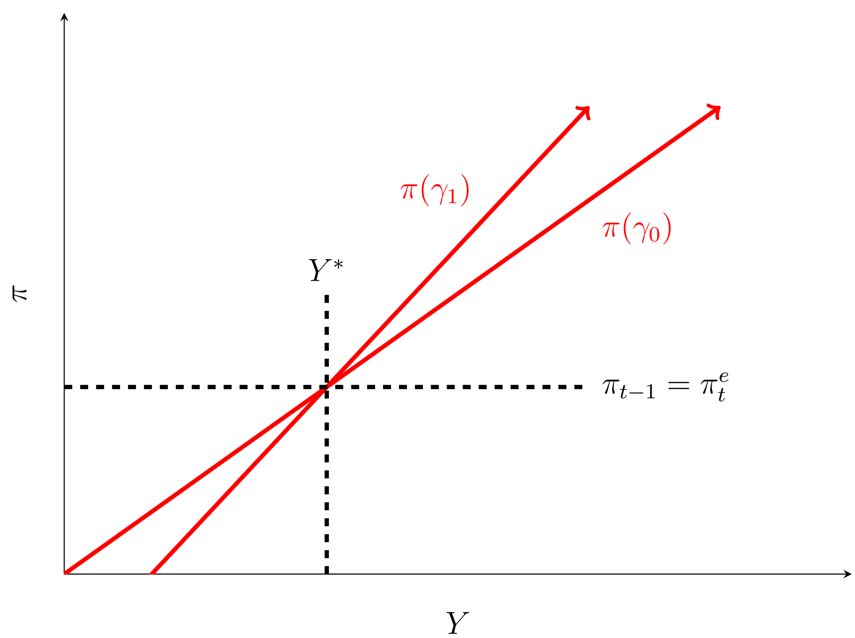
ϵ_t could be made up of oil price shocks, natural disasters or surprising wage bargaining outcomes.

In addition to labour considerations, the desired output level of firms is dependent on product market conditions. If firms have lower demand they will tend to lower prices to try and drive demand and thus lower inflation. Thus when output is equal to potential or desired output inflation will be unaffected by the product market. However if output is above potential, firms will raise prices resulting in increased inflation. Inversely, lower output will result in lower prices and lower inflation.

Considering this, we can develop an equation for the inflation rate with respect to expectations and the product market.

$$\pi_t = \pi_{t-1} + \gamma \left(\frac{Y_t - Y^*}{Y^*} \right) + \epsilon_t$$

Where γ describes the responsiveness of inflation to deviations in the output gap.



Here $\gamma_0 < \gamma_1$, so the γ_0 curve is less responsive to changes in Y and thus has a lower gradient. The two intersect at Y^*. The gradient of each curve is not exactly γ but rather some function of γ. At the output level Y^* the output dependent term is 0 so γ has no effect. At this level, it is exclusively π_t^e and ϵ_t which determine the inflation level. Because ϵ_t is taken to be 0 for the above plot, the two are simply equal.

Shocks to the Aggregate Supply Curve

Shocks to this curve might happen for a variety of reasons. These include supply side changes, like new resources or improved technology or changes to regulation. For example immigrant labour might increase potential output or Covid-19 lockdown regulations migth reduce potential output. Changes to inflation expectations in addition to exogenous inflation shocks have significant effects.

When potential output increases, the supply curve is directly shifted to the right; this can be easily understood by understanding that the potential output Y^* pegs the curve, and so moving it shifts the curve.

If expected inflation π_t^e increases, the curve will shift upward or equivalently left. It will move up by exactly $\Delta\pi^e$, again because the point (π_t^e, Y^*) always lies on the curve.

An inflation shock to ϵ_t will have the same behaviour.

