Part 1: Short-run Macroeconomics

1.1 The Goods Market

Composition of GDP
- Consumption: purchases of goods and services, including durable and non-durable goods
- Note that the most durable forms of consumption goods, such as white goods, sort of morph into the category of investment
- Investment: purchases of capital goods, distinguished between residential and non-residential investment
- Government: purchases of goods and services, whether they are investment or consumption; note that this does not include transfer payments
- Net exports: exports minus imports
- Note that there will be inventory accumulation if production > sales. Generally treated as a form of investment; we will ignore this, as it is generally small
- Total demand for goods Z written: \( Z = C + I + G + X - IM \)

The Linear Model
- Key behavioural assumption in short-run macroeconomics: \( C \) is simple (linear) function of aggregate disposable income \( Y_D \): \( C = c_0 + c_1 Y_D \)
- Slope parameter \( c_1 \) is the key, referring to the marginal propensity to consume (MPC)
- Note that this model is only a simplification; it gives positive consumption even with an income as zero, even though this makes no sense
- The simplified linear relationship is useful only as an approximation over a certain range for the economy as a whole, and will not apply for all individuals or all ranges of GDP

The Multiplier
- To calculate the GDP, we need to solve:

\[
Y = C + I + G \\
= [(C_0 + C_1)Y - T] + I + G \\
= \frac{1}{1 - c_1}(c_0 - c_1T + I + G)
\]

- Because \( \frac{dY}{dG} = \frac{1}{1 - c_1} \), GDP increases by more than the size of government spending, and so there is a multiplier effect
- The multiplier represents the marginal effect of a change in autonomous spending on output
- Note that in the US at the moment, it is thought that the multiplier is around 1.1-1.2
- The larger the multiplier, the more sensitive consumption is to income

Savings Approach to Equilibrium
- Another approach to the macroeconomic equilibrium is that investment must be equal to savings
- Investment is private savings \( S \) plus public savings \( T - G \)
Private savings is disposable income less consumption $S = Y_D - C$

Public saving is excess tax revenue $T$ over government spending $G$

The point of this analysis is to realise that consumption and savings decisions are one and the same thing

This gives rise to name “IS curve” for equilibrium in the goods market (investment = savings)

The Paradox of Thrift

- This arises essentially because the level of saving depends upon both the level of income and the size of the marginal propensity to save/consume, 62
- Consumers can increase the marginal propensity to save, but in doing so they reduce consumption spending, hence reducing income and reducing saving by as much as they tried to increase it in the first place, 62
- The reason for this is essentially the assumption that investment is exogenous (fixed), and does not change in response to consumer attempts to save more, 62
- As such, all ‘excess savings’ can only be eliminated by reducing income, 62

1.2 Financial Markets

Basic Terminology

- Financial wealth is the value of financial assets minus financial liabilities
- Wealth is a stock variable, i.e., measured at a given point in time
- Money is simply those financial assets that can be used directly to buy goods and services
- Note that money includes currency and direct deposits but not credit cards, as these are unsecured loans
- In economics, investment is purchase of new capital goods, machines, plants, buildings etc
- The purchase of shares of stock or other financial assets is called financial investment

Determinants of Money Demand

- Money $M$ pays no interest, but can be freely used for transactions (includes currency and direct bank deposits), which are proportional to nominal income $Y$
- Bonds $B$ pay interest, but cannot be used for transactions (by ordinary persons; large financial institutions can use them for transactions)
- Demand for $M$ and $B$ thus depend on transactions and the nominal interest rate
- The demand for money is inversely related to the interest rate $i$, as this represents the opportunity cost of holding money
- This is represented by $M^d = PY \times L(i)$, where $L(i)$ is a function describing the negative relationship between the demand for money and the interest rate
- Equilibrium in the money market will thus occur when $M^s = M^d = PYL(i)$

The Supply of Money

- The supply of central bank money is set directly by the central bank, with the interest rate occurring such that these supply and demand are equal, 80
- In reality, the central bank normally sets the interest rate and then supplies the amount of money demanded at this price, 80
- It generally does this via open market operations, usually the buying and selling of government bonds, 77
Open Market Operations

- Assets of Reserve Bank are its bond holdings
- Its liabilities are money stock issued (more on this in a minute)
- The Reserve Bank changes money supply by “open market operations”
- Expansionary operations involve buying bonds with money, M increases, i falls
- Expansionary operations involve selling bonds for money, M falls, i rises
- Note that in these open market operations the liabilities and assets of the Reserve Bank always increase and decrease by the same amount
- For example, the RBA creates an additional $1 million in money (liabilities), and then uses this to purchase an additional $1 million of assets (bonds)

Banks and Reserves

- The assets of a bank are its reserves (both in cash and held on accounts), bonds that it owns, and loans that it has made, 78
- The liabilities of a bank are its current account deposits, representing money they have borrowed from others, 78
- Note that for the central bank, its liabilities are the currency that it has issued and is held by either banks or the public, 79
- Banks keep as reserves some funds they have received in order to meet depositors’ withdrawals, meet obligations to other banks, and because of legal reserve requirements
- Reserve Bank liabilities are the money it has issued, called central bank money or high-powered money, and is held as currency by the public and as reserves by banks
- When these reserves are increased by the RBA, banks will increase the amount of money that they lend out, thereby creating more money
- From this analysis, it can be understood that the key reason that banks are of such great interest in studying the macroeconomy is because their liabilities are used as money by writing of checks and use of EFTPOS, 78

Interbank Market and the Cash Rate

- Banks generally like to keep their reserves as low as possible, as they bear very little interest
- As a result, there is an interbank market for bank reserves
- In equilibrium, demand for reserves must equal supply of reserves
- The interest rate determined in this market is called the cash rate
- By varying the amount of high-powered money each day, the Reserve Bank can set the cash rate that it wants

Interest Rates and Monetary Policy

- Note that the money supply controlled by the Reserve is not the same as the M in the IS-LM model
- The RBA only sets the reserves of high-powered reserve money, which in turn (generally) leads to changes in the broader money supply as a result of banks lending out these reserves
- Until now we assumed that the Reserve Bank chooses the money supply, though more usually monetary policy involves interest-rate setting, and then accommodating the demand of money so that this interest rate remained stable
- One reason for this is that it is very difficult for the central bank to target something so complex as the broader money supply, just as if it tried to target the thirty year mortgage interest rate rather than the overnight cash rate
Another reason for this is that interest rates are better understood in the public than money aggregates, and so this policy is more transparent.

Note that as a result of the dynamic interactions between fiscal and monetary policy, a lack of change in fiscal and monetary policy in response to some other exogenous change is not neutral, but itself represents an important decision.

The Cash Rate and Monetary Policy

Thus, the interbank overnight interest rate is not really itself the monetary policy of the bank, just an indication of what that monetary policy will be (e.g. expansionary or contractionary), 82-84.

The real monetary policy occurs as the central bank creates or retires money in the process of buying or selling bonds to and from banks in order to keep the overnight cash market interest rate at their desired level, 82-84.

Note that the effects of monetary policy will be multiplied by the money multiplier resulting from fractional reserve banking, 85.

1.3 The IS-LM Model

The Purpose of the Model

The major improvement of this model is that it incorporates the effect of changes in the interest rate on the demand for goods, particularly investment.

In this model, investment is endogenous, taken to depend on the interest rate and the level of income.

Making Investment Endogenous

So far, investment has been exogenous (taken as given).

In reality, investment depends positively on income (or the level of output), as firms facing high levels of demand will need to invest in additional productive capacity.

Investment also depends negatively on interest rates, as the higher the interest rate for a given return on investment, the less attractive will be that investment.

The IS Curve

The IS curve maps out the points of equilibrium between interest rates and output, where a given interest rate corresponds to a particular level of expenditure, and hence a particular level of output.

The IS curve slopes downwards because an increase in interest rates leads to an increase in the opportunity cost of investment, thereby leading to a fall in I.

This has a direct effect of reducing demand by reducing investment.

This in turn triggers a fall in income Y, fall in consumption C, multiplier effect.

Shifts in the IS curve occur whenever spending increases or decreases without a change in the interest rate, which could be driven by factors such as changes in consumer confidence.

The IS curve drawn for a given fiscal policy G, T; thus, changes in G or T will shift whole IS curve.

The LM Curve

The LM curve marks out the points of equilibrium in financial markets when money demand equals money supply, and the corresponding levels of Y and i that generate this equilibrium.

The LM curve slopes upwards because for a given money supply and price level, an increase in output will lead to an increase in the demand for money.
• Because by definition M and P are fixed, this must be offset by an equivalent reduction in the demand for money that comes as a result of higher interest rates
• The LM curve is drawn for given monetary policy M and price level P, so changes in M or P will shift the whole LM curve

General Equilibrium
• At general equilibrium, both the IS and LM relations must hold, which means that equilibrium occurs when the two curves intersect
• Points above the IS curve represents points of excess supply of goods relative to demand, whereas points below the IS curve represent points where there is a shortage of goods relative to demand
• Points above the LM curve represent points of excess supply of money, and visa-versa for under the LM curve
• This model is a static model, so says nothing about the amount of time it takes for adjustment to take

Fiscal Policy
• Fiscal contraction can occur through a decrease in G and/or an increase in T – tends to reduce budget deficit
• Fiscal expansion occurs through an increase in G and/or decrease in T – tends to reduce increase deficit
• Note that fiscal policy has no direct effect on the LM curve, only indirect effects through changes in output and interest rates
• Expansionary policies increase total expenditure and hence output, thereby shifting the IS curve to the right
• Contractionary policies reduce total expenditure and so shift the IS curve to the left
• The effectiveness of fiscal policy depends upon the slope of the LM curve, as this slope reflects the sensitivity of the interest rate to changes in GDP, and in turn the sensitivity of investment upon changes in the interest rate
• Investment may increase or decrease in response to fiscal policy, depending upon the sensitivity of investment to output and interest rates

Monetary Policy
• An expansionary monetary policy increases the supply of money, and so causes the LM curve to shift down, as a lower interest rate will prevail for the increased money supply
• However, this reduction in the interest rate will increase investment, hence increasing output and leading to an increase in y, and a resulting partial increase in i once again
• In this situation, the position of the IS curve is unchanged, but there will be movement along the IS curve
• Also, in the case of monetary policy, we know that investment will increase, as the interest rate is falling and income/output is increasing

Using a Policy Mix
• The combination of monetary and fiscal policies is known as the monetary-fiscal mix, or the policy mix
• Often interesting effects can occur if fiscal and monetary policy are combined in different and interesting ways
• For example, fiscal and monetary policies tend to have opposing effects on the interest rate
• As such, it should theoretically be possible to use them both together to alter output without changing interest rates

The Empirical Evidence
• Obviously it will take some time for consumers and businesses to react to changes in monetary and fiscal policy, and time for effects to be felt throughout the economy, 113
• Econometric evidence from the US suggests that changes in the federal funds rate do not have any effect at all on the economy for several months at least, and do not have their full effect for about two years, 113
• This evidence also suggests that the price level does indeed not change very much in the short run, taking up to a year and a half to change in response to monetary policy, 114
• Overall the data is consistent with the predictions of the IS-LM model, 113-114

How Powerful is Fiscal Policy?
• One problem is that it is very difficult to estimate what the marginal propensity to consume actually is
• You can’t just run econometric regressions to work this out, as normally the government spending is driven by the state of the business cycle
• What we need is a natural experiment where government changes in spending are driven by factors aside from the business cycle, like a major war
• The trouble with this is that such experiments are rare, and anyway are often unusual situations which may be somewhat unique (e.g. WWII)
• Another approach would be to try to build more detailed models of government spending, but this introduces new assumptions that are open to criticism

