IMF Working Paper

What Happens if Central Banks Misdiagnose a Slowdown in Potential Output Growth?

by Bas B. Bakker

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What happens if Central Banks misdiagnose a Slowdown in Potential Output Growth?

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Abstract

In the last few decades, real GDP growth and investment in advanced countries have declined in tandem. This slowdown was not the result of weak *demand* (there has been no shift along the Okun curve), but of a decline in *potential* output growth (which has shifted the Okun curve to the left). We analyze what happens if central banks mistakenly diagnose the problem as insufficient demand, when it is actually a supply problem. We do this in a *real* model, in which inflation is not an issue. We show that aggressive central bank action may revive *gross* investment, but it will not revive *net* investment or growth. Moreover, low interest rates will lead to an increase in the capital output ratio, a low return on capital and high leverage. We show that these forecasts are in line with what has happened in major advanced countries.

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[1] This paper has benefited from extensive discussions with Joshua Felman and from comments of Leslie Lipschitz, Natasha Che, Jaiqian Chen, Wenjie Chen, Antonio David, Manuk Ghazanchyan, David Hofman, Gee Hee Hong, Marta Korczak, Krzysztof Krogulski, Alvar Kangur, Li Lin, Erik Lundback Tonny Lybek, Pamela Madrid, Thomas McGregor, Roland Meeks, Gabor Pula, Tobias Roy, Sergio Sola, Emil Stavrev, and Frederik Toscani. All remaining errors are the sole responsibility of the author.

Contents

1 Introduction and Executive Summary

In the last few decades, advanced countries have seen a sharp deterioration in their key macroeconomic indicators:

- Between 1990 and 2000, real GDP grew by 2.9 percent annually; between 2008 and 2018, by 1.5 percent only.

- In the five years ending in 1990, gross investment rates averaged about 25 percent of GDP; in the five years ending in 2018, 21 percent only.

- Real short-term interest rates have fallen from about 4 percent in the five years ending in 1990 to -1 percent in the five years ending in 2018.

What explains this combination of falling output growth, declining investment rates and falling interest rates? The standard answer is that aggregate *demand* is weak (Summers (2014)). But if lack of demand were the problem, Okun's Law states that we should be seeing high rates of unemployment. And this is not what has happened. In the last five years, unemployment rates in advanced countries have come down very rapidly, despite very weak demand (Figures 1.1 and 1.2). The fall in unemployment was not the result of drop in labor-force participation; instead the employment to working age population has increased rapidly (Figure 1.3).

A fall in *potential output growth* can explain the combination of low growth and a rapid fall in unemployment. If potential output growth falls, the GDP growth rate associated with constant unemployment falls.

The slowdown is not a post-crisis issue only, but started in the early 1990s. IMF WEO estimates show that potential output growth in advanced countries has fallen from 3.2 percent in 1990 to 1.7 percent in 2018 (Figure 1.4).

Central banks, like other economists, initially missed the slowdown in potential output growth. In Japan in the 1990s, and the United Kingdom, the euro area and the United States in the 2000s, they thought that weakness in growth was *cyclical* and that potential output growth had remained strong (section 2).

What happens if central banks misdiagnose a slowdown in potential output growth? Does it really matter if they diagnose the problem as insufficient demand, when it is actually a supply problem? The standard reply is that monetary easing in reacting to a slowdown in potential output growth should lead to an increase in inflation. And since inflation in advanced countries has so far remained low, loose monetary policy is not a problem, in this view. It should be noted, however, that inflation also fell during the recoveries in the 1980s and 1990s (Figure 1.5).

But let's leave inflation aside. What is the impact on the real sector of a loosening of monetary policy when potential output falls? To answer this question we will consider a *real* model, where there is no inflation. We develop a production function-based model of potential output (section 3). In this model, output depends on the capital stock, the working age population, and labor-augmenting technological progress. We assume that wages are flexible; labor is fully employed. The labor force grows in in line with the

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working age population. Firms will expand the capital stock until the marginal product of capital is equal to the cost of capital (r_c) plus depreciation (δ). The cost of capital depends on the policy rate.

What happens if the growth rate of the working age population (n) and labor augmenting technological progress (g) falls?

- If the cost of capital *remains unchanged*, the growth rate of the capital stock and thus potential output will slow in line with the reduction in $n + g$.

- If the cost of capital *falls*, the growth rate of the capital stock will initially decline by less than the reduction in $n + g$. As a result, the decline in potential output growth will be mitigated. However, the capital output ratio will rise,[1] and the return on capital will fall. In the new equilibrium, the capital-output ratio is higher, the return on capital has declined in line with the reduced cost of capital, while growth has fallen back to $n + g$.

We next derive an investment equation for the steady state, where the gross investment to GDP ratio i is constant and GDP grows at rate $n + g$ (section 4). We show that the investment rate depends on $n + g$ and on the cost of capital. What happens if $n + g$ falls?

- If the cost of capital remain constant, the gross investment to GDP ratio will fall in line with $n + g$.

- If the cost of capital falls, *gross* investment will fall by less. With higher investment, the capital-output ratio will rise, capital consumption will increase, and *net* investment will fall back. We show that aggressive central bank action may revive *gross* investment, but not *net* investment or growth. The more aggressive central banks are, the more $\frac{K}{Y}$ rises.

Low interest rates may also trigger a change on the *liability* side, i.e., an increase in leverage. Firms can increase leverage by financing new investment with debt only. They can also issue debt to buy back shares. Increased leverage raises vulnerability of economies.

In short, the model predicts that if $n + g$ declines and interest rates are reduced, then potential output growth will fall, gross investment may or may not fall, capital consumption will rise, net investment will fall, the capital-output ratio will rise, returns on capital will fall, and leverage will increase. The predictions of this model are similar to what has actually happened in most advanced countries (section 5).

It may seem counter-intuitive that a decline in investment would coincide with an increase in the capital-output ratio. With capital-output ratios well above 1, a change in the investment-to-GDP ratio has only a modest impact on the growth rate of the capital stock. For example, if the capital-output ratio is 3, a one percentage point higher investment rate will lead to a $\frac{1}{3}$ percentage point higher growth rate of the capital stock

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[1]To see this, note that there are declining returns to scale, if only one of the production factors is increased.

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only. The flip-side is that to get a meaningful *reduction* in the growth rate of the capital stock, you need a large decline in the investment rate. If $n + g$ falls from 4 to 1, the growth rate of the capital stock needs to fall from 4 to 1 percent. With a capital-output ratio of 3, the investment rate needs to fall by 9 percentage points. If it falls by less, the capital-output ratio will increase.

The history of Japan since the early 1990s is a particularly striking example of the mechanisms outlined (section 6) In the early 1990s, $n + g$ dropped sharply. Aggressive monetary policy led to a sharp increase in the capital-output ratio, but the impact on growth was only temporary. The new equilibrium was one of low growth, a high capital-output ratio, and a low return on investment.[2]

So far we have argued that low investment rates are the result of low growth—not the cause. But could the causality have gone the other way around (section 7)? In the model above, it is true that an exogenous reduction in investment rates will lead to lower GDP levels (assuming $n + g$ remains unchanged), and in the near term to lower GDP growth. However, they will also be accompanied by a falling capital-output ratios, and increasing returns on capital—two factors that are at odds with what we observe in practice.

The results in this paper suggests that the often-held view that investment in advanced countries is "too low" may not be correct (section 8). Investment is indeed lower than in the past, but this is because $n + g$ has fallen. Raising investment without a corresponding increase in TFP or working age population growth may simply further boost capital-output ratios and further reduce the return on investment.

Indeed, if a country with low $n + g$ has high gross investment, it will not end up with high growth, but with high capital consumption. Take Japan and the United Kingdom. Japan has a *gross* investment rate of 24 percent, vs 17 percent for the United Kingdom.[3] But capital consumption in Japan is 22 percent of GDP, versus 12 percent for the United Kingdom.[4] *Net* investment in the United Kingdom is therefore higher than in Japan, which—together with faster working age population growth—helps explain why the United Kingdom, at 2 percent, is growing faster than Japan (1 percent).

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[2]Note that a low return on investment can coincide with a high share of profits in GDP. $r = \alpha \frac{Y}{K}$ If α (the profit share) is high, but $\frac{Y}{K}$ is low, the return on capital will be low.

[3]All numbers refer to averages over the past five years.

[4]Capital consumption numbers are from the national accounts.

Figure 1.1. Advanced Economies: Unemployment Rate

(Percent)
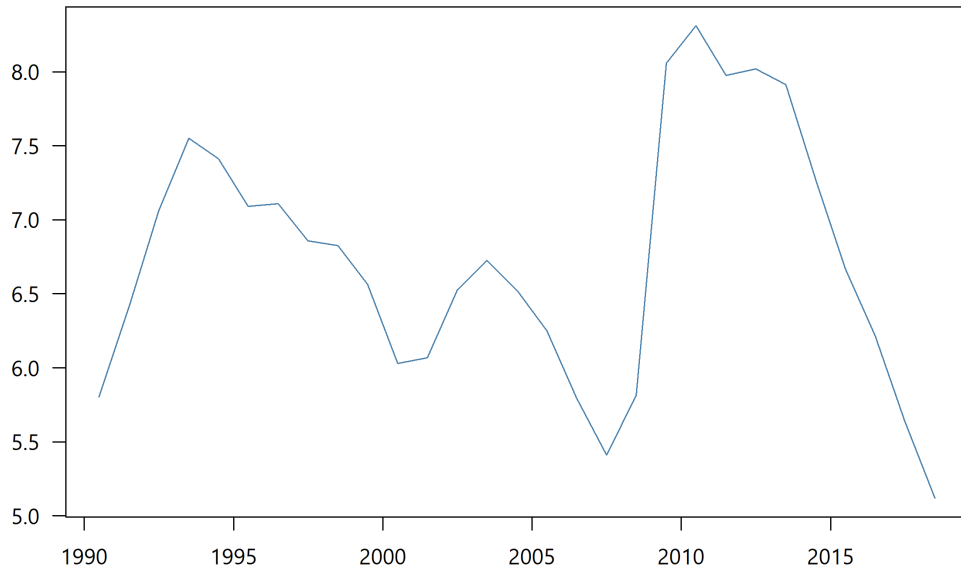
Figure 1.2: Advanced Countries: GDP growth and Change in Unemployment Rate

(Five-year periods)

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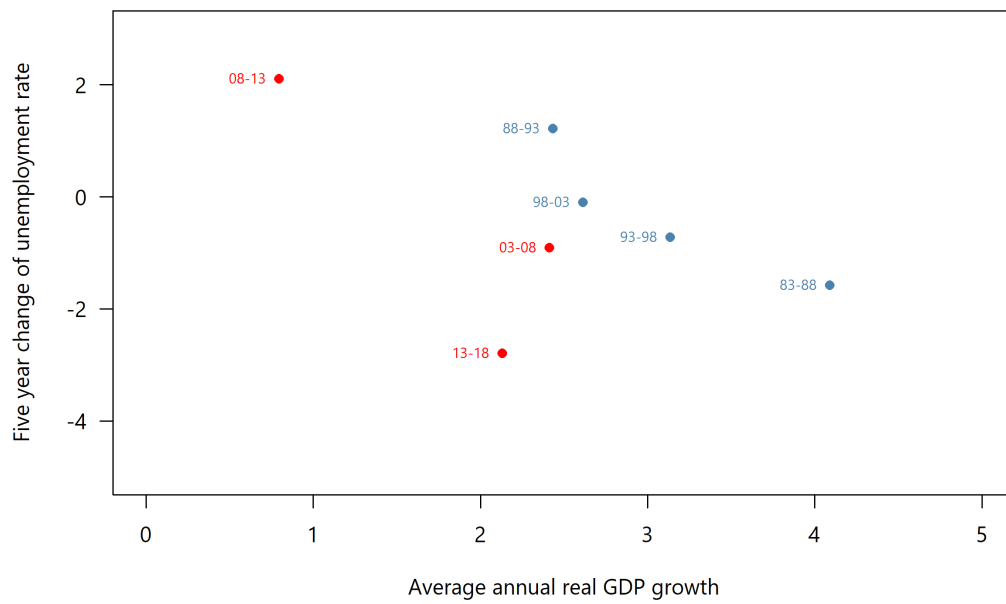
Figure 1.3. Employment Rates, 1980-2018