Equilibrium of Aggregate Supply and Demand Curves

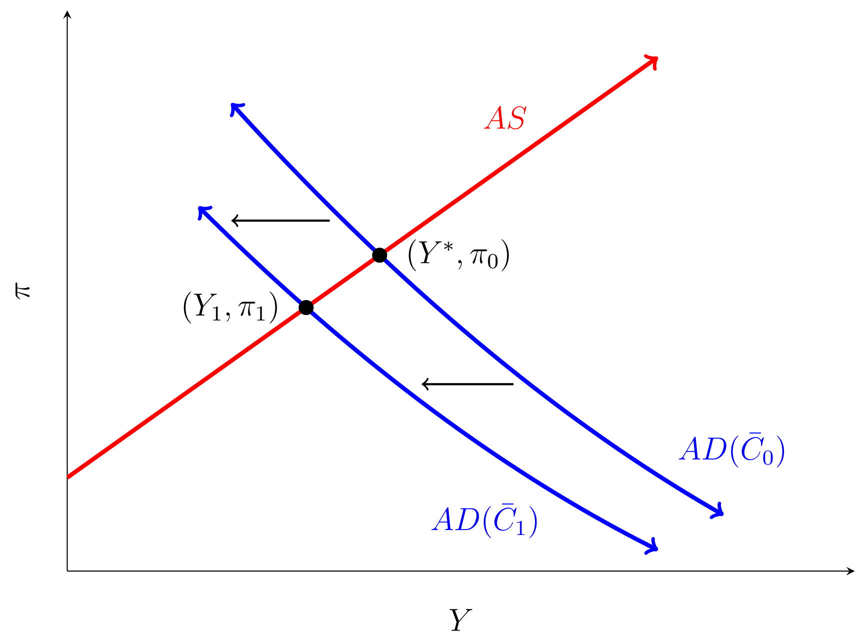
The goal of a theory of business cycles is to be able to describe the causes of output fluctuations. This can be explained through shifts in the aggregate demand and supply curves.

For the two curves to be in equilibrium, output must equal planned aggregate expenditure and firms pricing structures must be consistent with their desires. For a long run equilibrium, these must be satisfied however additionally there must also be a consistent trend of expected levels of inflation ($\pi = \pi^e$), Adjustment from a short run equilibrium to a long run equilibrium is undertaken by moderation of inflation.

We can consider as an example a drop in consumer spending.

$$C^d = \bar{C} + c(Y - T) - \gamma_c r$$

i.e. a reduction in $\bar{C}$. This will have the effect of a reduction in aggregate demand. This will imply a build up of inventories for firms, resulting in a drop in rate of increase of prices (i.e. inflation). This decline will be mitigated by the policy reaction function, causing the real interest rate to drop and thus investment to increase.



The above plot depicts the changes as the curve shifts from output level Y^* to Y_1. The end result is a fall in aggregate demand cause a fall in output and inflation level. This is a short-run result; because $\pi_1 < \pi^e$ this cannot be a long term equilibrium.

In general, we expect inflation and inflationary expectations to return the economy to long run equilibrium. In the case that $Y < Y^*$ as above, the economy will tend to have a falling inflation and inflationary expectations and thus the economy will return to a long-term equilibrium. When $Y > Y^*$ inflationary expectations will tend to increase, and the economy will once again self correct.

So essentially what happens is that the supply curve responds to a change in inflationary expectations by falling, which eventually leads to a new long term equilibrium when $AS = AD = \pi^e$.

In general, the key adjustment in the system is the change of expected inflation over time resulting in a return to long term equilibrium.

Implications

Changes in aggregate demand will generally cause output and inflation to move in the same direction. Changes in aggregate supply will tend to cause output and inflation to move in opposite directions. The overall impact of an shock to supply or demand is dependent largely on the size of the shock, as well as the relative slopes of aggregate supply and demand.

This makes sense; a steeper sloped curve will result in a larger shock comparative to a flatter curve, all else equal.

Keynesian policy is relevant to this process because generally the adaptation back to a long term equilibrium is quite slow, due to long term contracts and other factors. In this situation, we may have $u > u^*$, which is unpleasant. Through Keynesian policy, we can try to reduce u or moderate Y while the economy returns to equilibrium.

If however we accept that rapid price adjustment is the major factor in equilibrium, government intervention is less important and can indeed be seen to be undesireable. Which of these two takes is correct is an important issue in macroeconomics. Most economists tend to agree that intervention is productive however.

Phillips Curve

The Phillips curve shows a relationship between a low level of unemployment and a high level of inflation. This relationship has grown weaker over time.

Economic Growth

Economic growth has not been a constant over time. Until around 1750 C.E., there was little economic growth. With the advent of the industrial revolution in primarily western Europe, sustained growth occured in countries like Britain and Germany. As the growth spread to some other countries and accelerated, a large divergence in wealth occured between 1800 and 1950.

Output per capita is an important determinant of many important factors, including health and nutrition or education. Over time, countries are tending to become more similar in terms of per capita output.