1.4 Origins of the Financial Crisis

Overview of the Crisis
• Beginning around late 2006, the prices of houses throughout the US began to decline, leading to mortgage defaults and delinquencies
• Losses on mortgages and related assets caused financial institutions’ balance sheets to deteriorate
• Falling prices of assets leads to the need to sell some assets, which in turn leads to further declines of asset prices – this process is called deleveraging
• Interbank lending froze up, and led to modern runs on financial institutions
• Stock markets crashed, and the financial crisis spilled over to “real” economy

Historical Background
• Low interest rates in mid 2000s owing to lose money policy and large capital inflows into the US from China
• Complacency about risk due to the “great moderation” of inflation and unemployment
• Trends in banking contribute to the extent of the lending boom
• (i) innovation in securitization and structured finance, demand for highly-rated products increased demands for assets that can be pooled, reduced costs for borrowers
• (ii) greater levels of maturity mismatch
• In short, lending standards deteriorate

Traditional Banking
• The bank accepts deposits, pools them together, and loans them out
• These loans were typically left on the balance sheets of the bank and retained as assets
• The bank retained all the benefits and risks of these loans, and so were highly incentivised to carefully monitor these loans

Modern Banking
• Based on the ‘originate and distribute’ principle, whereby the activity of distributing mortgages was outsourced to a separate company, who then sold it back to a bank
• The trouble with this was that it is very difficult to sell mortgages in a market, as each is unique to the individual who owes it, the area of the house, etc
• One method to get around this was to pool a number of these mortgages together into instruments called collateralized debt obligations
• These CDOs were bonds that were backed by the stream of mortgage payments made from the loans of which they were comprised
• Typically they would be created by one company, who received interest payments from the banks, took a fee, and then returned the remaining earnings to investors who owned the CDO bonds

Credit Default Swaps
• Another related development was the rise of credit default swaps
• These were basically like insurance taken out on CDOs
• They were not quite like regular insurance, however, as the buyer need not have a direct interest in the thing being insured, thereby providing scope for a much greater volume of trade

Securitization
• Pass-through securitization is where ever bond holder has an equal claim upon repayments
• The main advantage of this was to reduce risk through diversification and increase the ease with which these things could be traded
• Around the late 1990s, the new development of this was the development of a capital structure for these CDOs, i.e., prioritization of claims to cash flows

Structured Finance
• Begin with a diversified portfolio of underlying assets
• Then slice up these assets into a prioritized capital structure of claims to cash flows, called tranches (French for slices)
• Super senior tranche – least risky, with the first claim to payments
• Mezzanine tranche – intermediate
• Junior or equity tranche – most risky, with the last claim to payments
• Last, sell different tranches to investors with different risk appetites (e.g., pension funds vs. hedge funds)

Layers of Securitization
• It was then realised that it was not necessary to stop at one round of securitization
• To do this, bundles of pools from the same tranche were constructed to create what were called CDO-squared or CMOs
• The creation of these involved a certain interaction with the ratings agencies
• This phenomenon was known as rating at the edge, where CDO-squared instruments were structured such that they just made the cutoffs to ensure particular credit ratings
• Outright collusion with rating agencies is and was illegal, but it was not illegal for the rating agencies to release their rating software and methodologies and then for these to be used by those bundling financial assets to rate on the edge
• In principle, risk shifted to those who want it and spread among many investors

Maturity Mismatch
• Traditional banking involves short-term liquid liabilities (deposits), coupled with long-term illiquid assets (loans and mortgages)
• This kind of banking was exposed to bank runs if there was no deposit insurance
• In more recent decades, however, banks (in effort to make higher profits) turned to new and innovative ways of effectively re-creating the potential for such a maturity mismatch
• This involved banks borrowing money on very short term loans, in a process called repo finance
• Repo finance involves the bank pledging to give assets to some other institution in exchange for a short-term loan
• These assets would then be transferred to the creditor in the event of non-repayment
• The difference between the value of the loan and the value of the pledged assets was known as a ‘haircut’, and was generally very small
• As a result, a large fraction of funding needed to be rolled-over every day, thereby exposing banks to the risk that they would not be able to obtain these funds when needed
• If creditors perceive a greater risk of repayment, then the haircut would increase, thereby preventing banks from borrowing as much money as they otherwise would, as they only have a limited number of assets they could pledge

Problems
• Many of the aforementioned transactions actually took place through shell corporations created by banks called special purpose vehicles, which enabled the banks to avoid various banking regulations and allow them to carry more debt
• The trouble was that the risk of default was correlated across mortgages (even from different parts of the country) more than was fully taken into account
• As such, each tranche was riskier than thought
• This was of course exacerbated by rating at the edge problem
• The overall result of these processes was that lending standards deteriorated
• The huge demand for mortgage bundles led to the rise of subprime mortgages to feed this demand
• Another factor in this deterioration of mortgage standards was the rise of financial intermediary institutions, which divorced the ownership from creation of mortgages, and hence made monitoring less effective

Timeline of the Crisis
• Trouble began brewing by late 2006
• Feb 2007 subprime mortgage crisis breaks - first significant spike in subprime defaults
• May–June 2007 ratings downgrades and reviews, and many tranches of subprime mortgages downgraded, causing prices to fall
• July 2007 first banks begin to fail, and investors become unwilling to hold loans collateralized by mortgage products
• August 2007 saw the first substantial declines in the perceived safety of even the highest rated mortgage backed security products
1.6 Policy Responses to the Crisis

Amplifying Mechanisms
- The typical estimate of lost wealth in US mortgage market meltdown is $200 billion
- But the US GDP is about $12,000 billion per year
- The question then is, how did this relatively small shock loss cause so much turmoil?
- The answer is that the internal workings of the financial system amplified the initial shock into a larger response – in particular, leverage is a powerful amplification mechanism

Leverage
- Leverage is defined by: leverage = your total assets / your total equity
- Leverage magnifies risk and return to owners
- For example, in a good year, if a $500k house appreciates by $50k, the return on investment = \( \frac{550 - 500}{500} = 0.10 \) or 10%
- However, because of leverage, the return on the homeowner’s equity will be \( \frac{150 - 100}{100} = 0.50 \) or 50%
- Conversely, in a bad year, if the house price depreciates by $50k, the return on investment is given by \( \frac{450 - 500}{500} = -0.10 \), while the loss of equity is given by \( \frac{50 - 100}{100} = -0.50 \)
- The more levered you are, the easier it is for falling house prices to bankrupt you
- The institutions will still have plenty of assets, but they also have about as many liabilities, so their solvency is in question

Bank Runs
- When institutions get into this position, they become very reluctant to lend money, but tend to it on whatever cash they have
- In the 1930s, a bank in such a position would be exposed to a bank run
- In the more recent crisis, the bank run took the form of creditors being less willing to roll over short-term credit, either because they want higher class assets as collateral, higher interest rates, or something similar
- Note that these banks may still be in a position to meet all their creditors, but if most of their assets are locked up on forms that are hard to sell or will greatly fall in price if sold all at once; thus ‘fire-sales’ can be very problematic

Leverage Cycles
- Asset prices increase. Net equity increases. To maintain constant leverage ratio, increase debt to match (balance sheet expands). Debt used to buy assets. Asset prices increase even more. Etc
- Asset prices fall. Net equity falls. To maintain constant leverage ratio, reduce debt to match (balance sheet contracts). Retire debt by selling assets. Asset prices fall even more. Etc

Fed Reserve Assets Before Crisis
- Consists mostly of securities held outright; are exclusively US Treasury bonds
- In addition, repo agreements are used to adjust the level of bank reserves
- Trades occur only with “primary dealers” (19 of them in July 2007)
- However, at the beginning of the crisis there was practically no direct loans to banks
- They also have some gold and foreign exchange reserves

Federal Balance Sheet Management
- There are two methods of balance sheet management: size and composition
• The size of the balance sheet is a policy choice
  – can create liabilities to purchase assets at will
  – changes in bank reserves determines level of interest rates
• Composition of assets and liabilities is also a policy choice
  – changes in composition determine interest rate spreads
• At first Fed response mostly consisted of (2), but turned to (1) after Lehman Brothers went bankrupt in Sept 2008

The Funds Rate
• Funds rate is the interest rate in the overnight market for excess bank reserves at the Fed
• In open market operations, Fed buys and sells securities to keep the fed funds rate at target
• These transactions are only carried out with the 19 primary dealers
• They are only conducted with the highest quality assets (fed bonds)
• These operations can be temporary [repo agreements] or permanent [outright] operations
• The reason for restricting this to primary dealers was simply for means of convenience and technical expertise, and it was expected that the primary dealers would almost immediately make subsidiary transactions with ordinary commercial banks

The Discount Rate
• The discount rate is the interest rate on a direct loan from Fed, set at premium above target fed funds rate
• These are available to any commercial bank, except for the primary dealers
• A much broader range of collateral is accepted, and the Fed will basically just take the bank’s word for it as to how much this is worth, and grant them the loan
• Before the crisis, this mechanism was rarely used, as it was an indicator that a bank was in trouble

Unconventional Monetary Policy Tools
• These began to be used basically because normal monetary policy was not working, as the banks were not passing on extra cash onto other banks
• Term Auction Facility (TAF): Allowed commercial banks to obtain discount window loans anonymously via auction, with a broad range of collateral accepted
• Term Securities Lending Facility (TSLF): Allowed dealers to borrow high-grade Treasury securities to ensure transactions (with other banks) occur. The securities were lent for up to 28 days, much longer than usual, with a broad range of collateral accepted. This was essentially a mechanism for banks to shift toxic assets to the Fed in exchange for higher quality treasury bonds
• Primary Dealer Credit Facility (PDCF): Effectively allowed dealers to borrow from the discount window, with a broad range of collateral accepted

Fiscal Policy Responses
• First was the Troubled Asset Relief Program (TARP)
• This was a fund to allow the US Treasury to buy “troubled” or “toxic” assets, i.e., illiquid difficult-to-value assets
• This was effectively a massive bailout of the banking system
• There were also increases in government purchases G and decreases in net taxation T to increase aggregate demand
Part 2: The AS-AD Model

2.1 Labour Markets

Overview of the Labour Force

- An airport can be crowded either because there is much busy throughput of traffic, or because there are a large number of delayed flights and waiting passengers, 124
- Similarly, a high unemployment rate may either reflect a highly dynamic workforce, or a large stagnant pool of unemployed, 124
- Distinguishing between these two possibilities requires the assistance of the monthly Labour Force Survey statistics about the state and movement of workers, 125
- The survey is conducted every month with a national sample of 60,000 people, who are each in the sample for a period of eight months, 125
- During normal periods, the rate of job turnover is large, about 5% of the total workforce per month, with about 70% of these being voluntary quits, 126
- The unemployment pool is also very dynamic, with a 50% turnover rate per month, 126
- Long-term unemployment (12 months or more) tends to follow the trend of the overall unemployment rate with a one-year lag, and is about 20% for Australia and 30% in the EU
- These figures are obtained from the Labour Force Survey, and are based on a monthly survey of 42,000 households and businesses

Wage Terminology

- Reservation wages: the wage that makes worker indifferent between working or being unemployed. Actual wages are higher than reservation wages
- The longer worker training takes and the more difficult it is, the more will it be in the interest of firms to keep the turnover rate down by offering above-reservation wages
- Labour market conditions: wages depend on labour market conditions, e.g., lower when unemployment is high, demand and supply for labour
- Efficiency wages: wage policies that link productivity/efficiency of workers to their wages and conditions (e.g. keep a good team together, raise morale, etc)
- Collective bargaining: occurs between individual firms or whole groups of firms (sectors) and trade unions, and is responsible for about 40% of all wage setting
- Awards: legally enforceable remuneration decisions by federal or state industry tribunals (and involving unions and employers) which account for about 20% of all wage-setting

Movements in Unemployment

- Unemployment increases rapidly during a recession (though usually with a lag), and then slowly declines afterwards, 128-129
- Firms usually prefer to cease hiring and rely on quits and retirements to reduce staffing levels before firing any workers, 129
- As such, rates of unemployed workers finding jobs are much lower in times of recession than in booms, 129-130
Wage Determination

- The wage setting relation is given by: $W = P^e f(u, z)$, where $W$ is the nominal wage and $z$ refers to all other factors that affect wages.
- $P^e$: wages depend on expected prices because price level because if prices are expected to double, workers will demand a doubling of nominal wages, while employers will be willing to pay up to twice as much as before.
- $u$: A higher unemployment rate means that worker’s have less bargaining power, and hence will receive lower wages.
- $z$: Higher unemployment insurance will tend to increase wages, as workers must be given a higher incentive to remain employed; this would operate through an increase in $z$.

