Investment

- This topic is related to consumption
  - Emphasis at this level on <u>microfoundations</u>

- Material quite closely follows chapter section on investment in Carlin and Soskice (2006) – scanned copy is available through the VLE reading list.

Investment

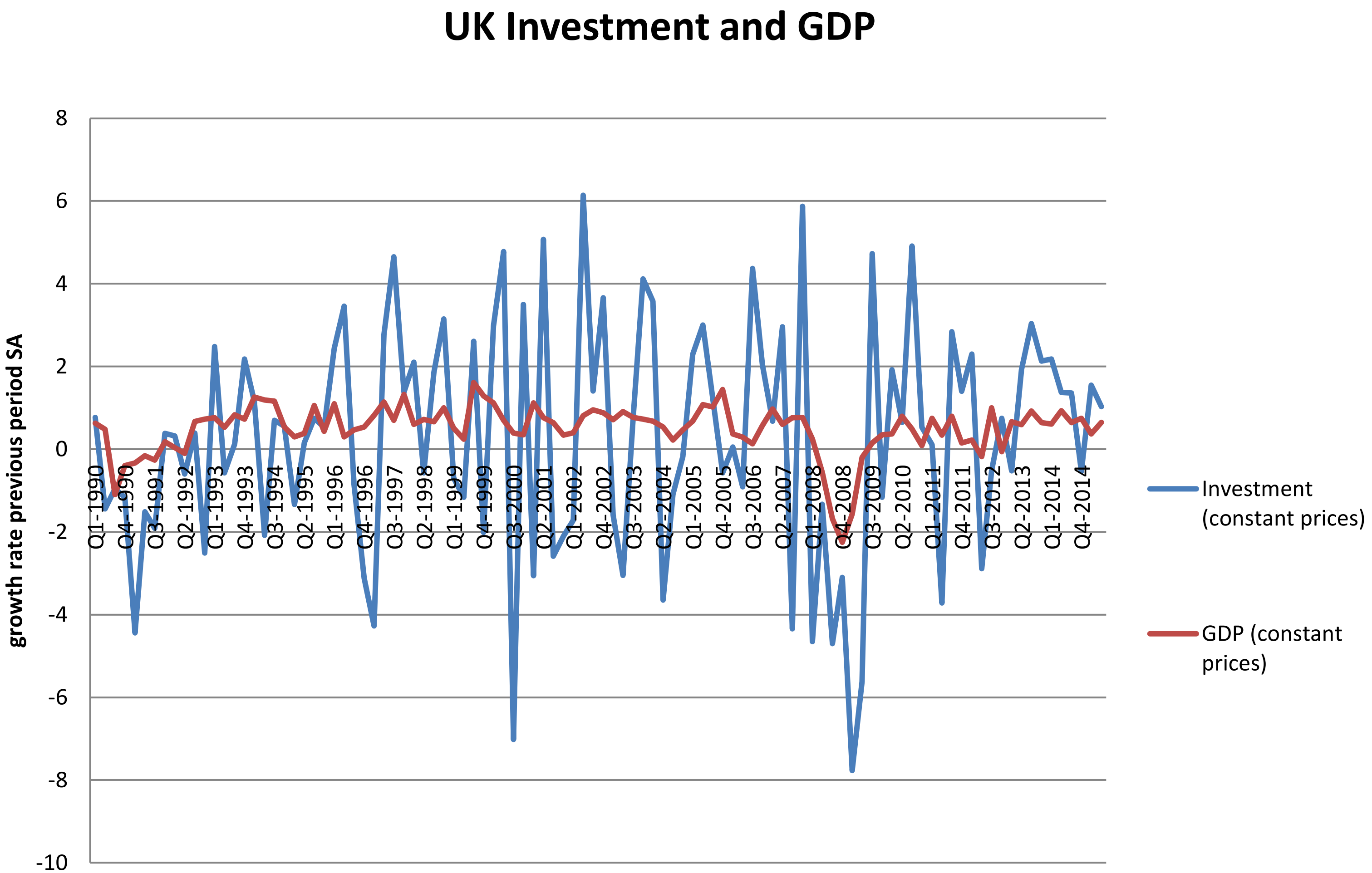
Types of Investment

- Business fixed investment (plant and machinery) – “Fixed Capital Formation”
- Residential Investment (dwellings)
- Inventory Investment (stocks of goods)