Even small differences in economic growth can lead to quite different outcomes. For example, where Japans per-capita ouput was only a quarter of Australia's around 1900, it has rapidly increased in the post-WW2 period to around the same figure.

Where the study of business cycles focussed on deviations from potential output and on the possibility of market failures, with fixed prices, with the goal of identifying effective govenrment intervention, the study of economic growth addresses changes in potential output with time and assumes adjustment of prices will mitigate market failures.

Productivity

We can represent output per capita as

$$\frac{Y}{P} = \frac{Y}{N} \cdot \frac{N}{P}$$

Here, N is the number of employed workers. $\frac{Y}{N}$ is labour *productivity*, units of output per worker. $\frac{N}{P}$ is the employment to population ratio. We can thus see that product per capita will be affected by worker productivity changes or employment ratio changes.

Productivity might be increased by something like improved technology, while employment to population is somewhat more difficult to increase. Interestingly labour productivity growth has slowed down somewhat since the GFC; some argue that this is due to mismeasurement due of digital products. Others argue that the reduction is still due to the GFC, while still others argue that new technology is becoming more difficult to discover and we will suffer a long term reduction in labour productivity growth.

This may be due to factors like further required education to reach the forefront of a field with advancing science and technology.

Other factors of productivity include institutions like political and legal environment, human capital (skills, training of workers), physical capital, land and natural resources, etc.

Production Function

Much of economic growth uses an *aggregate production function*

$$Y_t = A_t f(K_t, L_t)$$

Where Y_t is output in time period t, A_t is a measure of productivity (technology, etc), K_t is capital stock and L_t is labour force (factors of production). f is a production function which states how much K_t and L_t are able to produce. The Cobb-Douglas production function for instance looks like

$$Y_t = A_t K_t^{\alpha} L_t^{(1-\alpha)}$$

Where α is a constant defining how relatively important labour and capital are. $0 < \alpha < 1$. The function generally assumes the marginal products of labour and capital are positive, and that they are decreasing. Equivalently this states that their first derivatives are positive and second derivatives are negative.

Another assumption is that the function has a constant return to scale, i.e.

$$f(K, L) = Y \Rightarrow f(xK, xL) = xY$$

This has some useful implications

$$\frac{Y_t}{L_t} = \frac{f(K_t, L_t)}{L_t} = f\left(\frac{K_t}{L_t}, 1\right)$$

This tells use that output per worker depends on capital per worker but not on the size of the economy. In the Cobb-Douglas function we find that

$$Y_t = A_t K_t^{\alpha} L_t^{(1-\alpha)} \Rightarrow \frac{Y_t}{L_t} = A_t K_t^{\alpha} L_t^{-a} = A_t \left(\frac{K_t}{L_t}\right)^{\alpha}$$

Once again, it is evident that the size of output per capita is dependent on capital to worker ratio. If we plot output per worker against capital per worker, the curve will have an increase value with a decreasing slope.

Solow-Swan Model

The Solow-Swan model examines the relationship between variables like output per capita, savings rate, population growth and productivity. It highlights the importance of productivity growth for living standards.

The model begins with an initial capital stock K_0 and a level of labour L_0 and attempts to describe how these values change over time. To explain this it makes assumptions with respect to the production function and behaviour of households within the economy.

The model uses the aggregate production function approach of

$$Y_t = Af(K_t L_t)$$

Where A is *total factor productivity* a coefficient describing the overall productivity due to factors like technology and regulations. This displays the behaviour previously highlighted; positive first derivative and negative second derivative, in a addition to constant returns to scale.

The model describes a capital accumulation function of

$$K_{t+1} = (1-d)K_t + I_t$$

Where d is the depreciation rate and I_t is the amount invested in period t. Finally, the model uses a labour growth model with a function

$$L_{t+1} = (1+n)L_t$$

Where n is the growth rate of labour. The model assumes a constant saving rate given by θ, the marginal propensity for saving. This means that c, the marginal propensity for consumption is given by $1-\theta$. It additionally assumes full employment of capital and labour. It finally assumes that saving is equal to investment, that is

$$\theta Y_t = I_t$$

If we take our equation for capital growth and divide through by labour force, we can find the growth in capital per labour.