Price Determination

- Assume that production only depends upon the number $n$ of workers, GDP per worker is $Y$, and the markup of prices above marginal cost by firms is given by $\mu$.

$$
\begin{align*}
YN &= Wn \\
\frac{dY}{dn} &= W = MC \\
P &= (1 + \mu)W \\
1 &= \frac{(1 + \mu)W}{P} \\
W &= \frac{1}{P} \\
\frac{W}{P} &= \frac{1}{(1 + \mu)}
\end{align*}
$$

- The intuition behind this result is simple: if firms have more market power, they raise prices while keeping wages constant, thereby lowering real wages.
- If markets are perfectly competitive, then price = marginal cost ($\mu = 0, P = W$).
- The markup $\mu$ measures extent of imperfect competition in goods markets.
- In the real world, the markup is usually two percent or so for homogenous goods, and up to forty percent for highly differentiated goods (e.g. cars).

The Natural Rate of Unemployment

- As both the price-setting and wage-setting relations must simultaneously be satisfied, we can determine that the equilibrium will occur when $f(u_n, z) = \frac{1}{(1+\mu)}$.
- The equilibrium rate of unemployment that satisfies this relationship is known as the natural rate of unemployment.
- Actual unemployment rate $u$ fluctuates around $u_n$ because of business cycle conditions.
- The PS and WS curves can be plotted on a standard graph, with $W/P$ on the $y$-axis and $u$ on the $x$-axis.
- Using this mode, we find that an increase in unemployment benefits (affecting $z$) would increase the wage workers demand at a given level of unemployment, thus shifting the wage-setting curve upward.
- However, because the amount firms are willing to pay has not changed, this must be offset by an increase in the rate of unemployment, so overall real wages stay the same.
- Similarly, an increase in the markup will result in a downward shift of the price-setting relation curve, thereby necessitating an increase in unemployment in order to induce workers to accept the resultant lower real wages.
Tax Distortions and Unemployment

- Think of the PS curve as the maximum real wages that firms are willing to pay (after tax) – this is determined by marginal product and so is independent of unemployment
- The WS curve can be thought of as the minimum after-tax real wages that workers (or more accurately unions and other wage setters) are willing to accept - this declines with higher unemployment rates
- A tax on worker income will cause them to bid for higher wages, thereby shifting the WS curve to the right
- Similarly, a tax on employers per worker they employ will reduce the real wages they are willing to pay (after tax), shifting the PS curve down
- The combination of these factors means that higher taxes reduce real wages and raise the natural rate of unemployment

2.2 The Static AS-AD Model

Aggregate Supply

- One important thing to note is that in this model we do not enforce the assumption (made earlier) that prices are always equal to expected prices, 149
- The aggregate supply relation captures the effects of output on the price level, and is given by:
  \[ P = P^e(1 + \mu) f \left( 1 - \frac{Y}{L}, z \right) \]
- This means that a higher level of output tends to lead to an increase in the price level, and visa-versa, 150
- This arises because (assuming worker productivity is constant) a rise in output will be synonymous with a rise in employment, and hence a fall in unemployment, 150
- This in turn means that workers will have more bargaining power, and so wages will be bid up, thereby increasing costs and hence prices, 150
- Note that this will also occur for other inputs like the price of capital and natural resources

Slope of the AS Curve

- The AS curve slopes upward essentially because of the assumption of diminishing marginal productivity of labour (and capital and other things, but particularly labour)
- Higher levels of output thus lead to higher marginal costs (holding technology constant), and hence firms set higher prices
- Looking at it another way, as unemployment falls, the supply of (available) labour declines relative to demand
- Assuming that the supply of labour is perfectly inelastic, the only reason why this would lead to an increase in the price of labour (wages) is because of the downward sloping demand curve for labour
- This downward sloping demand curve for labour, in turn, is exactly the same thing as declining marginal productivity of labour!

Shifts in the AS Curve

- An increase in the expected price level is represented by an upward shift of the AS curve
- Output will only ever be equal to the natural rate of output when \( P = P^e \), although this can occur at any given value of \( P \)
- Note that when out of equilibrium, any initial increase in price expectations will feed back into a still higher price level in accordance with the equation \( P = (1 + \mu)P^e f(u, z) \)
Thus, it will take several iterations of ‘ratcheting’ in order to reach a new equilibrium

**Aggregate Demand**
- The aggregate demand relation captures the effect of the price level on output, 152
- More specifically, it marks out the equilibrium points that occur between the IS and the LM curve as the price level \( P \) is varied, 152
- In essence, higher prices translate into a lower real money stock, which in turn increases interest rates and therefore reduces spending, and thus giving the AD curve its downward slope
- Any variable other than price that shifts either the IS or LM curves will also shift aggregate demand, 152
- A tightening of monetary policy, for example, will lead to a leftward shift of the AD curve, 154

**Slope of the AD Curve**
- The AD curve is downward sloping because changes in prices lead to changes in the real money stock \( M \)
- This in turn leads to changes in the interest rate, and hence changes in investment spending that flow through into changes in \( Y \)
- Note that the increase in \( M \) is what really leads to the greater levels of investment – the reduction in the interest rate is really just the intermediate mechanism through which it operates
- Changes in monetary or fiscal policy – any variable that shifts the IS or LM curve, other than \( P \) – shift the AD curve

**Short-Run Equilibrium**
- In the short run, the equilibrium is found by first drawing in the AS curve for a particular given value of expected prices, 156
- The AD curve is then drawn in for given values of \( G, T, P^T \) and \( i_n \), 156
- The short-run equilibrium is given by the intersection of the two curves, and marks the point where good, financial and labour markets are all in equilibrium, 156
- In the medium run, however, the AS curve will shift up (caused by changing inflationary expectations) until the equilibrium occurs at the natural rate of output, 157-158
- Note that expected prices are always at the level where the current AS curve intersects the natural rate of output line, 157

**Medium-Run Equilibrium**
- Medium run equilibrium is reached when prices and expected prices are equal and \( Y = Y_n \), so that wage setters have no reason to adjust expectations
- The natural rate of output is that level of output that prevails when prices are equal to expected prices
- This equilibrium is achieved from shifts up or down in the AS curve, reflecting alterations in price expectations
- Note that the medium run equilibrium will always occur where the natural level of output intersects the current AD curve; the AS curve will keep shifting until it interests this point
- These shifts in the AS curve, in turn, are caused by the fact that prices differ from expectations, which difference leads to changes in expectations, changes in prices, and hence changes in output
- You can look at it this way: output could not have diverged from the natural level at all unless expected prices had been higher or lower than actual prices, whatever the original reason
2.3 Applying the AS-AD Model

Achieving Equilibrium
- If SR equilibrium occurs at $Y > Y_n$, it means that actual prices are higher than expected prices of wage-setters, 158
- This leads to workers (and owners of capital, land, etc) to demand higher prices to compensate, thus increasing costs of production and leading firms to raise prices further, 157
- However, the increase in prices will not be as great as the increase in expected prices, as the increase in prices reduces the supply of the real money stock, thus leading to a rise in interest rates and hence a reduction in spending (and thus output), 158
- This of course is assuming that the central bank adjusts its target interest rate upward to accommodate this movement; otherwise interest rates would not be able to rise at all

Contractionary Monetary Policy
- Suppose the RBA wants to reduce the price target
- In order to do this, they will increase the interest rate above the natural level
- This will in turn shift in the IS curve, and hence also shift in the AD curve
- At this point of short run equilibrium, actual prices will be below expected prices
- As a result, price expectations will fall, causing a downward movement in the AS curve
- This downward shift will occur slowly over time until expected prices, actual prices and the natural rate of output are all mutually consistent

Fall in Budget Deficit
- A decrease in the budget deficit $G$ initially decreases output as the AD curve shifts to the left
- Note that the reduction in $G$ will lead to a fall in interest rates and hence a rise in investment, but this will most likely not be enough to fully offset the decline in $G$ – a good way of thinking about this is the a lower $G$ means a fall in velocity
- As a result of this fall in output, the price level will fall below expected prices, thereby leading to a downward shift in the AS curve as price expectations adjust
- However, if we assume that the price target does not change, we know that the RBA will respond to this reduction in prices by reducing the interest rate (i.e. even further than it fell when $G$ was reduced, assuming that it has a price rather than interest rate target)
- This reduction in the interest rate in turn stimulates investment, thereby shifting the AD curve back to the right
- Note that if the central bank had acted to lower interest rates immediately, there would have been no fall at all in prices or output
- Although the price and levels of output will be the same in this new equilibrium, the composition of that output will change
- Specifically, the lower rate of interest translates into higher levels of investment and of course lower levels of government spending

Oil Supply Shock
- Oil is another input to production, so a rise in real price of oil will act like an increase in the markup to reduce the real wage
- An increase in the price of oil is equivalent to a rise in the markup because both increase the price relative to the wage level, thereby shifting down the PS curve
In the case of the rising price of oil, however, the mechanism is somewhat different, as here prices rise relative to wages because of an increase in the price of oil is an increase in the price of inputs, and hence is equivalent to an increase in the marginal cost for firms. This reduction in real wages will be reflected by a shift downward in the price-setting curve, which in turn will lead to a higher natural rate of unemployment, as per the wage-setting relation. This higher natural rate of unemployment reduces the natural level of output and also shifts up the AS curve, both of which occur through the duel mechanisms of a higher markup (less oil for inputs) and a higher natural rate of unemployment (fewer workers). In this example, we assume that the price target remains unchanged, which means that the initial rise in prices caused by the price shock will cause the RBA to raise interest rates in order to offset the increase in prices. This in turn will be reflected by a leftward shift of the AD curve, further reducing output. If output has still not reached its natural level, then either price expectations and/or the price target must change until it does. To maintain their price target after a price or demand shock, the RBA will have to change interest rates. Note that this change in interest rates will only persist for as long as it takes for the economy to return to medium-run equilibrium. In the long run interest rates will return to their natural level.

**Oil Shock and Unemployment**

- Note that the natural rate of unemployment only changes because of the markup $\mu$ of firms.
- Because firms hold some market power, it is not in their interest to increase output beyond a certain level by hiring more workers at a lower wage.
- Thus, an increase in the price of oil (or any other input) acts like an increase in the markup to reduce the natural rate of unemployment.
- The reason for this is that an increase in the real cost of oil represents an increase in marginal costs, hence increasing the overall size of the $\mu$ effect because of the relation $P = (1 + \mu)P^1 \gamma W^\mu$.
- This is similar to how any reduction in MC for a monopolist will lead them to somewhat expand output and lower price, and vice-versa for any increase in MC.

**The Neutrality of Money**

- Over time, price level $P$ decreases and effects of monetary contraction on output $Y$ and interest rate $i$ dissipate.
- Thus, a change in nominal money stock $M$ has no effect on output or interest rate in the medium run.
- Instead, changes in money stock are absorbed by changes in the price level.