We shall concentrate on the first of these

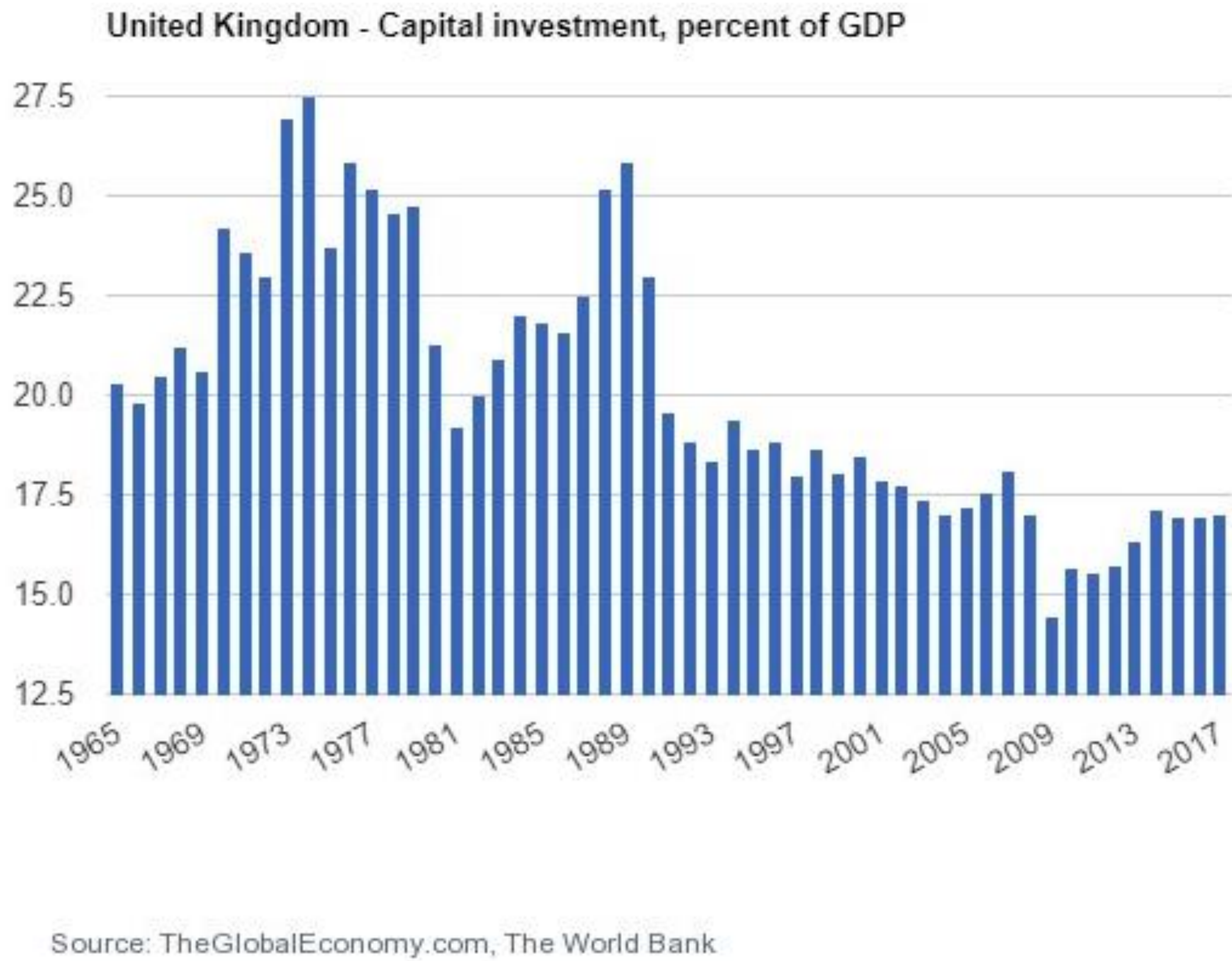
- Of all the components of GDP, investment is the most volatile.
- See next slide for UK data