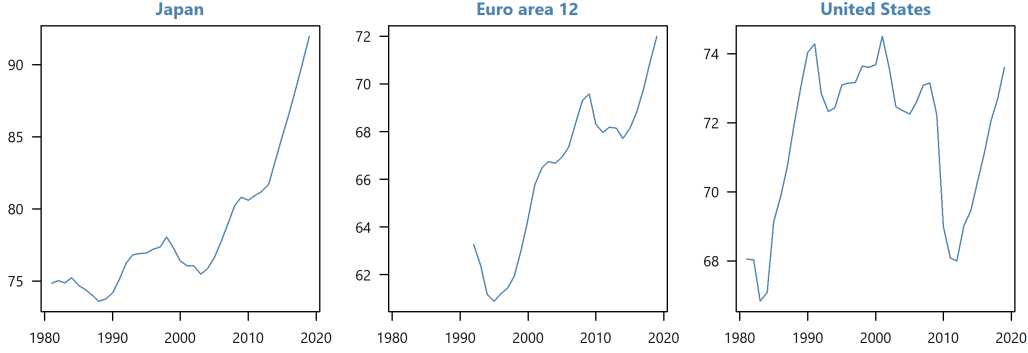(Employment as percent of working age population)

Japan

Euro area 12

United States

Figure 1.4. Advanced Economies: Potential GDP Growth

(Percent)
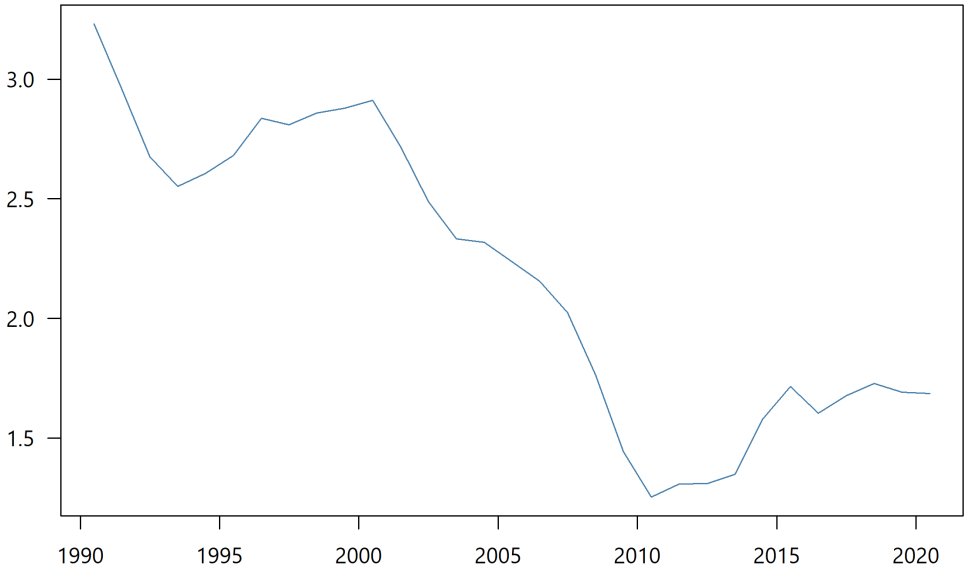
Figure 1.5: Advanced Countries: Output gap and Inflation
(Percent)

2010s

1990s

1980s
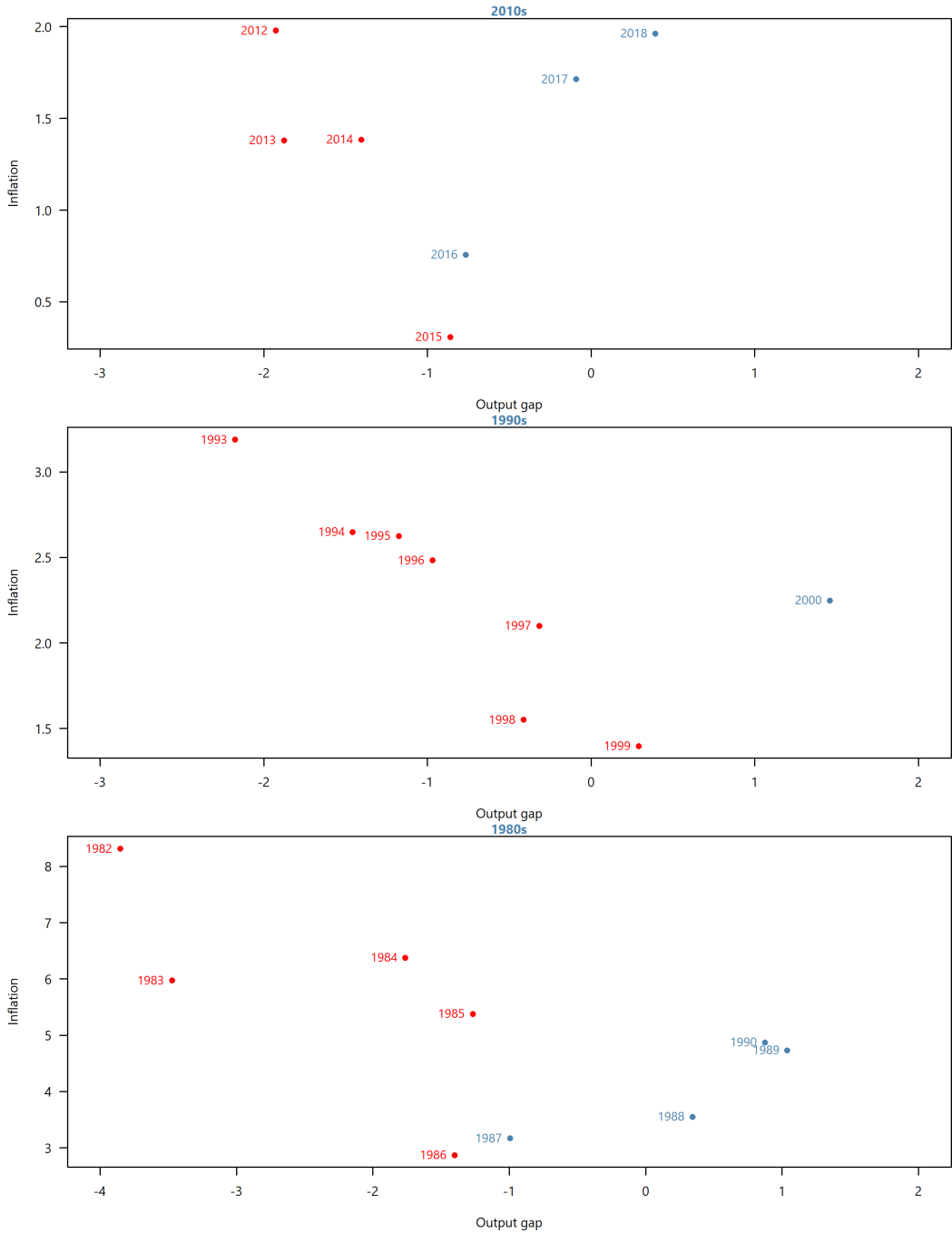
2 The Shift in Okun Curves and the Decline in Potential Output Growth

2.1 The leftward shift of the Okun curve

Okun's law stipulates a relationship between cylical unemployment and the output gap: Okun's law:

$$u_t - u_t^* = -\beta(Y_t - Y_t^*) \tag{1}$$

where u_t is unemployment, u_t^* the NAIRU, Y_t is the log of GDP, and Y_t^* is the log of potential GDP. Taking differences and assuming he NAIRU is constant, i.e. $\Delta u_t^* = 0$, we can rewrite this as:

$$\Delta u_t = \beta \Delta Y_t^* - \beta \Delta Y_t \tag{2}$$

Suppose GDP growth slows.

- If *demand* (ΔY_t) slows, there will be leftward movement *along* the Okun curve

- If *potential output growth* (ΔY_t^*) falls, the Okun curve will shift to the left.

As figure 2.1 shows, the Okun curve itself has shifted to the left, consistent with the finding that potential output growth has slowed.[5]

Figure 2.2 shows 10-year rolling regressions of the Okun curve, i.e.,

$$\Delta u_t = \alpha - \beta \Delta Y_t \tag{3}$$

This confirms that the while the *coefficient* of the GDP growth rate is pretty stable, there has been a steady downward shift in the *intercept*.[6]

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[5]If we assume that potential output growth has *not* slowed, the slowdown in GDP growth would be *cyclical*. We would then need to explain why, despite a slowdown in *cyclical* growth, the unemployment rate is declining rapidly.

[6]Note that the growth rate consistent with unchanged unemployment is $\frac{\alpha}{\beta}$.

Figure 2.1: Okun's Curve Advanced Countries, 1990-2000 vs 2008-18
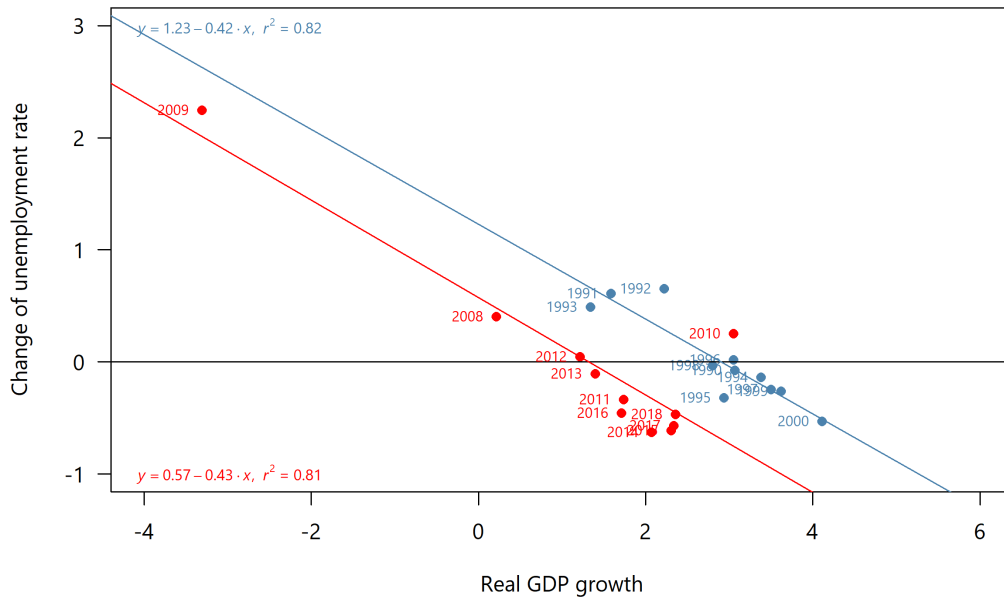
Figure 2.2: Ten-Year Rolling Regression of Okun's Curve Advanced Countries
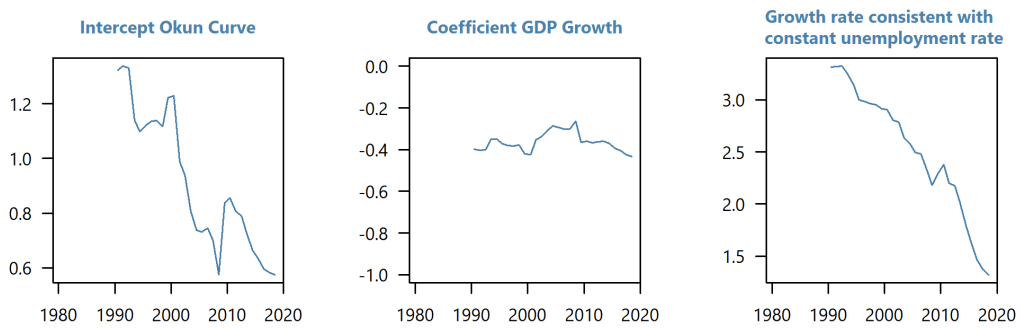
2.2 Slowdowns in potential output typically became evident only with the benefit of hindsight.