**2.4 Unemployment and the Phillips Curve**

**Deriving the Phillips Curve**

- Suppose we rewrite $P = (1 + \mu)P^e f(u, z)$ as $P = (1 + \mu)P^e (1 - \alpha u + z)$, just for simplicity.
- We can define inflation $\pi$ as $1 + \pi = \frac{P_t}{P_{t-1}}$ and expected inflation as $1 + \pi^e = \frac{P_t^e}{P_{t-1}}$.
- Expanding out the brackets and simplifying to include only the first order elements we end up with: $\pi = \pi^e - \alpha u + (\mu + z)$, which forms the definition of the Phillips curve.
- This indicates that expected inflation should affect actual inflation on a one-to-one basis.
• Also, higher unemployment should reduce inflation, while a higher markup should increase inflation

The Old Phillips Curve
• Before around 1960, when the Phillips Curve was discovered, average inflation in the US and UK was around zero, 182
• This meant that people generally expected that prices next year would be able the same as prices this year, 182
• The negative Phillips relationship emerged because when unemployment was low, workers bid up nominal wages, hence leading firms to increase their prices, thereby increasing the rate of inflation, 182
• This relationship held reliably over the course of the 1960s, and served as a reliable guide to policy makers, 182

The New Phillips Curve
• Beginning around 1970, however, this relationship totally broke down, 182-183
• Partly this was the result of higher inflation as a result of the two oil price shocks, 183-184
• Mostly, however, it was related to a change in the way in which workers and firms formed their expectations about prices, 184
• The biggest reason for this was that over the course of the 1960s, inflation became consistently positive, owing in large part to persistent expansionary fiscal policy, 184
• This is in contrast to the highly variable and unpredictable nature of inflation over the course of the first half of the 20th century, 184-185
• As a result, workers and firms began to form their expectations on the assumption that inflation would persistently be positive, 185
• Indeed, it was not so much that inflation had risen as that it became much more consistent, such that people began to expect inflation to be the same as it was last year, rather than expecting it to be about zero, 185
• As a result of this new situation, unemployment came to be correlated not with inflation itself, but with the rate of change inflation, 186
• Thus, high unemployment led to rising inflation, low unemployment falling inflation, 186

Inflation Expectations and the New Curve
• All of this suggested the need to build inflation expectations into the Phillips curve
• There are a number of different ways to do this; of the is a ‘backward looking’ extrapolation, whereby future expectations are based on past levels of inflation (called adaptive expectations)
• The expectations-augmented Phillips curve is a relationship between inflation and unemployment given a particular natural rate and inflation expectations
• Thus, changes in either the natural rate or expectations can disrupt the relationship
• This explains why the relationship also does not hold in the medium run, as inflationary expectations will not remain constant in the long-run if they are persistently wrong
• Note that prices rise by two distinct mechanisms on different time horizons
• Over the short run, prices rise or fall because of the diminishing marginal product of labour – this, however, is not enough to fully equate prices with expected prices
• In the medium-run, prices change because of altered price expectations, generally through the channel of higher expected prices leading to workers bidding up wages
The Natural Rate of Unemployment

- Milton Friedman had actually predicted this development beforehand, on the grounds that low unemployment could only be maintained so long as wage-setters systematically underestimated inflation, something they were unlikely to continue to do, 190
- He argued that the Phillip’s curve relationship was not “structural”, and hence policy-makers were not able to keep unemployment below a certain level without triggering inflation
- This insight led to the development of the concept of the natural rate of unemployment, or the rate that prevailed when inflation was equal to the expected rate of inflation, 190-191
- Indeed, using this analysis we can derive a new relation, whereby changes in inflation are caused by any deviation of employment from the natural rate of unemployment, 191
- The natural rate of unemployment can thus be defined as the rate of unemployment necessary to keep inflation zero, 191

NARU and Unemployment Swings

- In this approach, the natural rate of unemployment is sometimes called the NAIRU: the non-accelerating inflation rate of unemployment
- This account is such that changes in inflation are proportional to the difference between actual unemployment and the natural rate of unemployment
- For example, if inflation is higher (or at least higher than expected), prices rise faster than wages (as workers don’t push for as large pay increases as they should because they don’t expect inflation to be so high)
- This reduction in real wages leads to a reduction in unemployment below the natural rate
- Note that this is different from the previous employment analysis, which dealt with the natural rate of unemployment, which occurs only when expectations are met

Variations in the Natural Rate

- Note that natural rates of unemployment will vary substantially across countries, 192
- Japan, for example, traditionally had a very low natural rate of unemployment owing to its practise of lifetime employment, and subsequent low rate of job turnover, 194
- The natural rate of unemployment can also vary substantially across time, 193-194
- For example, it averaged about 3% in Europe in the 1960s, but now European unemployment averages around 8-9%, 194-195
- Changes in the level of inflation also tend to affect the relationship between unemployment and inflation, for example by changing the institutional arrangements for wage setting, 195
- As an example, higher inflation tends to increase the prevalence of wage indexation, which in turn increases the sensitivity of inflation to changes in unemployment, as everything can react much faster, 195-196
- Interestingly, it seems that the Phillips curve may break down during times of deflation, as workers are less willing to accept cuts in nominal wages than they are to accept inflation-caused cuts in their real wage, 196

2.5 The Dynamic AS-AD Model

Introduction to the Model

- This AS-AD model specifically incorporates dynamic elements of the economy much better
- It also explicitly allows for the central bank to have an interest rate target rather than a price target, as previous models assumed
Compared to the models in preceding chapters, the dynamic AD–AS model is closer to those studied by economists at the research frontier.

Moreover, economists involved in setting macroeconomic policy, including those working in central banks around the world, often use versions of this model when analysing the impact of economic events on output and inflation.

Five Key Building Blocks

1. Output equation: output depends negatively on real interest rate
2. Fisher equation: real interest rate is nominal interest rate less expected inflation
3. Expectations-augment Phillips curve: inflation depends on expected inflation and output gap
4. Adaptive expectations: expected inflation equal to current actual inflation
5. Monetary policy rule: nominal interest rate set in response to inflation and output gap

Output Equation

- Real output \( Y_t \) at date \( t \) is decreasing in the real interest rate \( r_t \)
  
  \[ Y_t = \bar{Y}_t - \alpha (r_t - \rho) + \varepsilon_t, \quad \alpha > 0 \]

- \( Y_t \): level of real output at date \( t \)
- \( \bar{Y}_t \): natural level of output at date \( t \)
- \( r_t \): real interest rate
- \( \rho \): natural real rate of interest (\( \rho > 0 \)), or the real interest rate at which, in the absence of any shock (\( \varepsilon_t = 0 \)), the demand for goods and services equals the natural level of output
- \( \varepsilon_t \): random shifts in aggregate demand, with a mean at zero \( E(\varepsilon_t) = 0 \)
- This is similar to IS equation in that output depends negatively on an interest rate
- Note that if \( r_t = \rho \), then \( E(Y_t) = \bar{Y}_t \)

Fisher Equation

- Real interest rate \( r_t \) is the nominal interest rate \( i_t \) less expected inflation: \( r_t = i_t - E_t(\pi_{t+1}) \)
- Where \( \pi_{t+1} \) is the inflation rate between period \( t \) and period \( t + 1 \), and \( E_t(\cdot) \) are the expectations conditional on information available at time \( t \)
- Interest rates \( r_t \) and \( i_t \) prevail at date \( t \), represent returns on investments from \( t \) to \( t + 1 \)
- The actual inflation rate between \( t \) and \( t + 1 \) is not known at \( t \), hence the need to consider expectations

The Taylor Rule

- Economics professor John Taylor suggested a simple guide to Federal Reserve decisions
- His ‘rule’ was: \( i_t = 2\% + \pi_t + \frac{1}{2} (\pi_t - 2\%) + \frac{1}{2} (Y_t - \bar{Y}_t) \)
- This rule holds that monetary policy should be such that the nominal interest rate increases more than one for one with inflation, such that the real interest rate also increases
- The failure of interest rates to rise sufficiently during the 1970s explains in large part the inflation of that decade

Dynamic AS Curve

- This is essentially the Phillips Curve with adaptive inflation expectations substituted in
- It takes the form of an upward sloping relation between output \( Y \) and inflation \( \pi \) with slope \( \phi \)
- It takes as given: (i) past inflation \( \pi_{t-1} \), (ii) natural output, \( \bar{Y}_t \) and (iii) supply shocks \( v \). Changes in these variables shift the DAS curve
Dynamic AD Curve
- This curve is a negative relationship between output and the inflation rate, with the slope dependent upon the sensitivity of the interest rate to inflation
- It takes as given: (i) inflation target $\pi^*$, (ii) natural output, $\bar{Y}_t$, and (iii) demand shocks $\epsilon$. Changes in these variables shift the DAD curve
- Note that it slopes downward in large part because of the Taylor rule, or actions of the RBA

Short Run Equilibrium
- At any given moment $t$, the two endogenous variables $\pi_t, Y_t$ are determined by the exogenous variables $\bar{Y}_t, \pi^*_t, v_t, \epsilon_t$ and one predetermined variable, $\pi_{t-1}$
- The short run equilibrium solution may have $Y$ above or below the natural level $\bar{Y}_t$ and inflation $\pi$ above or below target $\pi^*$

Long Run Equilibrium
- Long run equilibrium occurs when inflation is stable, $(\pi_t = \pi_{t-1})$, and shocks at their mean values ($v = 0$)
- Because of adaptive expectations, this implies inflation expectations are also stable
- A stable rate of inflation implies from the adaptive expectations Phillip’s curve that unemployment must be equal to its natural rate, which in turn means that output is at its natural level
- From the series of equations of the model, we see that in the long run monetary policy does not affect anything real; only inflation and the nominal interest rate

2.6 Applying the Dynamic Model

Basic Approach
- Start in long-run equilibrium
- Change one of the exogenous variables: $\bar{Y}, u_t, \epsilon_t, \pi^*_t$
- Hold the other exogenous variables constant
- Use DAS and DAD curves to determine both the impact effect (short-run equilibrium) and then subsequent dynamics as the macroeconomy responds to the change

Increase in Natural Rate of Output
- Increase in natural output $\bar{Y}_t$
- This shifts out the DAS curve, with inflation lower at any level of output (productive capacity has increased)
- It will also shift out the DAD curve, as inflation is higher at any level of output (income is higher, demand has increased)
- These two effects will always exactly cancel each other out in the long-run, hence there will be no change in inflation, and a permanent increase in output

Temporary Aggregate Supply Shock
- Adverse supply shock ($v > 0$) for one period, then reverts to zero
- The new DAS curve at $t$ is higher than previous DAS curve at $t - 1$, but DAD curve is unchanged
- Thus, on impact, inflation is higher and output is lower
- This occurs because output falls below its natural level as the central bank increases interest rates in response to inflation
- Over time, however, as inflation falls from $t$ to $t + 1$, new DAS curve at $t + 1$ shifts back down
• There will then be movement along DAD curve, eventually arriving back at the LR equilibrium

Persisting Aggregate Demand Shock
• In this case, aggregate demand is higher than normal ($\varepsilon_t > 0$) for several periods, then reverts to zero
• The new DAD curve at $t$ shifted out from previous DAD curve at $t - 1$, though on impact DAS curve is unchanged
• Thus, on impact inflation is higher and output is higher, just like the temporary shock
• However, as inflation rises from $t$ to $t + 1$, the DAS curve at $t + 1$ is shifted up (inflation expectations adjust), output falls as move along the new DAD curve
• Over time, inflationary expectations gradually rise, moving the DAS curve upwards, which will continue until the aggregate demand shock ends
• When this occurs, output rapidly declines, and then will slowly rise once again to reach its initial equilibrium level

Change in Inflation Target
• Suppose the inflation target is reduced from 2% to 1%
• This means that current inflation is above the new target, so nominal and real rates rise
• The new DAD curve at $t$ is shifted in from previous DAD curve at $t - 1$, while on impact DAS curve is unchanged
• Thus, on impact inflation is lower and output is lower (disinflationary recession)
• As inflation falls from $t$ to $t + 1$, the DAS curve at $t + 1$ is shifted down (inflation expectations adjust), and output rises as the economy moves along the new DAD curve