Investment



UK Investment and GDP
growth rate previous period SA
8
6
4
2
0
-2
-4
-6
-8
-10
Q1-1990
Q4-1990
Q3-1991
Q2-1992
Q1-1993
Q4-1993
Q3-1994
Q2-1995
Q1-1996
Q4-1996
Q3-1997
Q2-1998
Q1-1999
Q4-1999
Q3-2000
Q2-2001
Q1-2002
Q4-2002
Q3-2003
Q2-2004
Q1-2005
Q4-2005
Q3-2006
Q2-2007
Q1-2008
Q4-2008
Q3-2009
Q2-2010
Q1-2011
Q4-2011
Q3-2012
Q2-2013
Q1-2014
Q4-2014
Investment (constant prices)
GDP (constant prices)

Investment


United Kingdom - Capital investment, percent of GDP
27.5
25.0
22.5
20.0
17.5
15.0
12.5
1965
1969
1973
1977
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
Source: TheGlobalEconomy.com, The World Bank

Microfounded Investment

Firms are assumed to be profit-maximisers

(One justification: this is a legal requirement for PLCs)

Suppose revenue in all periods into the future from a capital stock of K is:

$$Pf(K)$$

where P is the (fixed) price level and f is the production function (labour does not enter here by Occam's Razor)

Microfounded Investment

If the real interest rate is constant, then the Net Present Value of this revenue stream is:

$$V_0 = \frac{1}{1+r}Pf(K) + \frac{1}{(1+r)^2}Pf(K) + \frac{1}{(1+r)^3}Pf(K) + \cdots$$

Hence

$$V_0 = \frac{Pf(K)}{r}$$

Microfounded Investment

Firms choose *investment* to maximize profits:

$$\Pi = \frac{Pf(I_t + K_{t-1})}{r} - C(I)$$

where $C(I)$ are investment costs.

We will consider three cases:

1. Perfect competition and no adjustment costs
2. Perfect competition and adjustment costs – Tobin's Q model of investment
3. Imperfect competition and no adjustment costs

Microfounded Investment

1. Perfect competition and no adjustment costs

Investment costs:

$$C(I) = P_I I$$

Where P_I is the exogenous price of investment goods and *I* is the volume of investment undertaken.

Microfounded Investment

1. Perfect competition and no adjustment costs

Profit-maximization at t=0 means maximization of:

$$\frac{Pf(I + K_{-1})}{r} - P_I I$$

Which requires

$$\frac{Pf'(K)}{r} - P_I = 0$$

hence

$$\frac{Pf'(K)}{rP_I} = 1$$

and $\frac{Pf'(K)}{rP_I} \equiv q$ (or 'marginal q')

Microfounded Investment

1. Perfect competition and no adjustment costs

$$\frac{Pf'(K)}{rP_I} \equiv q$$ (or ‘marginal q’)

- The numerator – the marginal *value* product of capital
- The denominator – the ‘user cost of capital’

Microfounded Investment

1. Perfect competition and no adjustment costs

At the optimum,

$$\frac{Pf'(K^*)}{rP_I} = 1$$

$$f'(K^*) = \frac{rP_I}{P}$$

e.g. $f(K) = K^{0.5}$, then

$$0.5(K^*)^{-0.5} = \frac{rP_I}{P}$$

Microfounded Investment

1. Perfect competition and no adjustment costs

and

$$(K^*)^{-0.5} = \frac{2rP_I}{P}$$

$$K^* = \left(\frac{2rP_I}{P}\right)^{-\frac{1}{0.5}} = \left(\frac{2rP_I}{P}\right)^{-2} = \left(\frac{P}{2rP_I}\right)^2$$