Economists initially missed the slowdown in potential output.

Japan in the 1990s

In Japan, the sharp slowdown in growth that occurred in the early 1990s was initially seen as largely cyclical. In 1996, WEO estimates suggested that output in 1996 was 3.5 percent below potential (Figure 2.3) These estimates were significantly revised later. According to estimates from 2018, output in 1996 was 1.3 percent *above* potential, and much of the slowdown in GDP growth in the 1990s was now seen as structural rather than cyclical.

United States, Britain and the Euro area in the 2000s

In 2006, the view was held that potential output growth in Britain and the United States had slowed little during the 2000s, and that output was still below potential (Figures 2.4 and 2.5) By 2018, this view had changed significantly. It is now thought that potential output growth slowed sharply during the 2000s, and that by 2006, GDP was well *above* potential. A similar picture exists for the euro area (Figure 2.6)

Figure 2.3. Japan: Potential Output Estimates, 1990-2000
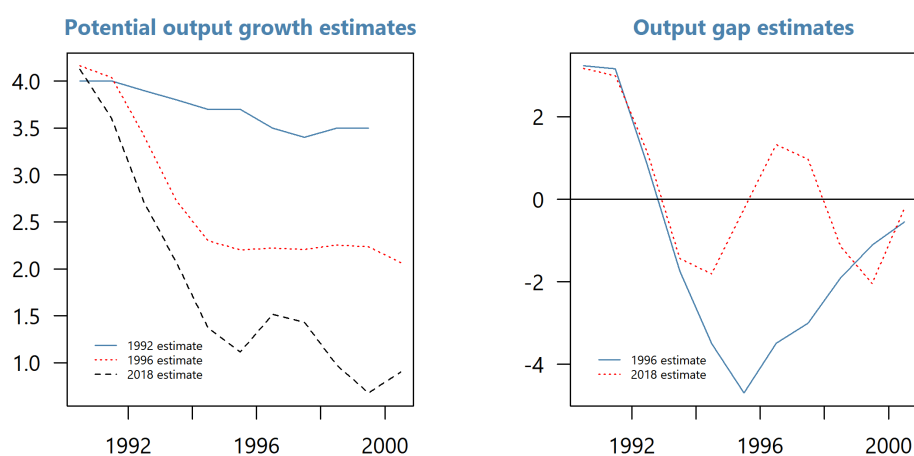
Source: WEO Database.

Figure 2.4. United Kingdom: Potential Output Estimates

Potential output growth estimates

Output gap estimates
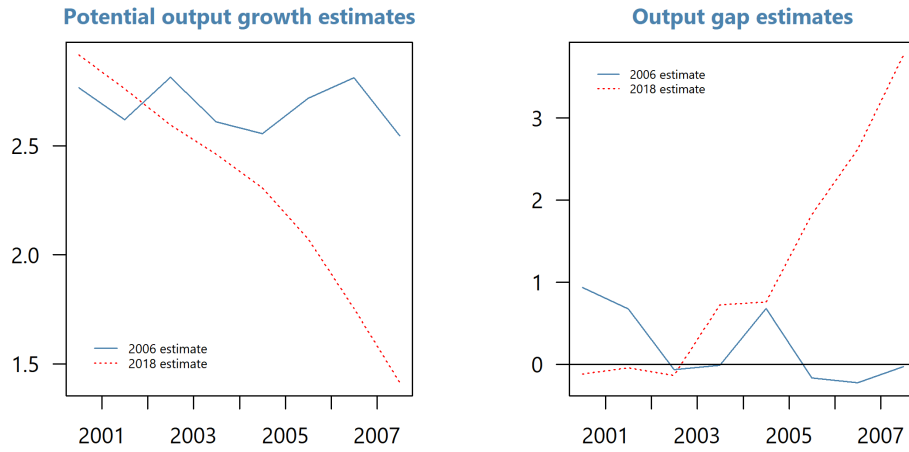
Source: WEO Database.

Figure 2.5. United States: Potential Output Estimates

Potential output growth estimates

Output gap estimates

Source: WEO Database.

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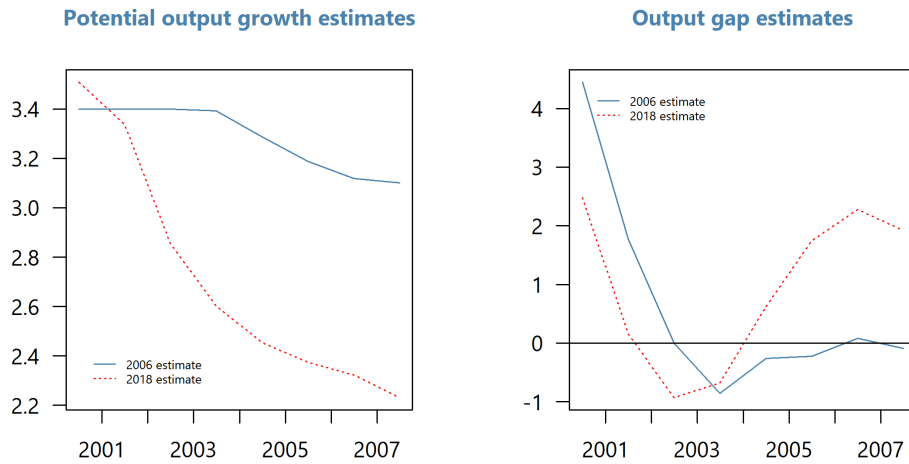
Figure 2.6. Euro area: Potential Output Estimates

Potential output growth estimates

2006 estimate
2018 estimate

Output gap estimates

2006 estimate
2018 estimate

Source: WEO Database.

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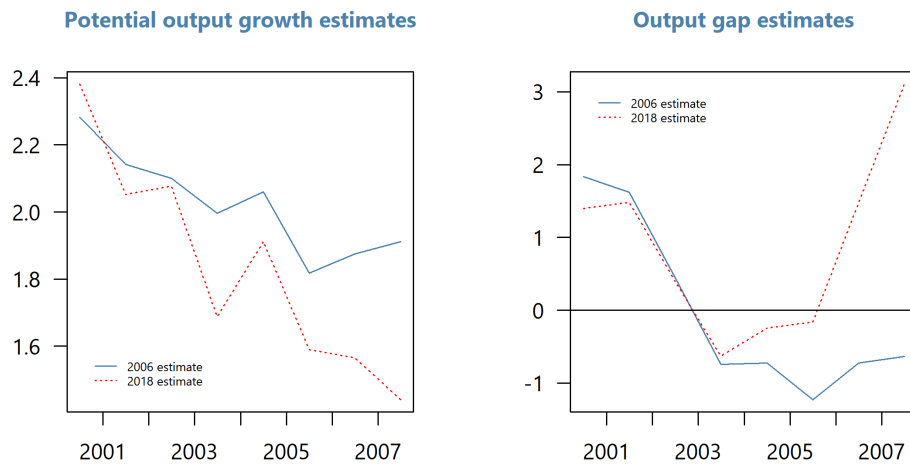
3 Potential Output, $n + g$, and the Cost of Capital: Theory

3.1 A model of potential output growth

Production follows a Cobb-Douglas production function:

$$Y = K^\alpha (A L)^{1-\alpha} \tag{4}$$

where A is labor-augmenting technological progress, which grows at rate g:[7]

$$\Delta \log A = g \tag{5}$$

We assume wages are flexible—labor is fully employed.[8] The labor force is a constant fraction of the working age population, which grows at rate n:

$$\Delta \log L = n \tag{6}$$

Taking logs, we can rewrite equation (4) as:

$$\Delta \log Y = \alpha \Delta \log K + (1 - \alpha)(n + g) \tag{7}$$

This can be rewritten as:

$$\Delta \log Y - (n + g) = \alpha \left(\Delta \log K - (n + g) \right) \tag{8}$$

The capital stock

Firms will expand the capital stock until the marginal product of capital is equal to the cost of capital (r_c) plus depreciation (δ):

$$\max_K K^\alpha (A L)^{1-\alpha} - (r_c + \delta) K - w L \tag{9}$$

It follows that:

$$\left(\frac{K}{A L} \right) = \left(\frac{\alpha}{r_c + \delta} \right)^{\frac{1}{1-\alpha}} \tag{10}$$

Taking logs yields

$$\log \left(\frac{K}{A L} \right) = \left(\frac{1}{1 - \alpha} \right) \log \left(\frac{\alpha}{r_c + \delta} \right) \tag{11}$$

Taking differences we get:

$$\Delta \log K = n + g - \left(\frac{1}{1 - \alpha} \right) \Delta \log(r_c + \delta) \tag{12}$$

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[7]Note that labor augmented technological progress can be derived from TFP growth and the labor-income share. See section 5.1.

[8]Note that is a model of *potential* output growth—not *actual* output growth.

The labor market

Wages are equal to the marginal product of labor:

$$w = \frac{\partial Y}{\partial L} = (1 - \alpha) A \left(\frac{K}{A L} \right)^{\alpha} \tag{13}$$

Taking logs and substituting equation (11) we get:

$$\log w = \log(1 - \alpha) + \log A - - \left(\frac{\alpha}{1 - \alpha} \right) \Delta \log(r_c + \delta) \tag{14}$$

Taking differences results in:

$$\Delta \log w = g - \left(\frac{\alpha}{1 - \alpha} \right) \Delta \log(r_c + \delta) \tag{15}$$

The full model

Combining the various equations, we get the following model:

$$\Delta \log Y = n + g - \left(\frac{\alpha}{1 - \alpha} \right) \Delta \log(r_c + \delta) \tag{16}$$

$$\Delta \log L = n \tag{17}$$

$$\Delta \log w = g - \left(\frac{\alpha}{1 - \alpha} \right) \Delta \log(r_c + \delta) \tag{18}$$

$$\Delta \log K = n + g - \Delta \log(r_c + \delta) \tag{19}$$

$$\Delta \log \left(\frac{K}{L} \right) = g - \left(\frac{1}{1 - \alpha} \right) \Delta \log(r_c + \delta) \tag{20}$$

$$\Delta \log \left(\frac{Y}{K} \right) = \Delta \log(r_c + \delta) \tag{21}$$

If the cost of capital is constant, output grows at rate $n + g$, employment at rate n, wages at rate g, the capital stock at rate $n + g$, the capital-labor ratio ratio at rate g, and the capital output ratio is constant.

3.2 What happens if $n + g$ falls?

If $n + g$ falls and the cost of capital remains unchanged, the growth rate of the capital stock ($\Delta \log K$) will slow in line with the reduction in $n + g$. This is because if it fell by less, the return on capital would fall below the cost of capital. As a result, potential GDP growth will fall in line with the reduction in $n + g$. Wages will fall in line with the reduction in g.