Tradeoff Between Output and Inflation Variability
• There is no long-run trade-off between output and inflation levels
• But there is a trade-off between output and inflation volatility
• This operates through the slope of the DAD curve
• This in term is determined by the choice of monetary policy rule parameters makes for either relatively more inflation volatility or relatively more output volatility
• Specifically, the slope of the DAD curve determines whether supply shocks mostly effect inflation or mostly effect output
• Flat DAD implies large change in output, small change in inflation
• Steep DAD implies small change in output, large change in inflation
• Inflation shocks are self-fulfilling because expectations of future inflation are built into the model

Importance of the Taylor principle
• The Taylor principle states that the nominal interest rate increases more than one for one with inflation
• This ensures that the DAD curve is downward sloping
• If this is not satisfied, the DAD curve will be upward sloping, resulting in highly unstable inflation dynamics and spiralling inflation
Part 3: Economic Growth

3.1 The Solow Model

Searching For Convergence

- Economic theory would predict that poor nations would grow faster than rich nations, and so would be able to catch up to them in a process called convergence, 241-243
- If we look at the data, we observe that this has occurred for OECD and East Asian nations, but not for the rest of the world, 235-237

Aggregate Production Function

- This is the relationship between economy-wide output and inputs: \( Y = F(K,N) \)
- \( Y \) aggregate output: real GDP
- \( K \) physical capital: plant and equipment
- \( N \) labor: number of workers employed
- The function \( F \) tells us how much output is produced for given quantities of inputs, and depends on the state of technology and productivity
- The state of technology \( A \) can be thought of as a set of “blueprints” defining range of products and techniques available to produce them
- This aggregate production function is such that there is constant returns to scale when all inputs are increased in the same ratio, but diminishing returns when only one input is increased

Output per Worker

- Output per worker is just a function of capital per worker \( K/N \)
- Since \( F \) is increasing but at a diminishing rate in \( K \), output per worker is increasing but at a diminishing rate in capital per worker
- Growth comes from capital accumulation \( K \) and from technological progress \( A \)
- We will see that because of diminishing returns, capital accumulation alone cannot sustain growth, and so growth in output per person is eventually determined by the rate of technological progress

Effect of Capital on Output

- To focus on capital accumulation, we make some simplifying assumptions: population, participation rate, unemployment rate all constant, and no technological progress
- In this situation, output per worker is an increasing concave function of capital per worker
- This function will have constant returns to scale, but diminishing marginal returns to capital and labour
- This function can be represented as: \( \frac{Y}{N} = f \left( \frac{K}{N} \right) \)

Effect of Output on Capital Accumulation

- Assume a closed economy with a balanced budget: investment equals savings
- Also assume that there is a constant private savings rate as a portion of income: \( S = sY \)
- Also assume a constant rate of depreciation \( \delta \)
- Thus the capital stock will be given by: \( K_{t+1} - K_t = I_t - \delta K_t \)
- If we divide this equation by constant \( N \) and substitute \( I_t = sY \) for investment we find:
- \( \frac{K_{t+1}}{N} - \frac{K_t}{N} = f \left( \frac{K_t}{N} \right) - \frac{\delta K_t}{N} \)
• Thus, the change in capital stock per worker is given by the investment per worker less depreciation per worker
• The steady-state will occur when investment equals depreciation (no net investment)

**Savings Rate and Output**

• As the capital stock is increased, output (and hence savings) increases by less and less, while depreciation increases in an exactly proportional relationship, 252
• This means that eventually depreciation always comes to equal gross investment, and so economic growth comes to a halt, 252
• Note that this means that the rate of growth in the long run is independent of the savings rate – depreciation will eventually catch up regardless, 252-254
• A higher savings rate, however, will lead to a higher level of income in the steady state, as a large equilibrium stock of capital will be capable of being supported, 254
• Likewise, in the case of a country continually growing through technological progress, this rate of progress too is independent of the savings rate, 255

**Golden Rule of Savings**

• Note that maximum consumption (as opposed to output) per worker is not maximised at maximum savings, as consumption varies inversely with savings
• This will produce an inverse U-shaped graph, with the maximum rate of steady-state consumption occurring at the so-called ‘golden rate’ of savings
• Higher rates of saving increase the level of output in the steady state, owing to the resultant ability to support a larger capital stock, 257
• This increase in output, however, comes at the cost of a larger portion of that output being required to offset the depreciation of the larger capital stock, 257
• Thus, if the increase in output as a result of the higher capital stock is less than the loss owing to increased depreciation offset requirements, total net output (i.e. consumption) will decline, 257
• The rate of savings that maximises steady-state income is known as the golden-rule rate of savings, 257
• Note that gross output (that is gross of depreciation) increases for every increase in the savings rate right up to 100%
• Net output, however, which is measured by GDP (think of value-added accounting) will decline once the ideal rate of saving is exceeded

**Incorporating Human Capital**

• Human capital refers to the skills and knowledge possessed by workers in an economy
• In order to incorporate human capital, we can include it as an additional parameter in the aggregate production function, with diminishing returns just like capital
• Indexes of human capital are normally constructed by summing the number of workers weighted according to their relative wages, assuming that these wages reflect marginal utilities
• This can be represented in an augmented production function: \( \frac{Y}{N} = f \left( \frac{K}{N}, \frac{H}{N} \right) \)
• An increase in \( K/N \) or average skill of workers \( H/N \) leads to increase in output per worker
• If we use the familiar solow model, we find that human capital behaves just like physical capital, increasing long-run output levels but not growth rates, 266
• Recently, however, endogenous growth theories have challenged this idea by proposing models that generate sustained growth without technological progress as a result of the interaction between increases in human and physical capital, 266
3.2 Technological Progress and Growth

**Technology and the Production Function**
- Technological progress is a very broad term, and can refer to higher levels of output using the same inputs of capital and labour, better products, or a larger variety of products, 272
- If, however, we define output not as the number of goods but as the underlying services provided by the good, we can simply think of technological progress as an increase in output for given amounts of input, 273
- This can be represented in our aggregate production function equation by placing the coefficient A in front of the factor N, 273
- Under this new model, output is now determined by two inputs: capital and effective labour
- In this augmented model, we will consider output and capital per effective worker, 273
- Output per effective worker will exhibit diminishing marginal returns just as it did in the simpler version of the model, 274

**Investment vs Effective Depreciation**
- Using the new model, we can construct a Solow-growth-type diagram in exactly the same manner as with the initial model, except that now output and capital per effective worker will be plotted, 274-275
- Similarly, the dynamics of the model will be determined by the relative sizes of depreciation per effective worker versus savings/investment per effective worker, 274-275
- In this model, capital per effective worker is increasing if investment is greater than effective depreciation, decreasing if investment less than effective depreciation
- Effective depreciation is given by: 
\[ (g_A + g_N + \delta) \frac{K_t}{A_tN_t} \]
- In the steady state, output per effective worker is constant, which means that Y must grow at the same rate as AN, 276
- This represents the investment needed to maintain an unchanging capital/effective labor ratio when technology and population are growing
- In a sense we need to accumulate capital not only in order to offset population growth, but also in order to offset technological growth, so that we have the same capital per ‘unit of technology’

**Balanced growth**
- In the steady-state, capital and output per effective worker are constants
- So in the steady-state, output grows at the same rate as the rate of growth of effective labor
- This is referred to as a balanced growth path
- As before, growth rates are independent of the savings rate, but the level of output per effective worker depends (positively) on s
- Because we know that AN simply grows as the rate of population growth plus the rate of technological progress, we can determine that the long-run rate of growth per capita will simply be equal to the technological progress rate, and hence will be independent of savings rates, 276
- The steady-state capital per effective worker falls when there is an increase in technological progress given the same saving rate
- In order to return the economy to the original steady-state point, the saving rate (= investment rate) needs to increase to cope with the higher level of technology
Determinants of Technological Progress

- The rate of technological progress is largely dependent upon expenditures upon research and development by government and private companies, and also the interaction between basic research and the application and adoption of these technologies, 278-280
- Expenditure on R&D is dependent upon the degree to which the developing firm expects to be able to benefit from its development, which in turn is assisted by patents, 281
- The rate of technological progress in western nations has decreased since the mid-1970s, though this is not because R&D has declined, and so it is not really known why it has occurred, 285-286

Institutions and Growth

- Differences in institutional quality is one of the most important factors preventing poorer nations from closing their technology gap with the developed world, 286
- Protection of property rights, in turn, seems to be one of the most important institutional requirements for growth, 286
- Improving institutions seems to be necessary for growth, but it is also very hard for poor countries to do without access to more resources, 287

3.3 Technological Progress and Employment

The Issue of Technological Unemployment

- The concern is that unemployment comes from the introduction of machinery (and other physical capital) that substitutes for labor
- It is a fact that labor-saving technological progress allows more output from the same number of workers
- Optimistic interpretation: more output with the same workers
- Pessimistic interpretation: same output with fewer workers
- The answer to this question seems to be that labor-saving technological progress can cause higher unemployment in short run, but not in medium-to-longer run

Establishing the Model

- In this case we abstract out the role of capital, and just look at Y=AN
- This equation can be interpreted in two ways; either N is basically constant and so an increase in A leads to an increase in Y, or Y is constrained (perhaps by demand), and so an increase in A leads to a reduction in N

Using the AS-AD Model

- An increase in A will lead to an outward shift of the AS curve, representing a higher output for any given price level
- Note that an increase in productivity A is the same as a reduction in marginal cost
- The effect on aggregate demand, however, is ambiguous
- If technological breakthroughs bring the prospect of higher profits and an investment boom, the demand for goods rises, and so aggregate demand shifts to the right, and output rises
- If, on the other hand, more efficient use of existing technologies requires little or no new investment, we find displaced workers, leading to more precautionary saving, reduced spending, and so a shift of the AD curve to the left
Either way, it is still an empirical question as to whether or not output increases by enough to prevent a decline in employment, 301-302

Measuring this in the short run can be very difficult, as it is hard to factor out business cycle effects, 302

**The Natural Rate of Unemployment**

- To examine the medium-run effect of technological change on employment, we must look to see if productivity has any effect on the natural rate of unemployment, 303
- When we do so, we find that (when expectations are correct) real wages are given by: \( \frac{W}{P} = \frac{A}{1+\mu} \)
  meaning that real wages move in direct proportion to changes in productivity, 303
- If real wages are the same and we hold aggregate demand constant (as we do in the medium run), levels of employment cannot change, 304-305
- Hence, increases in \( A \) will shift up both the wage- and price-setting curves by the same amount, thus leaving employment the same and real wages higher
- One can interpret this as being caused by the fact the worker’s bargaining power does not change with technological progress, and so their wages will always be proportional to their marginal product
- When we look at the empirical evidence, we actually find a strong negative correlation between levels of unemployment and rate of productivity growth, 305
- This can be explained by understanding that it takes a long time for expectations of future productivity growth to be incorporated into wage and bargaining decisions, 305-306
- As such, if productivity growth slows (as it did in the US and Europe in the 1970s-80s), wages will for a time increase faster than productivity, and hence the natural rate of unemployment will rise, 306-307

**Evidence on Productivity and Output**

- At least in Australia, productivity and output growth are almost perfectly correlated, thereby providing little evidence for technological unemployment

**Distributional Effects of Technological Change**

- Technological progress represents continual structural change, with old jobs and industries being destroyed and new ones being created, 308-309
- This process can lead to significant changes in the relative returns to different skills and levels of education, something that has occurred recently in the US, but not Australia, 309
- We can observe this increased spread in the rapid rise in the premium to a college degree in the US since 1980 (though a slower trend existed since 1950)
- This is puzzling, particularly given that the relative supply of college graduates has progressively increased over this period