Hence

$$I^* = K^* - K_{-1} = \left(\frac{P}{2rP_I}\right)^2 - K_{-1}$$

Microfounded Investment

1. Perfect competition and no adjustment costs

In general

$$I = I(r, P_I, P)$$

(underpinning the IS curve)

Investment:

- Falls with the interest rate
- Falls in the price of investment goods
- Increases in the price of final output goods

Microfounded Investment

2. Perfect competition and adjustment costs: Tobin's Q model of Investment

- e.g. costs associated with training workers to use new capital
- Adjustment costs normally assumed to be quadratic in the amount of investment:

$$C(I) = P_I I + \left(\frac{a}{2}\right) P_I I^2$$

Microfounded Investment

2. Perfect competition and adjustment costs: Tobin's Q model of Investment

Analysis now incorporates depreciation, hence

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

To simplify, assume linear production: $y = f_K K$, where f_K is the constant marginal product of capital.

Microfounded Investment

2. Perfect competition and adjustment costs: Tobin's Q model of Investment

Firm now chooses *I* to maximize:

$$\frac{Pf_K K}{1+r} + \frac{Pf_K K(1-\delta)}{(1+r)^2} + \cdots - P_I I - \left(\frac{a}{2}\right) P_I I^2$$

Which simplifies to

$$\frac{Pf_K(I_t + (1-\delta)K_{t-1})}{r+\delta} - P_I I - \left(\frac{a}{2}\right) P_I I^2$$

Microfounded Investment

2. Perfect competition and adjustment costs: Tobin's Q model of Investment

The first-order condition is

$$\frac{Pf_K}{r+\delta} - P_I - aP_I I = 0$$

Which implies

$$I = \frac{1}{a}\left(\frac{Pf_K}{P_I(r+\delta)} - 1\right)$$

Microfounded Investment

2. Perfect competition and adjustment costs: Tobin's Q model of Investment

i.e.

$$I = \frac{1}{a}(q - 1)$$

Note that q is a *sufficient* determinant of I.

Microfounded Investment

2. Perfect competition and adjustment costs: Tobin's Q model of Investment

- Greater adjustment costs (a)
  - *dampen* response of I to all other drivers
  - Could cause higher or lower I depending on whether $q \gtrless 1$.
- Greater value of marginal product of capital (Pf_K)
  - Increases investment (e.g. induced by technological progress or demand)

Microfounded Investment

2. Perfect competition and adjustment costs: Tobin's Q model of Investment

- Increases in *Relative* prices of capital goods (P_I/P)
  - reduces I
  - e.g. investment subsidies
- Increases in the real interest rate (r)
  - Reduces investment
- Increases in the depreciation rate (δ)
  - Reduces investment