If $n + g$ falls and the cost of capital falls, the growth rate of the capital stock will initially fall by less than the reduction in $n + g$. As a result, the growth rate of potential

GDP will exceed $n + g$, but by less than the growth rate of the capital stock.[9] Thus, the capital-output ratio will rise. Wage growth will exceed g.

The support to growth from the lowering of interest rates lasts only one period in this model. In the next period, capital will again grow in line with output, GDP growth falls back to $n + g$, and wage growth falls back to g. Wages grow in line

Simulation

We will assume for now that firms are entirely financed by debt. The cost of capital is therefore:

$$r_c = r_D \tag{22}$$

We assume that the cost of debt is equal to a risk premium, Π, plus the policy rate, r_p:

$$r_D = \Pi + r_p \tag{23}$$

Parameters

We will take $\Pi = 0.04$, $\delta = 0.06$, $\alpha = \frac{1}{3}$.

Starting situation

In the initial situation $n = 0.01$; $g = 0.03$, $r_p = 0.067$. This implies that $r_c = 0.107$; $r_c + \delta = 0.167 = \frac{1}{6}$ and $\frac{K}{Y} = 2$.

Reduction of $n + g$

Now n falls to 0; g falls to 0.01.

- If policy rates and the cost of capital remain constant, GDP growth will fall to 0.01, and the return on capital will remain constant.

- If the central bank lowers interest rates and the cost of capital falls, the slowdown in growth will be mitigated. In our simulation, the central bank lowers interest rates enough to keep growth at 0.03. As a result of the decline of the cost of capital, the capital-output will start to rise, and the return on capital will drop.

- To keep growth at 0.03, the central bank needs to keep lowering interest rates (Figure 3.1). Eventually policy rates will reach zero, and growth will fall back to 0.01. In the new equilibrium, the capital-output ratio is much higher, and the return on capital much lower.

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[9]Recall from equation (8) that we have $\Delta \log Y - (n + g) = \alpha \left(\Delta \log K - (n + g) \right)$.

Figure 3.1. The Impact of a Fall in n+g and Policy Rate Reductions: Simulations
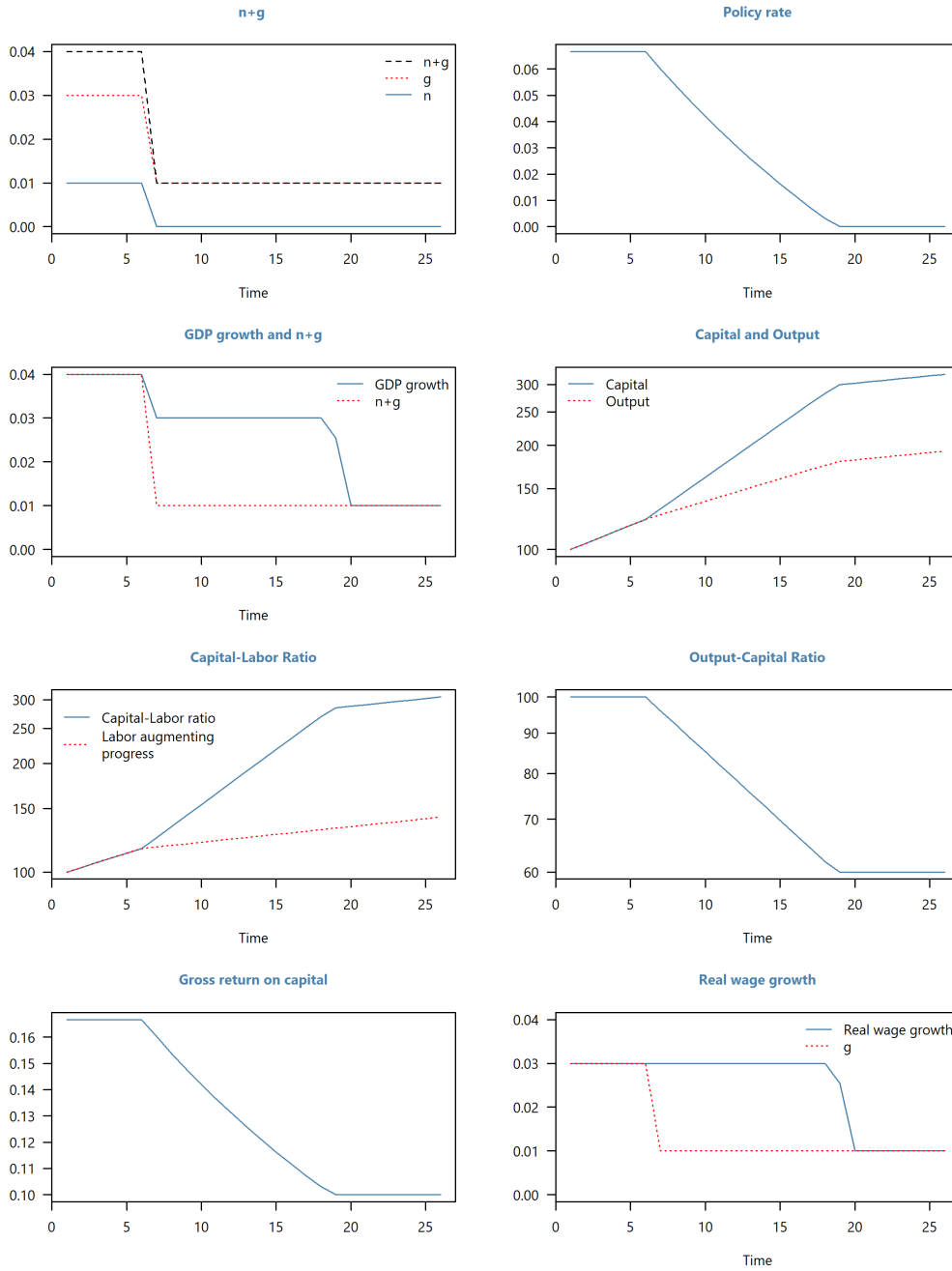
Source: Ameco database and IMF staff calculations..

4 Investment, $n + g$, and the cost of capital: Theory

4.1 Investment, $n + g$, and the cost of capital in the steady state

So far we did not have an explicit equation for investment. We will now derive one for the steady state. In the steady state, output and the capital stock grow at the same rate, while the investment rate i is constant.

$$\frac{\dot{Y}}{Y} = \frac{\dot{K}}{K} = n + g \tag{24}$$

The growth rate of the capital stock is equal to:

$$\frac{\dot{K}}{K} = \frac{i\,Y - \delta\,K}{K} \tag{25}$$

It follows that

$$\frac{K}{Y} = \frac{i}{\delta + n + g} \tag{26}$$

From equation (9 we obtain:

$$r_c + \delta = \alpha \frac{Y}{K} \tag{27}$$

Combining equations (26) and (27) we get

$$r_c + \delta = \alpha \left(\frac{n + g + \delta}{i} \right) \tag{28}$$

This implies that gross investment is equal to:

$$i = \alpha \left(\frac{n + g + \delta}{r_c + \delta} \right) \tag{29}$$
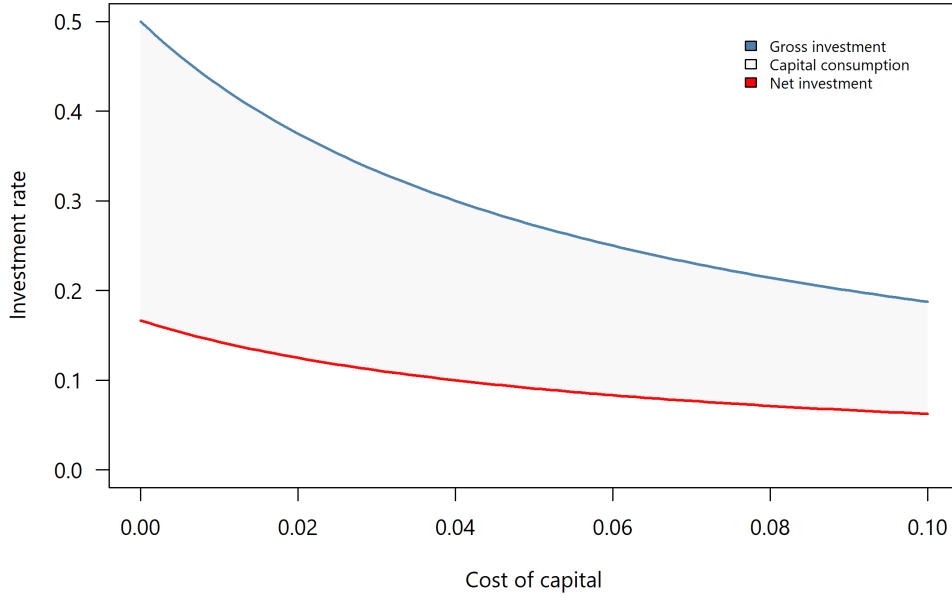
Net investment is equal to

$$i^n = i - \delta \frac{K}{Y} = \alpha \left(\frac{n + g}{r_c + \delta} \right) \tag{30}$$

Capital consumption is equal to

$$i - i^n = \frac{\alpha\,\delta}{r^c + \delta} \tag{31}$$

Figure 4.1 shows (for given $n + g$, δ and α) the link between the cost of capital, and gross investment, net investment and capital consumption.

Figure 4.1: Cost of Capital and Investment

4.2 What happens with investment if $n + g$ falls?

What happens with investment if $n + g$ falls? From equation (8) we can deduce:

$$i = (n + g + \delta) \frac{K}{Y} \tag{32}$$

If $n + g$ falls and the cost of capital remains unchanged, the capital-output ratio will remain unchanged. That means that gross investment will fall in line with the decline in $n + g$:

$$\Delta i = \left[\frac{K}{Y} \right] \Delta(n + g) \tag{33}$$

For every percentage point decline in $n + g$, the investment rate will decline by $\frac{K}{Y}$ percentage points. For example, if the capital-output ratio is 2, a 1 percentage point decline in $n + g$ will lead to a 2 percentage points decline of the gross investment rate.[10]

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[10] Note that the higher the capital-output ratio, the more investment will decline for a given decline of $n + g$. With a capital-output ratio of 2, each percentage point drop in $n + g$ will lead to a decline of investment by 2 percent of GDP. If the capital-output ratio is 3, each percentage point drop in $n + g$ will lead to a decline of investment by 3 percent of GDP. The intuition behind this is that the growth rate of the capital stock depends on both the investment rate and the capital-output ratio:

$$\frac{\Delta K}{K} = \frac{i\,Y - \delta\,K}{K} = i\frac{Y}{K} - \delta \tag{34}$$

If interest rates are reduced when $n + g$ falls, the cost of capital will fall, and gross investment will fall by less.