**Causes of Increased Wage Inequality**

- Skill-biased technological change: new technologies are substitutes for low-skilled labor but complements for highly-skilled labor, thereby increasing relative return to skilled labour
- International trade: new technologies make it possible to off-shore production to low wage countries
- Market structure: because of ‘superstar effects’, individuals may be able to use increasing returns to scale to capture large rents in their market
- Other possibilities: immigration? politics?
• Goldin and Katz (2008) have published a book about this called ‘The race between education and technology’

Part 4: The Open Economy

4.1 Openness in Goods and Financial Markets

Types of Openness
• (1) Openness in goods markets. Restrictions on trade include tariffs and quotas
• (2) Openness in financial markets. Capital controls can place restrictions on ownership of foreign assets and foreign ownership of domestic assets
• (3) Openness in factor markets. The ability of firms to choose where to locate operations and workers to choose where to work

Real Versus Nominal Exchange Rates
• The nominal exchange rate is simply the rate at which one currency can be exchanged for another
• The real exchange rate adjusts this to measure the relative prices of goods in different countries
• $P$ = Australian price index in $A$
• $P^*$ = US price index in $US$
• $E$ = nominal exchange rate, $US$ per $A$
• Real exchange rate $\varepsilon = \frac{P}{P^*/E} = \frac{EP}{P^*}$ = price of domestic goods / price of foreign goods
• An increase in the relative price of domestic goods in terms of foreign goods is a real appreciation, an increase in $\varepsilon$
• A decrease in the relative price of domestic goods in terms of foreign goods is a real depreciation, a decrease in $\varepsilon$

Changes in the Real Exchange Rate
• Note that this real exchange rate $\varepsilon$ is calculated using price indices in the two countries to be compared, and hence its absolute value is arbitrary, 414
• Relative changes in $\varepsilon$, however, are proportional to relative changes in the prices of goods between the two countries, 414
• A reduction in the real exchange rate over time means that Australian goods have become relatively cheaper, or equivalently that foreign goods are more expensive for Australians in real terms, 415
• Over shorter-terms, most of the variations in real exchange rates are caused by fluctuations in nominal exchange rates, 416

Multilateral Exchange Rates
• Bilateral exchange rates are between a pair of countries
• Multilateral exchange rates are between one country and a collection of other countries
• We use trade shares as weights to measure the average price of Australian goods relative to the average price of goods of Australian trading partners
• In multilateral exchange rate indices, real and nominal exchange rates tend to track each other very closely
Openness in Financial Markets

- The daily volume of world financial transactions in 2004 was about $2 trillion, almost all of which was trade in assets rather than goods and services, 418
- This means that short-term exchange rate fluctuations are driven mainly by international portfolio decisions rather than trade, 418
- Portfolio decisions refer to the choice of investors concerning how much of their wealth to hold in foreign versus domestic assets, 420-422
- This decision, in turn, will depend upon the relative levels of interest in the two countries, as well as the current and expected future exchange rate, 422
- The additional uncertainty associated with exchange rate fluctuations and other political factors (especially in the Third World) reduced foreign asset holdings below levels though would prevail based upon comparative interest rates alone, 422-424
- Because most countries do not want to face the political and economic upheaval associated with large, rapid changes in their exchange rate, interest rates tend to move in tandem across the world, 424-425

4.2 Open Economy in the Short Run

Demand in an Open Economy

- Demand for domestic goods is given by: \( Z = C + I + G + X - IM/\varepsilon \)
- Notice that imports are adjusted by the relative prices of goods so that the measurements are consistent
- Imports given by \( IM(Y, \varepsilon) \):
  - \( Y \) increasing in domestic output \( Y \) and in real exchange rate \( \varepsilon \)
  - \( \varepsilon \) higher real exchange rate makes foreign goods relatively cheap in domestic economy, increases demand for imports
- Exports given by \( X(Y^*, \varepsilon) \):
  - \( Y^* \) increasing in foreign output \( Y^* \) but decreasing in real exchange rate
  - \( \varepsilon \) higher real exchange rate makes domestic goods relatively expensive in foreign economy, decreases demand for exports

Diagrammatic Equilibrium

- We can represent imports and exports on a typical 45-degree diagram, 433
- The AA curve representing domestic demand minus imports will be below the original DD curve, but will have a flatter slope, 433
- This difference in slope arises as a result of the fact that as income increases, some of the additional demand ‘leaks out’ into larger imports, thereby reducing the strength of the multiplier, 433-434
- The ZZ curve is the same as the AA curve but with exports added, 434
- It is the same slope as the AA curve, as exports do not depend upon domestic income, and so there is no alteration of the multiplier, 434
- As in a closed economy, equilibrium occurs when the demand for domestic goods equals the production of goods domestically (\( Z=Y \)), 434
- Note that this need not occur in a condition where trade is balanced, 433

Increases in Domestic and Foreign Demand

- An increase in domestic demand has the same effect as in a closed economy, except that the multiplier will be smaller owing to the presence of imports, 435-436
In addition, because higher domestic output increases imports without affecting exports, it tends to lead to an increase in the current account deficit, 436

An increase in foreign demand acts like an increase in the velocity of money in the ‘exports’ stream of the economy, causing total exports to rise and hence stimulating the domestic economy, 437-438

Because economic stimulus effects spill over from one country to another in this way, coordination of macroeconomic policy between countries can be difficult, 438

Specifically, each country has an incentive to wait for other countries to launch fiscal expansions, as then they can benefit from economic stimulation without having to increase their trade deficits, 438-439

Games Countries Play

Increases in demand, both domestic and foreign, lead to increases in output. But they have opposite effects on trade balances

An increase in foreign demand is often preferred to an increase in domestic demand because it leads to an improvement in the trade balance

Thus, in a recession, countries with high trade deficits may be inclined to wait for foreign demand to stimulate their economy

Depreciation, Trade Balance and Output

The Marshall-Lerner condition occurs when a depreciation in the real exchange rate leads net exports to increase, and hence the trade balance becomes more positive, 440-441

This occurs because a lower real exchange rate means that exports become cheaper for foreigners to buy, while imports become more expensive, and so less is imported, 440-441

Note that in the short run we assume that domestic and foreign prices do not change, so movements in nominal exchange rates are reflected one-to-one by changes in the real exchange rate, 440-441

This increase in net exports would in turn lead to an increase in output, 441

However, the demand for imports is thought to be inelastic in the short run (say less than six months), so a real depreciation will initially lead to a decline in the trade balance owing to higher import prices

Savings, Investment and the Trade Balance

Private saving is given by \( S = Y - T - C = I + G - T + NX \)

So net exports are given by \( NX = (S - I) + (T - G) \)

This means that a trade surplus must correspond to an excess of total saving over investment

Hence, if saving remains constant, an increase in investment results in a deterioration of the trade balance

An increase in the government’s budget deficit, all else the same, leads to a deterioration of the trade balance

4.3 The Mundell-Fleming Model

Equilibrium in Financial Markets

Here we will assume that prices are constant and that \( P = P^* \)

We must then ask, how do investors allocate their assets across domestic versus foreign bonds or assets?
If we assume that there is perfect capital mobility and no arbitrage opportunities, we know that interest rates must be the same in both countries, when adjusting for expected changes in nominal exchange rates. This is referred to as the interest parity condition. It implies that interest rate differentials will lead to changes in the exchange rate.

Exchange Rate Expectations
- If expected future value of the Australian dollar increases, demand for Australian bonds increases and Australian dollar appreciates immediately.
- Interestingly, this also implies that if interest rates increase but investors do not change their expectations of future exchange rates, it must be the case that the current exchange rate will appreciate by the exact amount to offset the higher interest rates.
- For example, if Australian interest rates increase from 4% to 10% and future expected exchange rates don't change, the $AUD must immediately appreciate by 6%, as this will provide just enough ‘space’ for the AUD to depreciate just enough to offset the higher interest earnings, and hence maintain international equilibrium.
- The Mundell-Fleming model focuses on short run for which expected exchange rate is given, and so is a somewhat limited model.

Combining Goods and Financial Markets
- Now that we have a relationship between interest rates and the exchange rate, we can substitute this into the IS curve and hence derive the open-economy IS curve.
- Thus, changes in domestic interest rate affect the economy both directly through investment and money demand, and indirectly through the exchange rate effect on exports.
- Changes in foreign interest rates or expected exchange rates also affect domestic economy through net exports.
- Because of this additional effect of exports, the slope of the IS curve will be flatter in the open economy compared to the closed economy, 462.
- The LM relation is unchanged; it works exactly as it did in the closed economy, 462.

Monetary Policy
- As before, a decision by the central bank to increase the interest rate target will lead to an upward shift of the LM curve, thus lowering output, 463.
- This higher interest rate will also lead to an appreciation of the domestic currency, hence lowering net exports, 463-464.
- Note that the effect on imports is ambiguous, as the higher exchange rate tends to increase imports, while lower output tends to reduce it, 464.

Fiscal Policy
- Suppose there is a fiscal expansion and the central bank does not respond by changing interest rates. In this circumstance, the effect is exactly the same as in a closed economy, 464.
- If, however, the bank does increase interest rates to offset the inflationary pressure, this will lead to an appreciation of the currency, 464.
- This currency appreciation raises imports and lowers exports, while the boost in output owing to the fiscal expansion acts in the same direction to also increase imports, 464-465.
- Thus, the effect of this partly opposed fiscal expansion is unambiguously a worsening of the trade balance, 465.
This is the intuition behind the ‘twin deficits hypothesis’, or the idea that government budget deficits lead to trade deficits, 465

**The AS-AD Model with Exchange Rates**

- AD and AS in an open economy under fixed exchange rates look the same as in a closed economy
- However, in this case the AD curve slopes downwards because an increase in the price level leads to a higher real exchange rate, lower net exports and a decrease in real output
- This does not require adjustment in the nominal exchange rate, as prices can change instead
- Specifically, increases in the domestic price level $P$ relative to $P^*$ appreciates the real exchange rate $\varepsilon$, reducing net exports and hence reducing output

**Policy under Fixed Exchange Rates**

- If financial and exchange markets expect a pegged currency to hold into the future, then expected and current exchange rates are the same, 469
- For a small country, this means that they must set interest rates at the world level
- This means that under fixed exchange rates, the reserve bank gives up monetary policy as an instrument, and must instead simply supply whatever quantity of money is demanded at the interest rates that maintain their desired peg, 470
- This further implies that in order to maintain the requisite interest rate, the central bank must accommodate any changes in fiscal policy; matching any fiscal expansion by monetary expansion, and vice-versa, 470-471
- This also implies that fiscal policy is much more powerful in fixed exchange-rate regimes, as none of the effect will be lost through changes in $E$
- There will also be no crowding-out effect, at least for a small country, as nothing they can do will significantly change world interest rates
- All this is summarised in the Mundell-Fleming trilemma, which says that it is impossible to maintain all three of (i) perfect international capital mobility, (ii) independent domestic monetary policy and (iii) fixed exchange rate

**Policy under Flexible Rates**

- Under flexible exchange rates, monetary policy is amplified owing to the effect on short-run nominal exchange rates, 497
- This ‘overshoot’ phenomenon refers to the fact that if the central bank raises interest rates in order to achieve a lower price target, the nominal exchange rate must immediately rise to a level sufficiently high such that it can depreciate every year until the interest rate policy returns to normal, thus maintaining real investment returns at the global average, 496-497
- This immediate real appreciation reduces net exports, hence amplifying the contractionary effect of the initial monetary policy, 497-498
- In the medium run, a fiscal shock (e.g. increase in $G$) must be exactly cancelled out by a reduction in exports, as medium-run GDP must be the same, 498
- In order for this to occur, there must be a medium-run real exchange rate appreciation

**4.4 Exchange Rate Regimes**

**Types of Exchange Rate Regimes**

- Flexible (or “floating”) exchange rate: market conditions determine exchange rate
• Fixed (or “pegged”) exchange rate: government sets price by buying and selling foreign currency to maintain the price; this will collapse if the government runs out of reserves
• Intermediate cases (“crawling peg”)