Microfounded Investment

2. Perfect competition and adjustment costs: Tobin's Q model of Investment

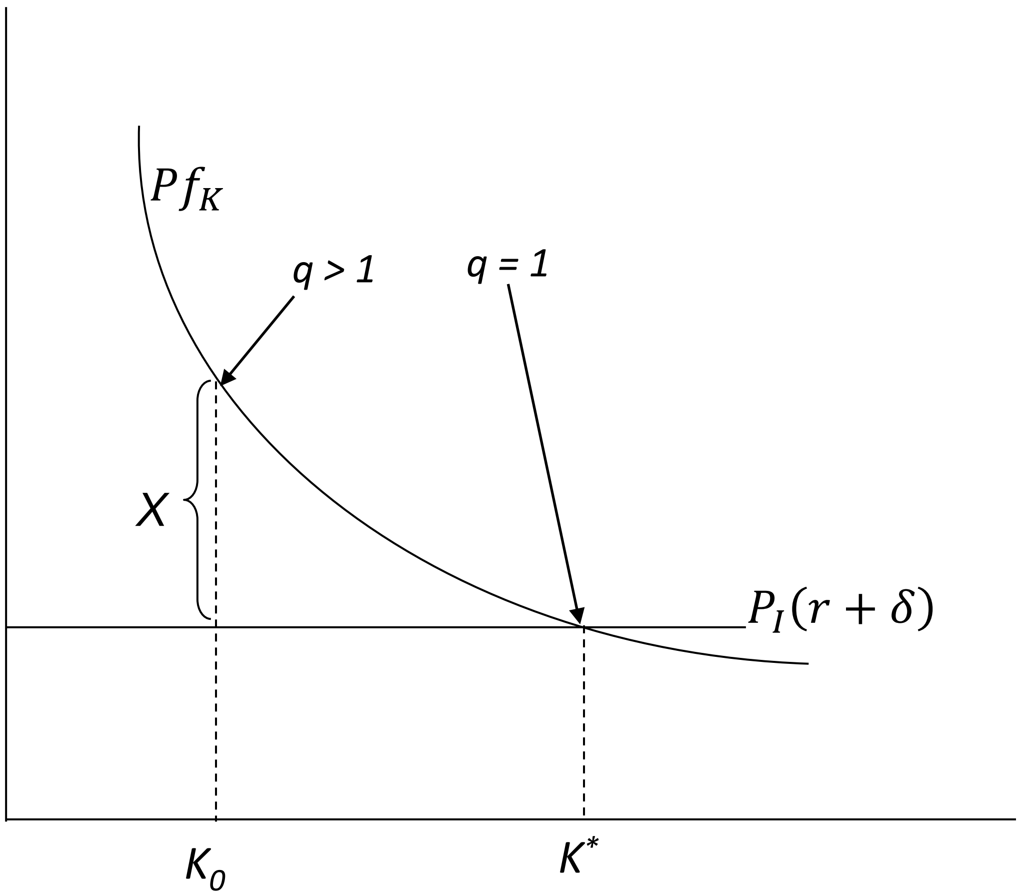
Measuring q

Recall $I = \frac{1}{a}(q - 1)$ and $q = \frac{Pf_K}{P_I(r+\delta)}$.

Suppose a small change in the capital stock of a firm. Then

$$q = \frac{\Delta\text{Market Value}}{\text{purchase price of additional capital goods}}$$

Tobin's *q* Model of investment



- Firms with a capital stock of K_0 receive revenue of *X* above cost of capital on each additional unit of *K*
- The market value of firm depends on expected future profits.
- Because of *X* the market will place a high value on firm - so (q > 1)
- Investment will take *K* to K^* where $q = 1$

Microfounded Investment

2. Perfect competition and adjustment costs: Tobin's Q model of Investment

Defining (average) Q:

$$Q = \frac{\text{Market Value}}{\text{replacement cost of capital stock}}$$

Q and q are related, but also Q is observable (i.e. at the level of the firm.)

Microfounded Investment

2. Perfect competition and adjustment costs: Tobin's Q model of Investment

$$Q = \frac{\text{Market Value}}{\text{replacement cost of capital stock}}$$

The role of Q in a simple example:

- Average market price of house: £200,000
- Cost to build a new house: £120,000
- Tobin's $Q = \frac{£200{,}000}{£120{,}000} = 1.67$
- Since $Q > 1$ investment (building) will take place

Microfounded Investment

3. Imperfect competition and no adjustment costs

- Price now endogenous, with demand curve:

$$y_i = P_i^{-\eta}\left(\frac{Y}{n}\right) \Leftrightarrow P_i \quad = y_i^{-\frac{1}{\eta}}\left(\frac{Y}{n}\right)^{\frac{1}{\eta}}$$

Where *Y* is aggregate demand, η is the elasticity of demand and n is the number of sectors (each firm is a sector: i=1,…,n).