Numerical Example

Figure 4.2: Cost of capital, n+g, and Investment
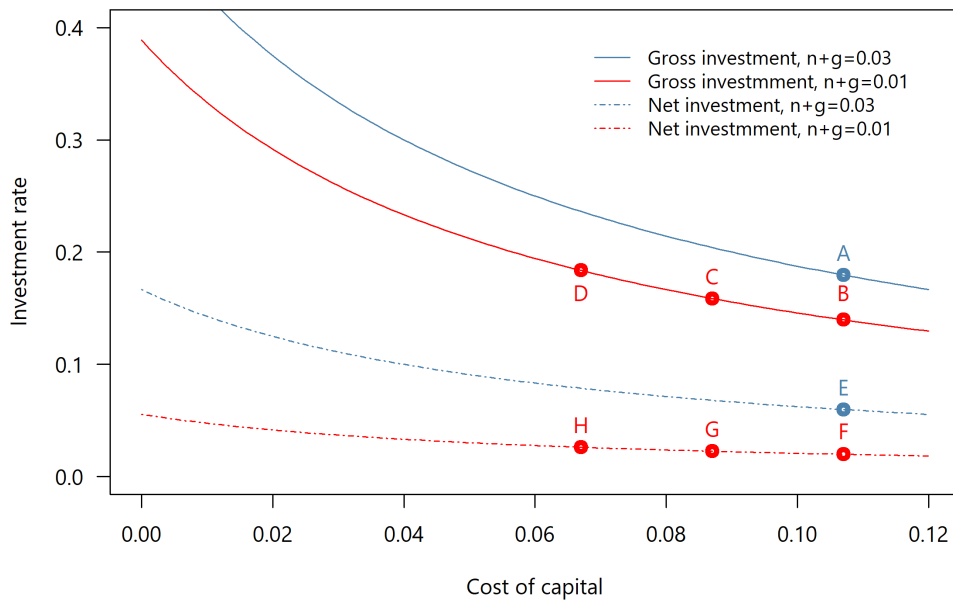
Figure 4.2 gives an example (with $\alpha = 1/3$, and $\delta = 0.06$). If $n + g$ falls from 3 to 1 percent:

- If the cost of capital remains unchanged, gross investment will fall from A to B; net investment from E to F.

- If the cost of capital falls a little, gross investment will move to C, net investment to G.

- If the cost of capital falls a lot, gross investment will move to D, net investment to H.

- In this example, D is higher than A, but H is lower than E.

The numbers underlying the chart are in Table. 1. They show that

- If the cost of capital remains constant, gross and net investment fall, and the capital-output ratio remains constant.

- If the cost of capital falls, gross investment will decline less—and may even increase.

- However *net* investment will always fall, as capital consumption rises.

Table 1: Numbers underlying the chart

	A and E	B and F	C and G	D and H
n+g	0.03	0.01	0.01	0.01
Gross return on capital	0.17	0.17	0.15	0.13
Net return on capital (=cost of capital)	0.11	0.11	0.09	0.07
Gross investment rate	0.180	0.140	0.159	0.184
Capital consumption	0.120	0.120	0.136	0.158
Net investment rate	0.060	0.020	0.023	0.026
K/Y	2.00	2.00	2.27	2.63

4.3 Intuition: How can falling investment coincide with rising capital-output ratios?

It may seem counter-intuitive that a decline in investment would coincide with an increase in the capital-output ratio. To see why, consider the following.

The growth rate of the capital stock is equal to:

$$\frac{\Delta K_{t+1}}{K_t} = \frac{i\, Y_t - \delta K_t}{K_t} = i\frac{Y_t}{K_t} - \delta \tag{35}$$

With capital-output ratios well above 1, a change in the investment-to-GDP ratio has only a modest impact on the growth rate of the capital stock. For example, if the capital-output ratio is 3, a one percentage point higher investment rate will lead to a $\frac{1}{3}$ percentage point higher growth rate of the capital stock only.

The flip-side is that to get a meaningful *reduction* in the growth rate of the capital stock, you need a large decline in the investment rate. With a capital-output ratio of

3, if $n + g$ falls from 4 to 1, the growth rate of the capital stock needs to fall from 4 to 1 percent. With a capital-output ratio of 3, the investment rate needs to fall by 9 percentage points. If it falls by less, the capital-output ratio will increase.

To see the math of this example, suppose that $\alpha = \frac{1}{3}$, $n + g = 0.04$, $\delta = 0.06$, and $i = 0.30$. This implies that $\frac{K}{Y} = 3$ and net investment is 0.12. Now assume that $n + g$ falls to 0.01. If gross investment declines to 0.27, net investment will fall from 0.12 to 0.09 initially. The growth rate of the capital stock therefore slows to 3 percent[11].

What happens with GDP growth? From equation (8) we can deduce that:

$$\Delta \log Y = n + g + \alpha \left(\Delta \log K - (n + g) \right) \tag{36}$$

With the capital stock growing at 3 percent, $n + g$ at 1 percent, and $\alpha = 1/3$, GDP will grow at 1⅔ percent. With the capital stock growing at 3 percent, and GDP at 1⅔ percent, the capital-output ratio will increase.

4.4 Low interest and leverage

So far, we have looked at the *asset* side only. Lower interest rates reduce the cost of capital, which increases investment.

But low interest rates may also trigger a change on the *liability* side. Low interest rates are likely to trigger an increase in leverage. Firms can increase leverage by financing new investment with debt only. They can also issue debt to buy back shares.

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[11]With a capital-output ratio of 3, every three percentage points decline in investment leads to a 1 percentage point lower growth rate of the capital stock.

5   Potential Output, Investment, $n + g$, and the cost of Capital: Evidence

5.1 $n + g$ and interest rates have fallen

Working age population growth and labor-augmenting technological progress have declined in advanced countries (Figure 5.1). For example, in Japan, their combined growth rate slowed from an annual average of almost five percent in the five years ending in 1990, to close to zero in second half of the 1990s. In the United States they slowed from an average of 4½ percent in the five years ending in 2000, to 2½ percent in the five years ending in 2007, and 1¼ in the five years ending in 2017. In most advanced countries, labor augmenting technological progress plus working age population growth is currently below 1 percent.[12]

At the same time, interest rates have fallen in most countries. Both short-term and long-term interest rates have fallen, both in nominal and in real terms (Figure 5.2).

**Figure 5.1. Labor Augmenting Technological Progress
plus Working Age Population Growth**
(Five year moving average)

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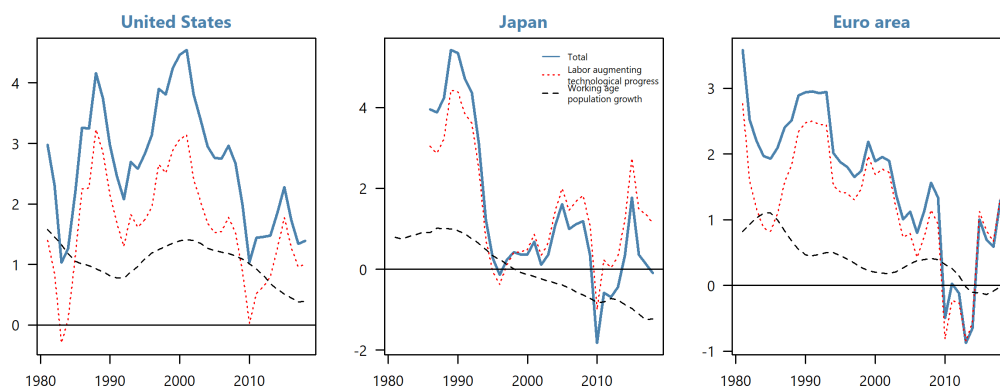
[12]We derive labor augmented technological progress from TFP growth and the labor-income share. It follows from equation (4) that

$$\frac{dY}{Y} = \alpha\frac{dK}{K} + (1-\alpha)\frac{dL}{L} + (1-\alpha)g \tag{37}$$

Total factor productivity growth is derived as:

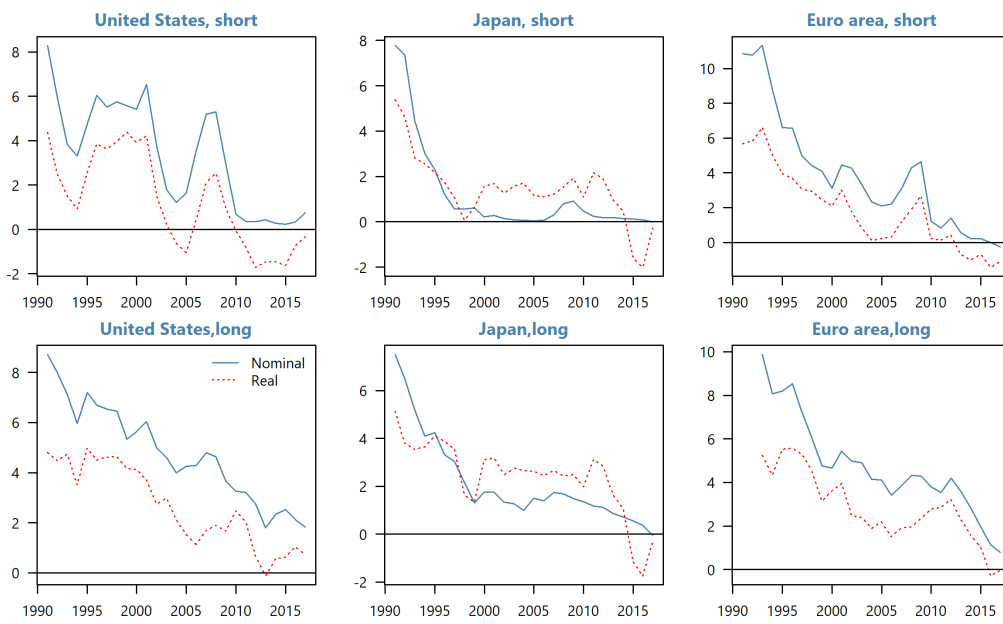$$g_{tfp} = \frac{dY}{Y} - \alpha\frac{dK}{K} - (1-\alpha)\frac{dL}{L} \tag{38}$$

It follows that:

$$g = \frac{g_{tfp}}{1-\alpha} \tag{39}$$

We derive g from estimates of TFP growth and the labor income share in the EU Commission staff Ameco database.

Figure 5.2. Interest Rates

United States, short
Japan, short
Euro area, short

United States, long
Japan, long
Euro area, long

Nominal
Real

25

5.2 Stylized facts

The model developed so far predicts that if $n + g$ declines and interest rates are reduced, then:

- Potential output growth will fall

- Gross investment may or may not fall

- The capital-output ratio will rise

- Capital consumption will rise

- Net investment will fall

- Returns on capital will fall

- Leverage will increase

Potential output growth has fallen

Figure 5.3. Potential Output Growth
(Percent, Five-year moving average)
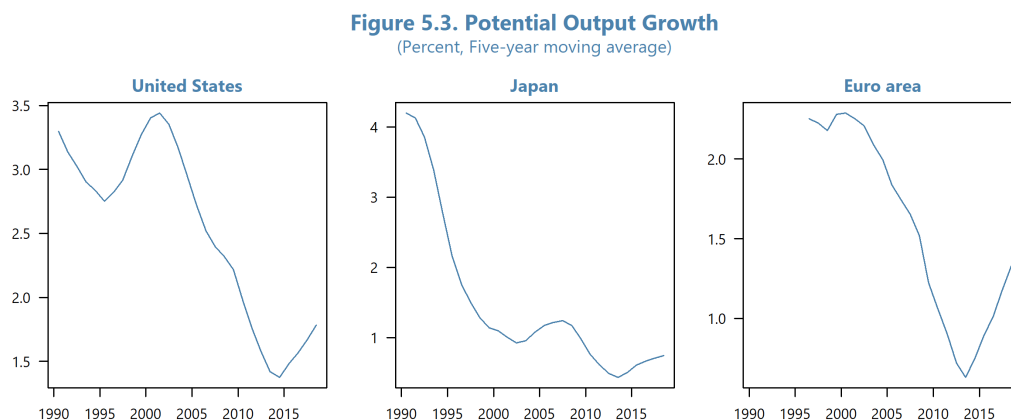
According to WEO database estimates, potential GDP growth has fallen (Figure 5.3). In Japan, potential output growth has slowed from 4 percent in 1990 to less than 1 percent currently.