Medium Run Irrelevance of Regime Type
• In the medium run, the economy reaches the same real exchange rate and the same level of output whether it operates under fixed exchange rates or under flexible exchange rates
• The difference is the mechanism by which adjustment takes place
• Under fixed exchange rates, the adjustment takes place through the price level rather than through the nominal exchange rate
• In short run, fixed nominal exchange rates also imply fixed real exchange rates; however in the medium run, the real exchange rate is flexible: it adjusts through changes in the price level
• As such, in the medium run the real exchange rate and real output are independent of nominal exchange rate regime (a version of “monetary neutrality”)

Arguments For Devaluation
• With a fixed exchange rate, a devaluation (a decrease in the nominal exchange rate) leads to a real depreciation in the short run (a decrease in the real exchange rate), and hence a short run increase in output
• A devaluation of the correct size can return an economy in recession back to the natural level of output
• Indeed, this is how stimulation is achieved in an economy with fixed exchange rates, as clearly a interest rates cannot be used

Arguments Against Devaluation
• In practice, it is difficult to achieve the “correct” amount of devaluation
• With a devaluation, the price of imported goods increases, making consumers worse off
• This may lead workers to ask for higher nominal wages, and firms to increase their prices as well, hence leading to an inflation problem

Exchange Rate Crises
• These tend to occur when investors perceive that a fixed exchange rate is overvalued and will soon likely be devalued, 487
• Such an overvaluation occurs, in turn, when a country with a fixed exchange rate has a higher rate of inflation than those countries to whom their currency is pegged, 487
• Another condition crises can occur is if internal conditions call for a decrease in the domestic interest rate, which cannot practically occur without a devaluation, 487
• As soon as financial markets expect a devaluation at some point in the future, they will require much higher rates of interest in order to convince them to keep their funds invested in that country, 487
• Such expectations may also lead to speculative attacks selling the currency, thereby making the present fixed rate unsustainable
• The government then has two options (i) give in and devalue, or (ii) try to maintain fixed rate, probably at the cost of very high interest rates and a potential recession
• The interest rates needed to counteract this can be huge, in the hundreds of percent points, so it is often impossible to do without causing a recession, 487-488
• For example, if expected devaluation by 3% in 1 month, then the (annualised) 1 month interest rate has to rise by $3\% \times 12 = 36\%$ to prevent massive capital outflows
The central bank of that nation may try to maintain the higher rate even in spite of investments selling and taking their money, but eventually they will run out of foreign reserves to do so, hence forcing a devaluation, 488

Why Flexible Exchange Rates Change

- Under flexible exchange rates, the current rate is determined essentially by three factors: domestic interest rates, foreign interest rates, and the expected future exchange rate, 490-491
- It is not surprising therefore that \( E_t \) may change even if current \( i_t \) does not
- Of course, the expected future exchange rate itself is determined by expected future interest rates, which in turn are related to central bank decisions, so the reality of determining or predicting exchange rates can be very difficult, 491-492
- When flexible exchange rates were first observed after the collapse of the Bretton Woods agreements, they came as something of a surprise, as they were much more variable and erratic than expected, 493
- This was thought to be caused by speculation, until later it was understood that these fluctuations were actually the rational reaction to news about future interest rates and exchange rate conditions, 493

Pros and Cons of Fixed Exchange Rates

- May severely constrain domestic monetary policy (e.g., \( i = i^* \))
- Can be difficult to maintain credibility of a given fixed rate given external shocks
- Imminent devaluation may lead to very high interest rates
- On the benefits side, fiscal policy may be more powerful

Pros and Cons of Flexible Exchange Rates

- May be excessively volatile, difficult to control via monetary policy
- Volatility in nominal exchange rate implies short run volatility in real exchange rate, fluctuations in trade balance and real output
- The consensus opinion amongst economists is that flexible exchange rates are generally preferable, as fixed exchange rates tend to lead in messy severe recessions
- Exceptions might be for tightly integrated countries (e.g., experience similar real shocks, have high factor mobility between them, etc), or if the central bank cannot credibly control domestic inflation

Common Currency Areas

- A common currency (extreme form of fixed exchange rate), such as the euro, lowers transaction costs in trade and finance
- For countries to benefit from a common currency, probably need:
  - (i) to experience similar shocks; thus, so roughly the same monetary policy is suitable for all
  - (ii) high factor mobility, helps adjust to shocks

Part 5: Formulae and Calculations

Basic Macro Model

Demand for Goods

\[ Z = C + I + G + X - IM \]
Consumption function
\[ C = c_0 + c_1 Y_D \]
\[ Y_D = Y - T \]
\( c_1 \): the marginal propensity to consume
\( Y_D \): disposable income

Equilibrium Output
\[
Y = Z \\
Y = C + I + G \\
= [(C_0 + c_1)Y - T] + I + G \\
Y = \frac{1}{1 - c_1} (c_0 - c_1T + I + G)
\]
\( \frac{1}{1 - c_1} \): spending multiplier
\( c_0 - c_1T + I + G \): autonomous spending

GDP Notation
\( $Y_t = \) nominal GDP in period \( t \)
\( Y_t = \) real GDP in period \( t \)
GDP deflator: \( P_t = \frac{Y_{t+1}}{Y_t} \)
Inflation rate: \( \pi_t = \frac{\beta_t P_{t-1}}{P_t} \)

Unemployment Notation
\( L = N + U \): labor force (number of people)
\( N = \) employed
\( U = \) unemployed

The IS-LM Model

Savings Approach to Equilibrium
\[
S = Y_D - C \\
S = Y - T - C \\
S = C + I + G - T - C \\
S = I + G - T \\
I = S + (T - G) \\
I = (Y_D - C) + (T - G) \\
I = \left( (Y - T) - [c_0 + c_1(Y - T)] \right) + (T - G) \\
I = -c_0 + (1 - c_1)(Y - T) + T - G \\
Y = \frac{1}{1 - c_1} (c_0 - c_1T + I + G)
\]
\( (T - G) \): government saving
\( S \): private savings
\( c_0 - c_1T + I + G \): autonomous spending (not dependent on \( Y \))

Making Investment Endogenous
\[ I = b_0 + b_1 Y - b_2 i \]
Money Demand
\[ M^d = PY \times L(i), \quad \frac{dL}{dt} < 0 \]
\[ M^s = M_{\text{TARGET}} \]

The IS Curve
\[ Y = C + I + G \]
\[ = c_0 + c_1(Y - T) + b_0 + b_1Y - b_2i + G \]
\[ Y = \frac{1}{1 - c_1 - b_1}(c_0 - c_1T + b_0 - b_2i + G) \]

The LM Curve
Financial market equilibrium: \( M = PYL(i) \)

M: nominal money supply
P: price level
PY: nominal income
\( L(i) \): decreasing function of interest rate

\[ Y = \frac{M}{PL(i)} \]

The Labour Market

Wage Setting Relation
\[ W = Pf(u, z) \]
\[ W = P^e f(u, z) \]

W = nominal wage
P = price level
u = unemployment rate
z = other factors that affect wage setting

Price Setting Relation
\[ P = (1 + \mu)W \]
\[ \frac{W}{P} = \frac{1}{P^e(1 + \mu)} \]

\( \mu \) = markup over marginal cost

Natural Rate of Unemployment
\[ \frac{1}{1 + \mu} = f(u_n, z) \]

\( u_n \) = natural unemployment rate

Tax on Employment
In the case of an increase in on-cost employer taxation:
\[ P = (1 + \mu)W(1 + t) \]
\[ \frac{W}{P} = \frac{1}{(1 + \mu)(1 + t)} \]

In the case of an increase in income tax on workers:
\[
(1 - \tau)W = Pf(u, z)
\]
\[
\frac{W}{P} = \frac{1}{1 - \tau} f(u, z)
\]

**Natural Level of Output**
\[
Y_n = N_n = (1 - u_n)L
\]

$L$ = size of the labour force
$N_n$ = number of employed persons at natural rate of output
This equation assumes that each worker produces one unit of output

**Static AS-AD Model**

**Expectations Wage Setting Relation**
\[
W = P^e f(u, z)
\]

**Aggregate Supply Curve**
\[
P = (1 + \mu)W = (1 + \mu)P^e f(u, z)
\]
\[
P = (1 + \mu)P^e f\left(1 - \frac{Y}{L}, z\right)
\]

**Equilibrium in Goods Market**
\[
Y = C(Y, T) + I(Y, i) + G
\]

**Equilibrium in Financial Markets**
\[
\frac{M}{P} = L(Y, i)
\]

**Aggregate Demand Curve**
- Reserve Bank targets an interest rate $i$ and lets $M$ be determined by financial markets
- Choose $i$ on basis of equation $i = i_n + \alpha(P - P_T), \alpha > 0$
- An increase in $P$ above target $P_T$ causes $i$ to rise, demand falls and hence $Y$ falls
- Implies downward sloping AD curve in $(Y, P)$ space

**Short Run Equilibrium**
Takes value of expected prices $P^e$ as given

**Medium run equilibrium**
Occurs when $P = P^e$ and $Y = Y_n$

**The Oil Shock Model**
\[
Y = O^{1-\gamma} N^\gamma
\]
\[
P = (1 + \mu)P_0^{1-\gamma} W^\gamma
\]
\[
P = (1 + \mu)^{1-\gamma} \left(\frac{P_0}{P}\right)^{(1-\gamma)/\gamma} \times W
\]
\[
\therefore P = (1 + \mu)^{1-\gamma} \left(\frac{P_0}{P}\right)^{(1-\gamma)/\gamma} P^e f\left(1 - \frac{Y}{L}, z\right)
\]

$\gamma$ is the cost share of labor in production
$O$ is the input of oil into production
N is the input of labour into production

\( P_0 \) is the price of oil

**The Phillips Curve**

**Deriving the Phillips Curve**

Inflation: \( 1 + \pi = \frac{P_t}{P_{t-1}} \)

Expected inflation: \( 1 + \pi^e = \frac{P^e_t}{P^e_{t-1}} \)

\[
P = (1 + \mu)P^e f(u, z) \]

\[
P = (1 + \mu)P^e (1 - \alpha u + z) \]

\[
\frac{P}{P_{t-1}} = \frac{(1 + \mu)(P^e)}{P^e_{t-1}} (1 - \alpha u + z) \]

\[
(1 + \pi) = (1 + \mu)(1 + \pi^e)(1 - \alpha u + z) \]

\[
\pi = \pi^e - \alpha u + (\mu + z) \]

**Original Phillips Curve**

Assume \( \pi^e_t, \mu, z \) all held constant

\[ \therefore \pi_t = -\alpha u_t + \text{constant} \]

**Augmented Phillips Curve**

Suppose \( \pi^e_t = \theta \pi_{t-1} \): adaptive expectations

\[ \therefore \pi_t = \theta \pi_{t-1} - \alpha u_t + (\mu + z) \]

**Natural Rate of Unemployment**

Where \( P = P^e \) or equivalently \( \pi = \pi^e \) (medium run equilibrium):

\[
0 = -\alpha u_n + (\mu + z) \]

\[
\alpha u_n = (\mu + z) \]

\[
u_n = \frac{\mu + z}{\alpha} \]

**Accelerationist Phillips Curve**

\[
\pi_t = \theta \pi_{t-1} - \alpha u_t + (\mu + z) \]

\[
i_t = \pi_t - \theta \pi_{t-1} = -\alpha u_t + \alpha u_n \]

\[
i_t = \theta \pi_{t-1} + \alpha u_n - \alpha u_t \]

\[
i_t = \theta \pi_{t-1} = \alpha(u_n - u_t) \]