$$K_{t+1} = (1-d)K_t + I_t$$

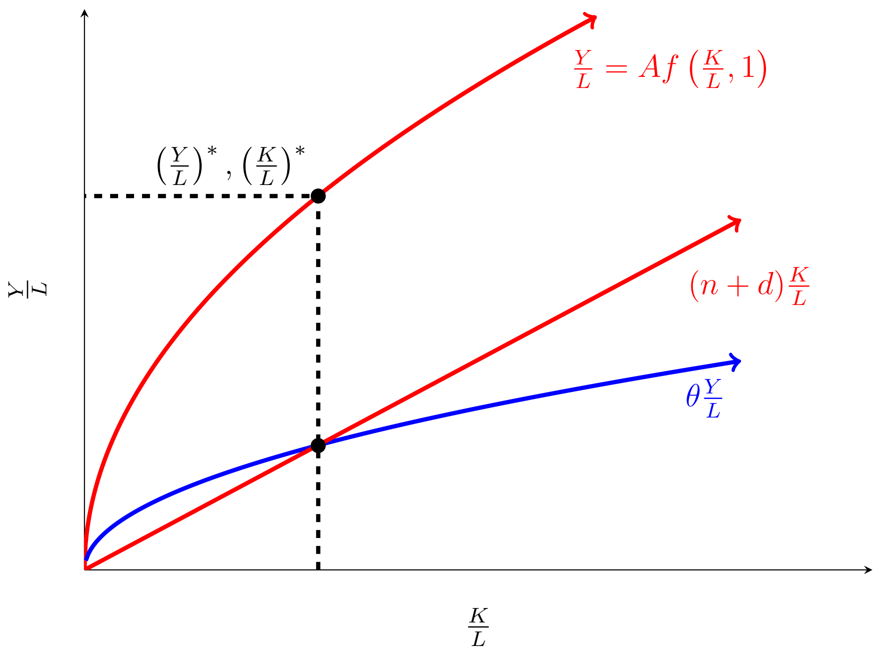
$$\frac{K_{t+1}}{L_{t+1}} = \frac{(1-d)K_t + I_t}{L_{t+1}} = \frac{(1-d)K_t + \theta Y_t}{(1+n)L_t} = \frac{1-d}{1+n}\frac{K_t}{L_t} + \frac{\theta}{1+n}\frac{Y_t}{L_t}$$

$$\Rightarrow \Delta\frac{K_t}{L_t} = \frac{K_t+1}{L_t+1} - \frac{K_t}{L_t} = \left(\frac{1-d}{1+n} - 1\right)\frac{K_t}{L_t} + \frac{\theta}{1+n}\frac{Y_t}{L_t}$$

If we observe that n is generally quite small, being the population growth rate, then $1+n \approx n$ means that we can rewrite the above as

$$\Delta\frac{K_t}{L_t} = \theta\frac{Y_t}{L_t} - (d+n)\frac{K_t}{L_t}$$

Where the left term on the right side is savings per worker, and the right term is *replacement investment*. This replacement investment is the amount of investment required to keep the capital to labour ratio a constant. The Solow-Swan model looks for a situation where this change in the capital to labour ratio is 0.



By plotting replacement investment, saving per working and output per worker we can find the equilibrium outcome of this system. At the intersection of saving per worker and replacement investment we find the equilibrium level of capital per worker. A the same capital per worker value, we find the equilibrium level of output per worker. The output per worker level of the equilibrium point is the level of savings per worker, while the distance between the two marked points is the level of consumption per worker.

In the case that savings per worker is more than replacement investment (i.e. a point on the savings curve left of the equilibrium), quantity of capital will increase, resulting in a shift into equilibrium. In the case that it is less than replacement (i.e. to the right of equilibrium), level of capital per worker will decrease to equilibrium.

We can use this plot to perform comparative statics; for instance we can see that an increase in the saving rate θ will effect a shift up in the saving curve resulting in a higher level of capital to labour and a higher level of output per worker.

Implications

We have seen that the Solow-Swan model implies a steady-state level of capital per worker, which the economy will tend to return to. It also implies that output per worker depends upon capital per worker.

We can use the model iteratively to determine values for capital per worker, output per worker and consumption per worker to describe the economy at each point of time.

The implication of the steady state of the system implies that for output per worker to change, some exogenous factor like θ, A etc must change. Holding these other variables equal, this implies that the rate of growth of output is dependent simply on rate of growth of labour $(Y' = n)$.