Gross investment has fallen—to varying degrees

Gross investment has fallen in advanced countries (Figure 5.4), albeit with significant differences accross countries. In Japan, investment has declined most sharply; in the euro area it has held up relatively well.
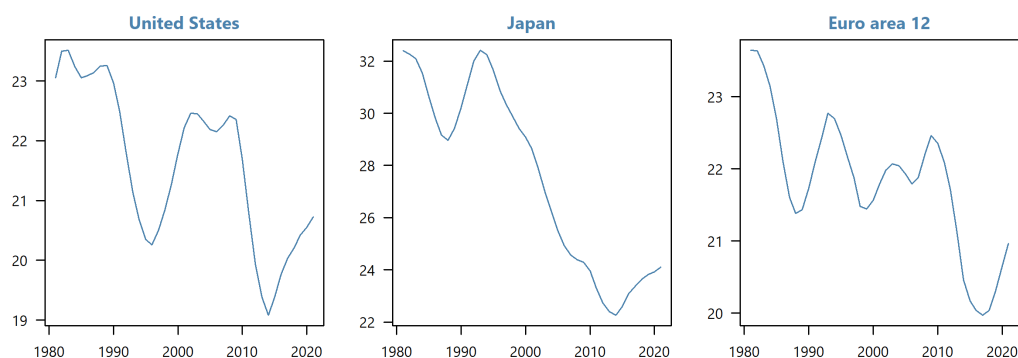
Figure 5.4. Gross Investment Rates
(Percent of GDP)

The capital services to GDP ratio has increased

To assess the productivity of capital, we can not simply add the various components of the capital stock—we need to correct for the fact that longer-lived assets produce less output per year.[13] A method that corrects for the fact that low depreciation assets yield less gross income per capital, is the "capital services method" (OECD (2009)). Capital services are estimated through a capital-income weighted average of the growth rates of each asset.

According to the Penn World Database version 9.1,[14] capital services have increased faster than GDP (Figure 5.5); capital productivity has declined (Figure 5.6).

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[13]Longer-lived assets not only have a lower depreciation rate—which is why they live longer—they also produce less output per unit of capital *each year* than shorter-lived assets. To see this, assume that the net return on investment (value added minus depreciation of the capital stock) for each period is equal for all assets:

$$\frac{Y_i - \delta_i K_i}{K_i} = c \tag{40}$$

It follows that:

$$\frac{Y_i}{K_i} = c + \delta \tag{41}$$

The higher the depreciation rate (i.e., the shorter-lived the asset), the more output an asset produces each year for the same amount of capital. In others words, for the same amount of investment, short-lived assets contribute more to GDP *in a given year* than long-lived assets.

[14]See Feenstra et al. (2015).

Figure 5.5: Capital Services and GDP, 1990-2017
(1990=100)

United States

Japan

Capital services
GDP

Italy

Germany

France
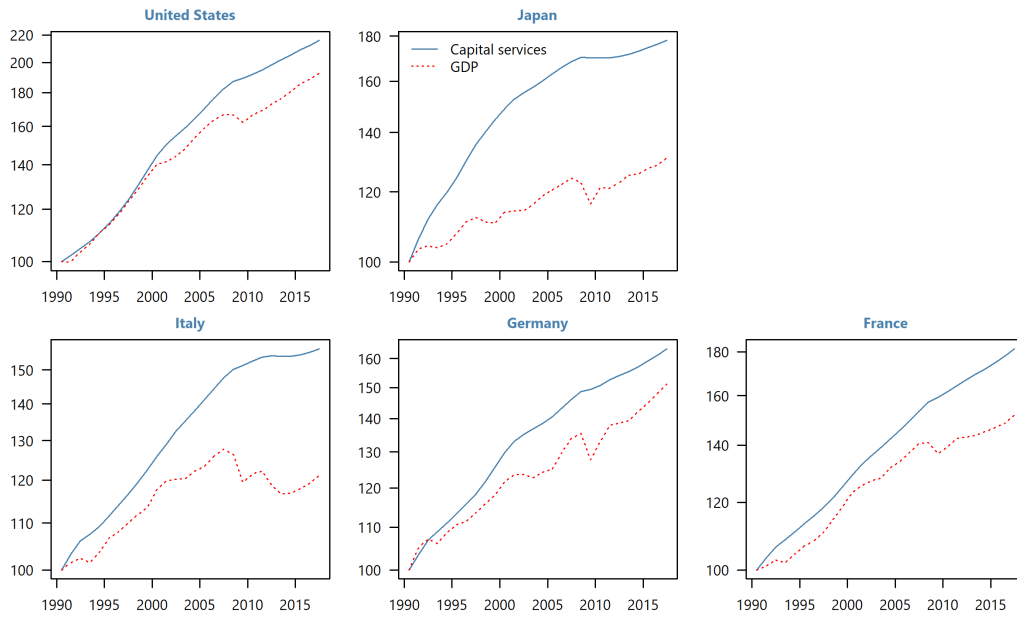
Source: Penn World Table, version 9.1.

Figure 5.6: Capital Services to Output, 1990-2017
(1990=100)

United States

Japan

Italy

Germany

France
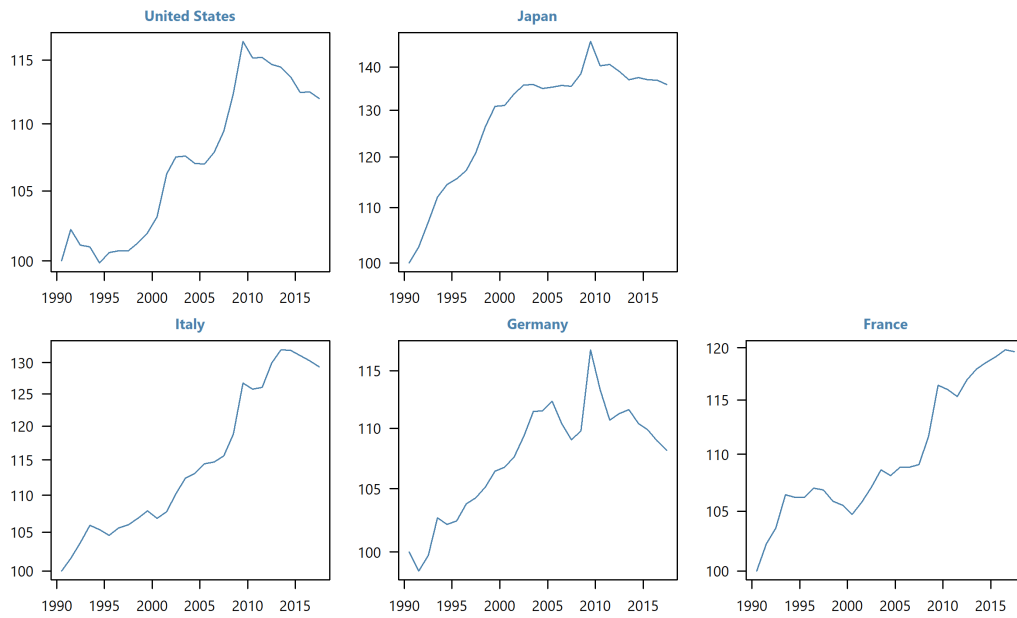
Source: Penn World Tables, version 9.1.

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Capital Consumption has increased

Capital consumption has increased (Figure 5.7).[15] It has increased particularly sharply in Japan and the euro area countries.[16]

Figure 5.7. Capital Consumption
(Percent of GDP, five-year moving average)
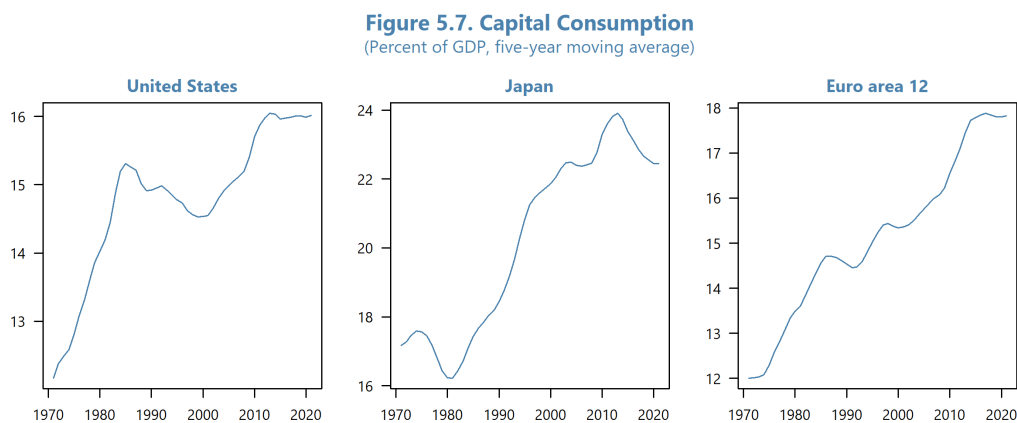
Net investment has declined

Net investment has declined in advanced countries, most dramatically in Japan (Figure 5.8).

Figure 5.8. Net Investment Rates
(Percent of GDP)

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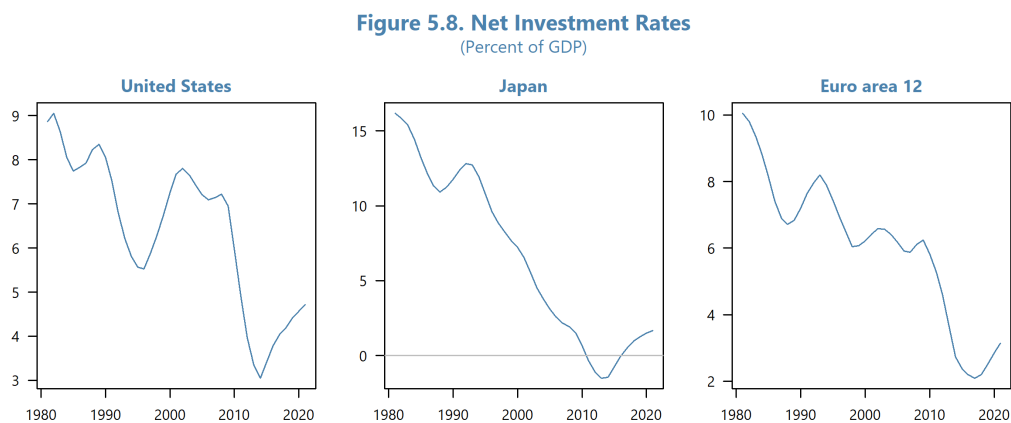
[15]We take capital consumption from the National Accounts.

[16]Interestingly, the United Kingdom stands out as a country where capital consumption has not increased since 2000 and the gross investment rate is the lowest of all countries in the chart, suggesting that target returns in this country have remained constant, despite the drop in policy rates.

Returns on capital have fallen

According to Penn World Tables, the rate of return on capital has fallen in advanced countries (Figure 5.9). Returns have fallen even though labor income shares have declined, as the increase in the capital-income share has been more than offset by the increase of the capital-output ratio:

$$r = \alpha \frac{Y}{K} = \frac{\alpha}{\frac{K}{Y}} \tag{42}$$

In Japan, for example, the capital income share (the complement of the labor income share) has increased by about 10 percent, while the capital output ratio has increased by about one third.

Figure 5.9: Real internal rate of return, 1990-2017
(Percent)

Source: Penn World Table, version 9.1.

Leverage has increased

Figure 10.1 shows that leverage in the United States and the Euro area has increased sharply. In Japan, there has been deleveraging after the banking crisis in the mid-1990s, which followed after a low-interest rates induced borrowing binge. The combination of low returns on capital and high leverage make economies vulnerable to shocks.