**Dynamic AS-AD Model**

**Five Basic Equations**

\[
Y_t = Y_t - \alpha(r_t - \rho) + \epsilon_t \quad (1) \]

\[
r_t = i_t - E_t \pi_{t+1} \quad (2) \]

\[
i_t = \pi_t = E_{t-1} \pi_t + \phi(Y_t - \bar{Y}_t) + \nu_t \quad (3) \]

\[
E_{t-1} \pi_t = \pi_{t-1} \quad (4) \]

\[
E_t \pi_{t+1} = \pi_t \quad (4a) \]

\[
i_t = \pi_t + \rho + \theta_{\pi}(\pi_t - \pi^*_t) + \theta_{y}(Y_t - \bar{Y}_t) \quad (5) \]

**Equilibrium Conditions**

\[
Y_t = \bar{Y}_t \]
Meaning of Terms
$Y_t$: level of real output at date $t$
$\bar{Y}_t$: natural level of output at date $t$
$r_t$: real interest rate
$i_t$: nominal interest rate
$\rho$: natural real rate of interest ($\rho > 0$)
$\varepsilon_t$: random shifts in aggregate demand, mean zero $E(\varepsilon_t) = 0$
$\pi_{t+1}$: inflation rate between period $t$ and period $t + 1$
$\pi_t^*$: the inflation target at period $t$
$E_t(x)$: expectations of $x$ conditional on information available at date $t$
$\phi$: sensitivity of inflation to output gap
$\nu_t$: random shifts in aggregate supply

Dynamic AS Curve
This is found by substituting equation 4 into equation 3

Upward sloping relation between real output and inflation: $\pi_t = \pi_{t-1} + \phi(Y_t - \bar{Y}_t) + \nu_t$

Dynamic AD Curve
This is found by substituting equation 4 into equation 2, then substituting equation 5 into the result. The result of these manipulations is in turn substituted into equation 1

Downward sloping relation between real output and inflation: $Y_t = \bar{Y}_t - \frac{\alpha\theta}{\alpha + \alpha\gamma}(\pi_t - \pi_t^*) + \frac{1}{\alpha + \alpha\gamma}\varepsilon_t$

The Solow Model

Aggregate Production Function
- Relationship between economy-wide output and inputs, capital and labor: $Y = F(K, N)$
- Exhibits positive but diminishing returns to capital and labour

Output per Worker

$$\frac{Y}{N} = \frac{F(K, N)}{N} = F\left(\frac{K}{N}, \frac{N}{N}\right) = F\left(\frac{K}{N}, 1\right)$$

Capital Accumulation
Change in capital stock per worker given by investment per worker less depreciation per worker

$$I = S = sY$$

$$\frac{K_{t+1} - K_t}{N} = I_t - \delta K_t$$

$$\frac{K_{t+1}}{N} - \frac{K_t}{N} = \frac{I_t}{N} - \frac{\delta K_t}{N}$$
\[
\frac{K_{t+1}}{N} - \frac{K_t}{N} = sY - \delta K_t \\
\frac{K_{t+1}}{N} - \frac{K_t}{N} = sf(\frac{K_t}{N}) - \delta \frac{K_t}{N}
\]

Consumption Golden Rule
Consumption levels in the steady state given by
\[
\frac{C}{N} = (1 - s) \left(\frac{Y}{N}\right) \\
\frac{C^*}{N} = (1 - s) \frac{s}{\delta}
\]

The Steady State
\[
\frac{Y}{s} = \delta \frac{K}{N}
\]

Growth Approximation Rule
\[
g_Y \approx \ln Y_1 - \ln Y_2 \\
g_K \approx \ln K_1 - \ln K_2
\]

Technological Progress and Growth

Aggregate Production Function
- Technological progress reduces number of workers or capital needed to achieve given output \( Y \) (real cost reduction): \( Y = f(K, AN) \)
- Technological progress increases \( AN \), effective amount of labor

Output per Effective Worker
\[
\frac{Y}{AN} = \frac{F(K, AN)}{AN} = F\left(\frac{K}{AN}\right)
\]

Growth Rates
\[
\frac{Y_{t+1}}{Y_t} = 1 + g_Y; \quad \frac{A_{t+1}}{A_t} = 1 + g_A; \quad \frac{N_{t+1}}{N_t} = 1 + g_N
\]
\[
\therefore \quad \frac{Y_{t+1}N_t + A_{t+1}N_{t+1}}{A_tN_t} = \frac{1 + g_Y}{(1 + g_A)(1 + g_N)} \approx 1 + g_Y - g_N - g_A
\]

Capital Accumulation
Change in capital stock per effective worker given by investment (savings) per effective worker less depreciation per effective worker (effective depreciation)
\[
(1 + g_A + g_N)\left(\frac{K_{t+1}}{A_{t+1}N_{t+1}} - \frac{K_t}{A_tN_t}\right) = sf(\frac{K_t}{A_tN_t}) - (g_A + g_N + \delta) \frac{K_t}{A_tN_t}
\]

Balanced Growth
Occurs when \( \frac{K}{AN} \) and \( \frac{Y}{AN} \) are constant, which also means that \( \frac{Y_{t+1}}{Y_t} = \frac{K_{t+1}}{K_t} = 1 + g_A + g_N \)
Steady State

\[ s \left( \frac{Y}{AN} \right) = (\delta + g_A + g_N) \left( \frac{K}{AN} \right) \]

Technological Progress and Employment

Augmented AS Curve

\[ P = P^e (1 + \mu) \frac{A^e Y}{A^e LA} \]

Employment and Output

\[ N = \frac{Y}{A} \]

Growth Rates

\[ g_N = g_Y - g_A \]

Open Economy Basics

The Real Exchange Rate

\[ \varepsilon = \frac{P}{P^e} = \frac{EP}{P^e} \]

Savings, Investment and Net Exports

\[ Y = C + I + G + NX \]
\[ S = Y - T - C \]
\[ = (C + I + G + NX) - T - C \]
\[ = I + G - T + NX \]
\[ NX = (S - I) + (T - G) \]

The Marshall-Lerner Condition

\[ NX = X - IM/\varepsilon \]
\[ = X(Y^{++}, \varepsilon^-) - \frac{IM(Y^+, \varepsilon^+)}{\varepsilon} \]
\[ = f(Y^{++}, Y^+, \varepsilon^-) \]

If this last step is satisfied, then the Marshall-Lerner condition is said to hold

Open Economy IS-LM Model

The Demand for Goods

\[ Z = C + I + G + X - IM/\varepsilon \]
\[ Z = C(Y - T) + I(Y^+, r^-) + G + X(Y^{++}, \varepsilon^-) - IM(Y^+, \varepsilon^+)/\varepsilon \]

If \( P = P^* = \text{constant} \) and \( r = i \) then

\[ Z = C(Y - T) + I(Y^+, i^-) + G + NX(Y^+, Y^{++}, E^-) \]

Exchange Rate and Interest Rates

\[ 1 + i_t = (1 + i_t^*) \frac{E_t}{E_{t+1}^e} \]
\[ i_t \approx i_t^* - \frac{E_{t+1}^e - E_t}{E_t} \]
If $E_{t+1}^e$ is constant then

$$E_t = \frac{(1 + i_t)}{(1 + i_t^e)} E^e$$

New IS-LM Equations

$$IS: \quad Y = C(Y - T) + I(Y, i) + G + NX \left( Y, Y^*, \frac{(1 + i_t)}{(1 + i_t^e)} E^e \right)$$

$$LM: \quad \frac{M}{P} = YL(i_0)$$

Where $Y^*$ is foreign GDP and $i_0$ is the RBA interest rate target

Open Economy Equilibrium Condition

$$Y = C(Y - T) + I(Y, i^* - \pi^e) + G + NX \left( Y, Y^*, \frac{\bar{E} P}{P^*} \right)$$

Where $\bar{E}$ is the fixed nominal exchange rate and $i^*$ are foreign interest rates (equal to $i$)

Exchange Rate Crisis Equation

$$E_t = \frac{(1 + i_t)}{(1 + i_t^e)} E_{t+1}^e$$
Part 6: Special Exam Notes

- One’s stock of wealth must all be either in money or stocks. Hence \( W = M^d + B^d \)
- To find multiplier, write accounting identity, expand brackets, subtract all terms with \( Y \) in them to the other side, then simplify for \( Y \)
- To find equilibrium in IS-LM model, equate the two curve equations and then solve for \( Y \) and \( i \)
- Demand for bonds increases with wealth, but actually declines with income (look at the equations), so income only raises demand for bonds if it also increases wealth
- When calculating fiscal and monetary policy multipliers, differentiate the equilibrium GDP equation (e.g. relative to \( i \)), not just the national income accounting identity, as this does not endogenise changes in the interest rate
- Flatter IS or LM curves mean that that type of policy is more effective (i.e. bigger effect on output)
- The natural rate of output is determined as a medium-run equilibrium condition in the labor market, the information is then transferred to the AS relation
- The AS curve is derived from the wage and price-setting relation; it is also very closely related to the Phillips curve
- The slope of the AD curve relates to the stickiness of wages and prices
- Note that the wage and price setting curves are used to find the natural rate of unemployment. Do not try to use them with the AS-AD curve, which deals with cyclical unemployment!
- If there is a credible fixed exchange rate, foreign and domestic interest rates must be equal
- Balanced budget multiplier changes if investment made endogenous
- The original Phillips curve does not imply there is no natural rate of unemployment
- Fisher hypothesis: Real interest rate = Nominal Interest Rate - Expected Inflation Rate
- The Marshall-Lerner condition is satisfied when a reduction in the real exchange rate leads to an increase in net exports
- The Mundell-Fleming Model is simply the open economy version of the IS-LM model
- If the interest rate is close to zero so that the LM curve is very flat, fiscal policy is very effective
- The natural rate of interest is the rate of interest that prevails at medium run equilibrium. Shifts in \( G \) or \( I \) will change it permanently.

The IS Curve

\[
Y = C + I + G \\
Y = \frac{1}{1 - c_1 - b_1}(c_0 - c_1 T + b_0 - b_2 i + G)
\]

The LM Curve

Financial market equilibrium: \( M = P Y L(i) \)

Labour Market

\[
W = P^e f(u, z) \\
P = (1 + \mu)W \\
\frac{1}{1 + \mu} = f(u_n, z)
\]

Taxed Labour Market

\[
P = (1 + \mu)W(1 + t) \\
(1 - \tau)W = Pf(u, z)
\]

Static AS Curve
\[ P = (1 + \mu) P^e f \left( 1 - \frac{Y}{L}, z \right) \]

**The Phillips Curve**

\[ \pi = \pi^e - \alpha u + (\mu + z) \]

\[ \pi_t - \theta \pi_{t-1} = \alpha (u_n - u_t) \]

**Natural Rate of Unemployment**

Where \( P = P^e \) or equivalently \( \pi = \pi^e \) (medium run equilibrium):

**Solow Model**

\[ \frac{Y}{AN} = F \left( \frac{K}{AN} \right) \]

**Growth Approximation Rule**

\[ g_y \approx \ln Y_1 - \ln Y_2 \]

\[ g_K \approx \ln K_1 - \ln K_2 \]

**Steady State Output**

\[ s \left( \frac{Y}{AN} \right) = (\delta + g_A + g_n) \left( \frac{K}{AN} \right) \]

**Steady State Consumption**

\[ \frac{C}{AN} = (1 - s) \frac{Y}{AN} \]

**Technological Progress and Employment**

\[ P = P^e (1 + \mu) \frac{A^e}{A} \frac{Y}{LA} \]

\[ N = \frac{Y}{A} \]

**Real Exchange Rate**

\[ \varepsilon = \frac{P}{P^*/E} = \frac{EP}{P^*} \]

**Open Economy Output**

\[ NX = X - IM/\varepsilon \]

\[ Z = C + I + G + X - IM/\varepsilon \]

**Exchange Rates and Interest Rates**

\[ i_t = i_t^* - \frac{E_{t+1}^e - E_t}{E_t} \]

\[ E_t = \frac{(1 + i_t)}{(1 + i_t^*)} \frac{E^e}{E_t} \]