The model can be extended by including growth in productivity and output per worker, which explains how countries can grow richer. The current model only shows us that capital per labour is less a driver of increased welfare than is productivity growth.

Empirics of Economic Growth

The Solow-Swan model suggested that an economy tends toward a steady-state capital to labour ratio, and indicated that long run growth occurs due to growth in productivity.

Convergence

Convergence is the idea that countries might become more similar over time. Absolute convergence suggests that all economies should converge to be more like each other; in some way, this is a test of the Solow-Swan model; countries with similar characteristics should tend to similarity.

It suggests an inverse relationship between output per worker and growth rate in similar countries. Statistics from the real world do not support this outcome; either because the model does not reflect the world very well, or because countries are not in reality similar in the real world.

This leads to the conditional convergence hypothesis; that all economies should converge to some value, while similar countries should converge to roughly the same value. When restricting the hypothesis in this way, such as by looking at "open economies", there is more support for it.

Growth Accounting

Growth accounting is a way of splitting output growth into productivity, capital stock, and labour growth. It is useful because it allows us to gain insight into what is driving output growth in an economy. It doesn't necessary account for what is driving these factors; e.g. if an institution has effected some regulation resulting in improved productivity or some technology has done so.

We begin this analysis with the production function

$$Y_t = A_t f(K_t, L_t)$$

We then take the logarithm of each size, and then differentiate with respect to time this equation.

$$\log(Y_t) = \log(A_t) + \log(f(K_t, L_t))$$

$$\frac{1}{Y}\frac{\mathrm{d}Y}{\mathrm{d}t} = \frac{1}{A}\frac{\mathrm{d}A}{\mathrm{d}t} + \frac{1}{f(K,L)}\frac{\mathrm{d}f(K,L)}{\mathrm{d}K}\frac{\mathrm{d}K}{\mathrm{d}t} + \frac{1}{f(K,L)}\frac{\mathrm{d}f(K,L)}{\mathrm{d}L}\frac{\mathrm{d}L}{\mathrm{d}t}$$

Here, the terms from left to right are the growth rate of output, the growth rate of productivity, with the last two terms representing the growth rate of capital with respect to labour and the growth rate of labour with respect to capital. In general,

$$\frac{1}{z(t)}\frac{\mathrm{d}z}{\mathrm{d}t} = \hat{z}$$

Where $\hat{z}$ is the growth rate of z (growth with respect to time). Using this, and some other manipulations of our original equations we can rearrange to find the equation

$$\hat{Y} = \hat{A} + \frac{rK}{Af(K,L)}\hat{K} + \frac{wL}{Af(K,L)}\hat{L}$$

To do this, we multiply the two labour and capital terms by $\frac{A}{A}$ and use the expressions for the value of w and r in a competitive market given by the marginal products of labour and capital

$$w = A\frac{\mathrm{d}f}{\mathrm{d}L} \quad r = A\frac{\mathrm{d}f}{\mathrm{d}k}$$

to replace the relevant terms.

We then use the equation $Y = wL + rK$, divided through by Y $(= Af(K, L))$ to understand $\frac{wL}{Y}$ as the labour share of output and $\frac{rK}{Y}$ as the capital share of output.

We can then understand the above equation as stating that the growth rate of output $\hat{Y}$ is given by the growth rate of productivity $\hat{A}$ multiplied by the capital share, multiplied by growth rate of capita $\hat{K}$ multiplied by labour share, multiplied by growth rate of labour, $\hat{L}$.

Given that we have access to data on output Y and output growth $\hat{Y}$, including labour share and capital share, interest rates r and capital stock K, wages w, employment L and employment growth $\hat{L}$, and investment (which implies) $\hat{K}$, there is only one unknown $\hat{A}$, sometimes known as the Solow residual. Thus, this equation is useful for finding growth in total factor productivity in an economy.

Essentially, the equation says all growth in an economy not due to increases in capital or labour are due to increases in productivity, due to technology, regulation, etc.

One can calculate using margin of error to avoid bias in the estimate of productivity growth.

Applications

An application of these principles was in the study of the East Asian Tigers; successful East Asian countries undergoing rapid growth. Much of the success of these countries could be attributed to increases in capital stock and labour, with less influence from increases in total factor productivity. The high saving rates motivated by government policy effected high rates of growth in capital stock resulting in rapid economic growth.

An idea that arises from this result is that increases in savings, while motivating increases in output per worker in the short term, has long-term implications that are less favourable.