30

Figure 5.10. Non-financial Corporate Debt to GDP ratio, Advanced Countries
(Percent of GDP)
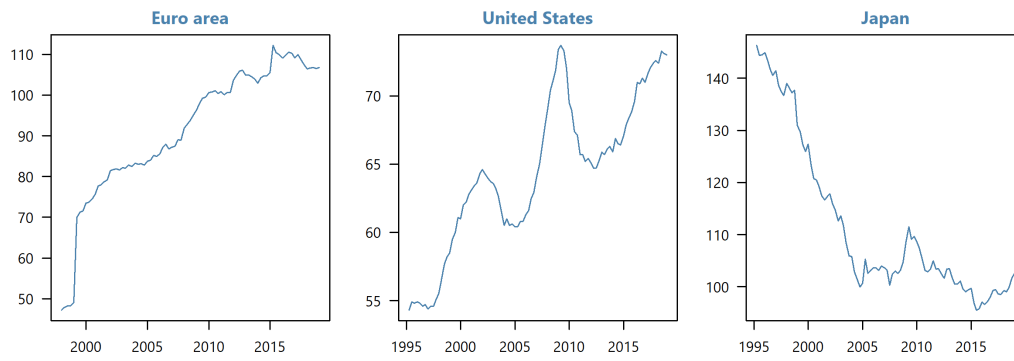
6   Country Case: Japan

Japan is an illustrative example of the mechanism discussed so far. After the land price and stock market boom deflated in the early 1990s, GDP growth slowed sharply. In reaction, policy rates were reduced sharply (Figure 6.1).

Low interest rates helped boost investment. Gross investment declined only gradually (Figure 6.2). In 1997 gross investment was still 29 percent of GDP—down only 4 percentage points from the peak in 1990, and unchanged from the level in 1987. The result of sustained high gross investment was a sharp increase in capital consumption, which peaked at 25 percent of GDP in 2009, and even today is still around 22 percent of GDP, compared with 16 percent of GDP in the United States and 12 percent in Britain.

The capital stock increased rapidly, but this did not lead to a rapid increase of GDP (Figure 6.3). The capital-output ratio increased sharply, and the return on capital fell. Eventually investment dropped, and the capital-output stopped rising. By now, growth of capital services is in line with growth of GDP. Both grow at a low rate, but this is consistent with a low rate of $n + g$. Figure 6.4 shows the dramatic decline of the contribution of labor productivity and population growth to growth in Japan.

Finally, Okun's law still holds in Japan (Figure 6.5). However, the level of GDP growth consistent with unchanged unemployment has fallen sharply.

Figure 6.1. Japan: Short-term Interest Rate
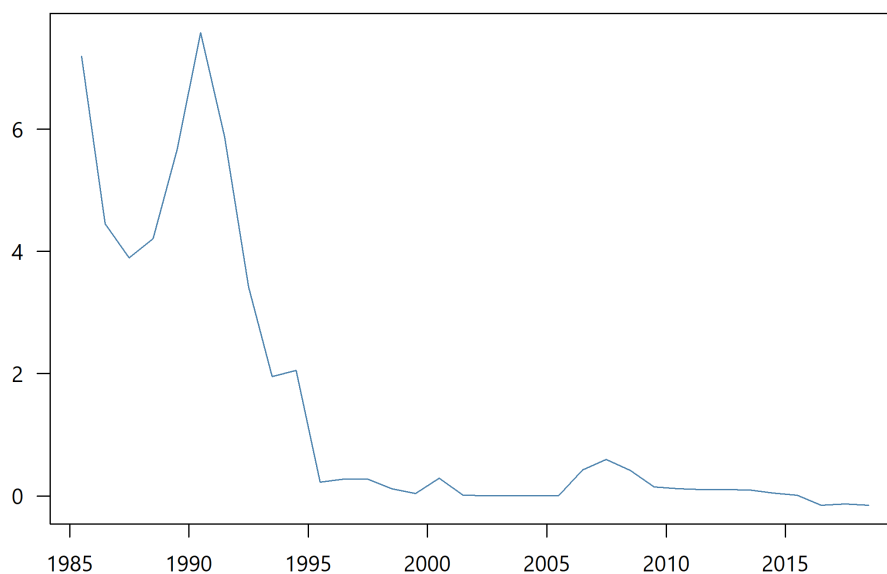
Source: WEO Database.

Figure 6.2: Japan: Gross and Net Investment

(Percent of GDP)

Gross Investment and Depreciation
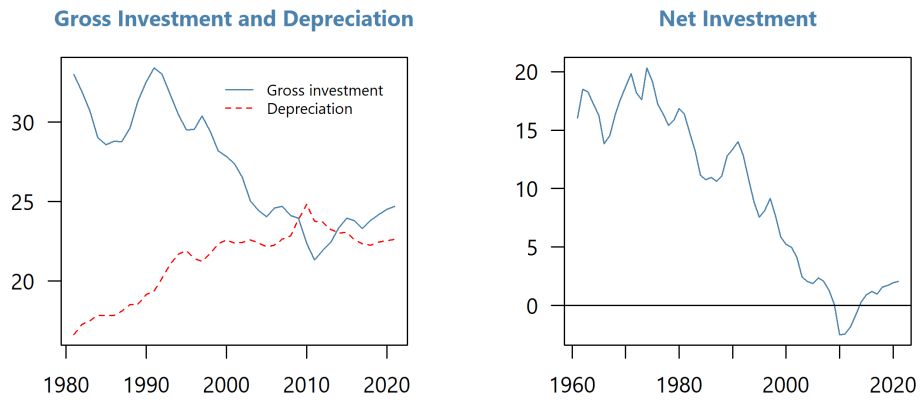
Net Investment

Figure 6.3: Japan: Capital Services and GDP

(1990=100)

33
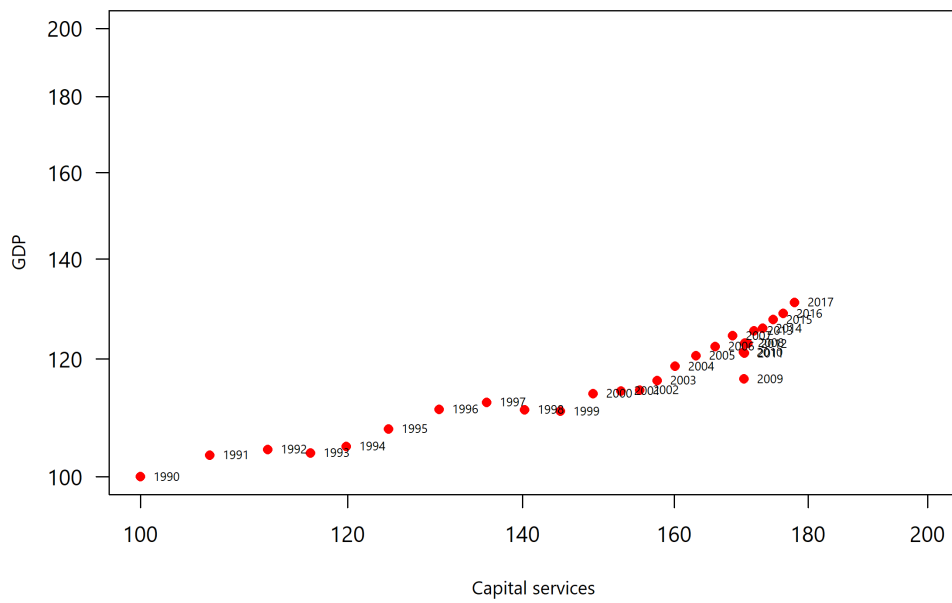
Figure 6.4. GDP Growth Japan

Change in logs, annualized)

Legend:
- Contribution labor productivity growth
- Contribution population growth
- Contribution increase emmployment rate
- GDP growth

x-axis: 1980-1990, 1990-2000, 2000-2010, 2010-2020
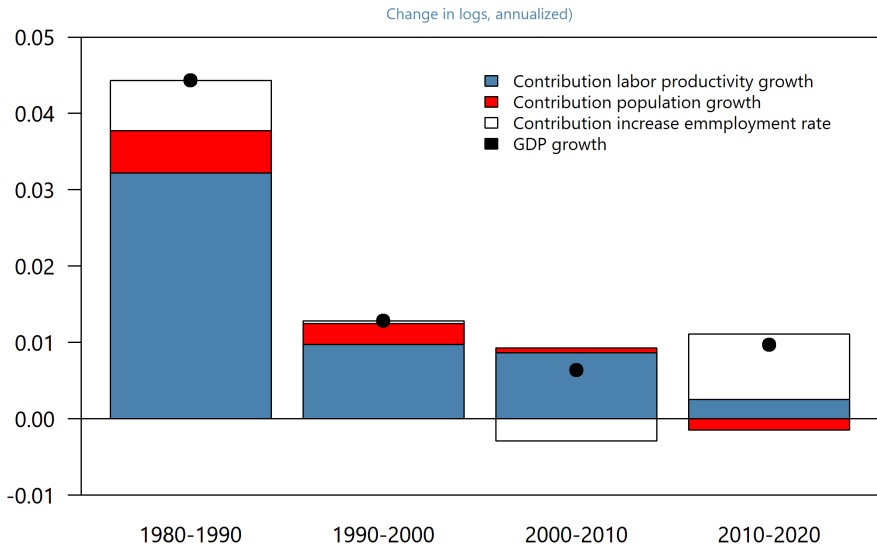
Figure 6.5: Okun's Curve Japan, 1980-1990 vs 2008-18

$y = 0.60 - 0.13 \cdot x, \ r^2 = 0.53$

$y = -0.0079 - 0.13 \cdot x, \ r^2 = 0.54$

y-axis: Change of unemployment rate

x-axis: Real GDP growth
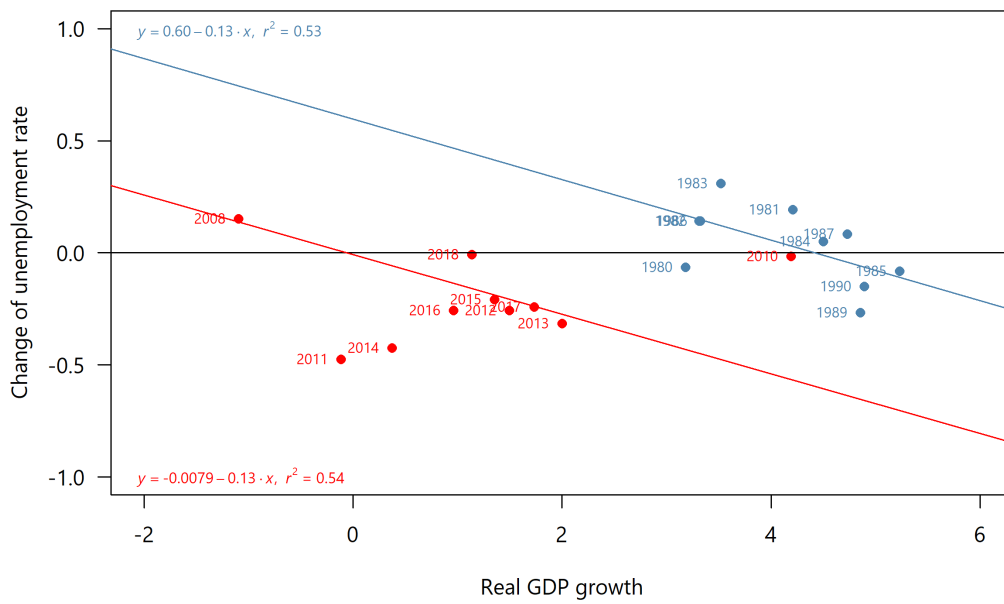
7 The Impact of Higher Investment

7.1 Could Low Investment have been the Cause of Low Growth?

So far we have argued that low investment rates are the *result* of low growth—not the cause. But could the causality have gone the other way around?