Microfounded Investment

3. Imperfect competition and no adjustment costs

Issue: if the firm increases K_i, it now results in a fall in price.

Choice of investment level maximizes:

$$\frac{P_i f(K_i)}{r+\delta} - P_I I_i$$

With First Order Condition (FOC):

$$\frac{1}{r+\delta}\frac{\partial\left(P_i f(K_i)\right)}{\partial I_i} - P_I = 0$$

Microfounded Investment

3. Imperfect competition and no adjustment costs

In the (simplifying) situation of $y_i = f(K_i) = K_i$

$$\frac{\partial\big(P_i f(K_i)\big)}{\partial I_i} = \frac{\partial\left(y_i^{-\frac{1}{\eta}}\left(\frac{Y}{n}\right)^{\frac{1}{\eta}}K_i\right)}{\partial I_i}$$

$$= \frac{\partial\left(K_i^{-\frac{1}{\eta}}\left(\frac{Y}{n}\right)^{\frac{1}{\eta}}K_i\right)}{\partial I_i} = \frac{\partial\left(K_i^{1-\frac{1}{\eta}}\left(\frac{Y}{n}\right)^{\frac{1}{\eta}}\right)}{\partial I_i}$$

Microfounded Investment

3. Imperfect competition and no adjustment costs

Note that $K_i = (1-\delta)K_{i,t-1} + I_i$, hence

$$\frac{\partial\big(P_i f(K_i)\big)}{\partial I_i} = \frac{(\eta - 1)}{\eta}\left(\frac{Y}{n}\right)^{\frac{1}{\eta}} K_i^{-\frac{1}{\eta}}$$

Substituting this into the FOC above, then

$$\frac{1}{r+\delta}\frac{(\eta - 1)}{\eta}\left(\frac{Y}{n}\right)^{\frac{1}{\eta}} K_i^{-\frac{1}{\eta}} - P_I = 0$$

Microfounded Investment

3. Imperfect competition and no adjustment costs

Hence

$$K_i \quad = \left(\frac{\eta - 1}{\eta(r + \delta)P_I}\right)^{\eta} \frac{Y}{n}$$

And so using $I_i = K_i - (1 - \delta)K_{i,t-1}$ then

$$I_i = \frac{1}{n}\left(\frac{\eta - 1}{\eta(r + \delta)P_I}\right)^{\eta} (Y - (1 - \delta)Y_{t-1})$$

This is the <u>accelerator</u> model of investment.

Evidence

- Microfounded theories argue for the importance of:
  - q (or Q) – which depends on the ratio of the market value of the firm and the replacement cost of capital (in the case of competition in goods markets)
  - Economic growth – or ‘scale’ effects (in the case of imperfect competition)

- Empirically the former seem to be unimportant relative to the latter

Evidence

Why?

- Real (goods) markets are imperfect?
- Observed market value (share price*number of shares – or ‘market capitalization’) a poor measure of true market value (i.e. capital markets arguably not fully efficient, and subject to noise trade)
- Investment is ‘lumpy’ – hence *observed* Q>1, but investment may still not take place
  - Observed data on investment is also *very* discontinuous

Evidence

Why?

- Cash flow & Credit constraints
  - Reminiscent of empirical consumption findings: ‘excess sensitivity’ to cashflow
- The role of uncertainty & risk aversion
  - Entails ‘option value’ to *not* investing
  - Hence expected rate of return must be meaningfully higher than investment costs

Conclusions

- Investment remains difficult to understand, specify or certainly forecast.
- The emphasis here is on microfounded decisions – whether embedded in:
  - Competitive markets – Tobin's Q model of investment – arguing that $\mathrm{Q} = \frac{\text{Market Value}}{\text{replacement cost of capital stock}}$ is a <u>sufficient</u> determinant of investment
  - Imperfect competition – emphasising <u>scale</u>-economies – and giving an underpinning for the Accelerator model