If g remains constant, and investment drops, the result will be a decline in GDP *growth rates* (in the short run) and a decline in GDP *levels* (in the longer run). So does this mean that lower investment could have been the cause of lower GDP growth?

A lower investment rate (with unchanged g) also leads to lower capital-output ratios. This is at odds with has been observed in practice, suggesting that causality has not gone from lower investment to lower growth.

So far we have assumed that g is exogenous. What happens if g depends on the investment rate, with higher investment leading to higher g? In that case, lower investment will have a permanent effect on GDP growth. However, it will also lead to *lower* capital-output ratios, which is at odds with has been observed in practice.

To see this, assume that that the growth rate of labor-augmenting technological progress depends on the investment rate:

$$g = g_0 + \lambda i \tag{43}$$

We now can rewrite equation (26) as:

$$\frac{K}{Y} = \frac{i}{n + g_0 + \lambda i + \delta} = \frac{1}{\lambda + \frac{n+g_0+\delta}{i}} \tag{44}$$

If i drops, g and hence GDP growth will fall. However, we also get a decline in the capital-output ratio.

7.2 The Impact of Higher Investment on Output and Consumption Levels

So far we have argued that higher investment rates will lead to higher GDP *levels*—but only have a temporary effect on GDP growth. How important is the impact on GDP levels quantitatively?

In his textbook, Romer (2019), page 25) derives an expression for the elasticity of the balanced-growth-path level of output with respect to the saving rate in Solow Swan models. Replacing the saving rate with the investment rate we get the following expression:

$$\frac{\frac{\partial y^*}{y^*}}{\frac{\partial i^*}{i^*}} = \frac{\alpha}{1 - \alpha} \tag{45}$$

where α is the capital-income share. If $\alpha = \frac{1}{3}$, a increase in the investment rate from 20 to 21 percent (a 5 percent increase) will lead to a 2.5 percent increase in the steady state path of GDP. Assuming that the higher investment is accompanied by a higher saving rate, the steady state path of consumption will increase by 1.2 percent.[17]

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[17]As the ratio of consumption declines from 0.80 to 0.79, consumption increases from 0.80*1 to 0.79*1.025.

In the five years ending in 2007, the investment rate in advanced countries was 23.0 percent, in the five years ending in 2018, 21.6. If investment had remained at pre-crisis ratios, the steady-state-growth-path level of output would have have been 3.2 percentage points higher. To put this in perspective, GDP in 2018 was 12.4 percent lower than what was forecast in the Spring 2007 WEO (Figure 7.1). This further confirms that disappointing growth was not the result of disappointing investment, but of disappointing TFP growth.

Figure 7.1: Advanced economies: GDP and Potential GDP in WEO Vintages

GDP and Potential GDP Levels
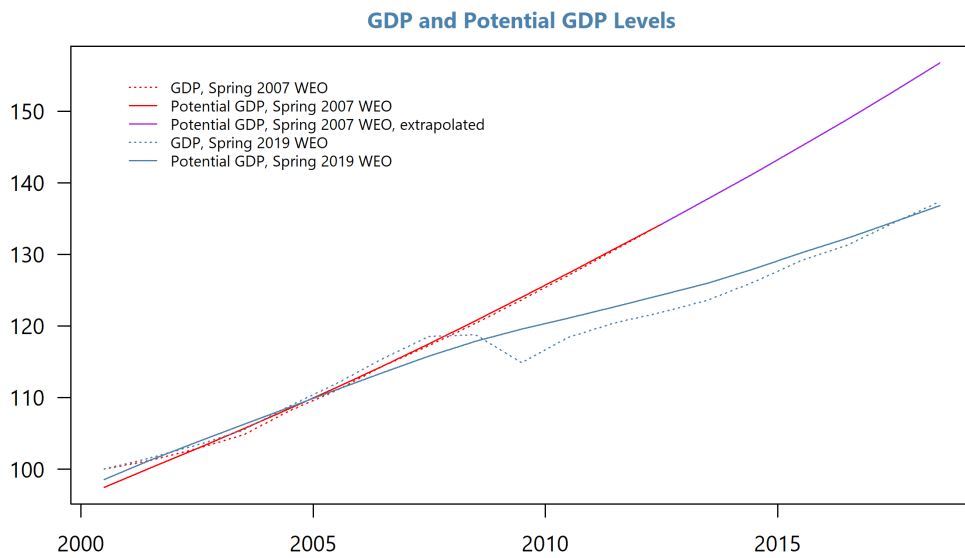
8   Is Investment in Advanced Countries too Low?

The results in this paper suggests that the often-held view that investment in advanced countries is "too low" may not be correct. Buti and Mohl (2014), for example, argued that investment in the euro area was below trend, which "reduces aggregate demand, thus lowering short-term growth, and it also hampers medium-term growth through its effect on the capital stock."[18]

Investment is indeed lower than in the past, but this may be because $n + g$ has fallen. Raising investment without a corresponding increase in TFP or working age population growth may simply further boost capital-output ratios and further reduce the return on investment.[19]

These findings are in line with Gros (2014) who also questions whether investment in Europe is really too low: "However, there are fundamental reasons to believe that the investment rate in the euro area will remain permanently depressed. The investment gap so often invoked is anyway much smaller than widely believed because any comparison with the peak level reached at the peak of a credit boom in 2007 is inappropriate. But investment rates in the euro area are likely to remain below the more normal levels of before the credit boom because the potential growth rate of the euro area has declined so much under the twin impacts of lower labour force growth (now turning negative) and a fall in overall productivity (a longer term trend whose root cause is difficult to ascertain)."

In fact, if a country with low $n + g$ has high gross investment, it will not end up with high growth, but with high capital consumption. Take Japan and the United Kingdom. Japan has a *gross* investment rate of 24 percent, vs 17 percent for the United Kingdom.[20] But capital consumption in Japan is 22 percent of GDP, versus 12 percent for the United Kingdom. *Net* investment in the United Kingdom is therefore higher than in Japan, which—together with faster working age population growth—helps explain why the United Kingdom, at 2 percent, is growing faster than Japan (1 percent).

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[18] The OECD has issued similar warnings. See, for example, the FT article "Raise investment to maintain global growth, says OECD", available at https://www.ft.com/content/14e52150-d418-11e7-8c9a-d9c0a5c8d5c9;

[19] So far we have assumed that technological progress is *disembodied*. If technological progress is *embodied*, the link between technological progress and investment becomes even stronger. If embodied progress is high—say new computers are much better than existing computers, as a result of which their quality-adjusted price is falling rapidly—there is a strong incentive to invest, while if progress is slow, such incentives are much weaker.

If technological progress is embodied, we can also get a link from higher investment to higher productivity. If embodied technological progress is rapid (as it was in the late 1990s when the quality-adjusted price of information processing equipment was falling rapidly) this may be important. But it is much less important today, as price declines of information processing equipment have declined sharply, suggests that embodied technological progress in the United States has slowed sharply.

[20] All numbers refer to averages over the past five years.

9 The Trap of Low Interest Rates

So far we have argued that a prolonged period of low interest rates will lead to high capital-output ratios, high capital consumption, a low return on capital and high leverage.

In the new equilibrium a continuation of high gross investment is needed *just to stay put.* If the capital-output ratio is high, capital consumption is high, and *gross* investment needs to be high just to cover capital consumption. Japan needs investment of over 22 percent of GDP *just to keep the capital stock constant.* Lower investment means that the capital stock starts to shrink, and GDP will start to decline.

This also means that when the capital-output ratio is high, continued low interest rates are needed, as the return on gross investment is low. Japan invests around 24 percent of GDP, for a GDP growth rate of less than 1 percent. Clearly, the return on investment in Japan is very low.[21] If interest rates rise, low return investment will drop, the growth rate of the capital stock will fall, and GDP growth will drop. In addition, with high leverage, NPLs will likely increase.

In other words, a prolonged period of low interest rates will lead to a decline of the natural rate of interest rate. This suggests that the decline in the natural interest rate may not have been the *cause*, but the *result* of low policy rates.

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[21]Poland, for example, invests around 20 percent of GDP and grows by 4 percent.

10 Conclusion

In the last few decades, GDP growth, investment rates and interest rate in advanced countries have all come down in tandem. This paper has argued that this was not due to a lack of demand—there has not been a shift *along* the Okun curve. In fact, in the last five years, unemployment has come down very rapidly, even though growth was modest.

Instead, low growth was the result of a decline in $n + g$, which reduced potential growth, and shifted the Okun curve to the left. In the 1990s, 3 percent growth was consistent with unchanged unemployment in advanced countries; these days 1.3 percent growth is. The decline in $n + g$ has also reduced investment. Firms cut investment to prevent a sharp drop in the return on capital.

Central banks missed the slowdown in potential output growth. In Japan in the 1990s, and the United Kingdom, the euro area and the United States in the 2000s, they thought that weakness in growth was *cyclical* and that potential output growth had remained strong (section 2).

We analyze what happens if central banks mistakenly diagnose the problem as insufficient demand, when it is actually a supply problem. We do this in a *real* model, in which inflation is not an issue. We show that aggressive central bank action may revive *gross* investment, but it will not revive *net* investment or growth. Moreover, low interest interest rates will lead to an increase in the capital output ratio, a low return on capital and high leverage. We show that these forecasts are in line with what has happened in major advanced countries.

The results in this paper suggests that the often-held view that investment in advanced countries is "too low" may not be correct. Investment is indeed lower than in the past, but this is because $n + g$ has fallen. Raising investment without a corresponding increase in TFP or working age population growth may simply further boost capital-output ratios and further reduce the return on investment. In fact, if a country with low $n + g$ has high gross investment, it will not end up with high growth, but with high capital consumption, as the example of Japan demonstrates.

They also suggest that a prolonged period of low policy rates may lead to a decline of the natural rate of interest. If low policy rates lead to a high capital-output ratio, continued high gross investment (and thus low policy rates) is needed just to stay put.

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Data Sources

Figure	Variable	Source	Code	Description
1.1	Unemployment rate	WEO	lur	
1.2	Real GDP	WEO	ngdp_r	
1.2	Unemployment rate	AMECO	lur	
1.3	Employment	AMECO	ANAA	
1.3	Working age population	AMECO	ADAA	Population: 15 to 64 years
1.3	Employment rate			Calculated as ratio of employment in persons to working age population.
1.4	Potential GDP growth	WEO	npgdp_rpch	
1.5	Output gap	WEO	ngap	
1.5	Inflation	WEO	pcip	
2.1	Real GDP growth and unemployment rate	WEO		See 1.2
2.3-2.6	Potential GDP and output gap	AMECO		See 1.4 and 1.5
5.1	Total factor productivity	AMECO	GUGM	
5.1	Working age population	AMECO	ADAA	
5.1	Labor income share	AMECO	GJAA	
5.1	Labor augmenting technological progress			Calculated from tfp growth and labor income share. See text.
5.2	Short-term interest, nominal	AMECO	LPBQ	
5.2	Short-term interest, real	AMECO	LQBQ	
5.2	Long-term interest rate, nominal	AMECO	LSBQ	
5.2	Long-term interest rate, real	AMECO	LTBQ	
5.3	Potential output growth	WEO		See 1.4
5.4	Gross investment	AMECO	BPAA	Gross capital formation
5.4	Nominal GDP	AMECO	EGAA	
5.5-5.6	Capital services	PWT	KSERV_g	
5.5-5.6	Real GDP	PWT	GDP_g	
5.7	Capital consumption	AMECO	BYAA	Depreciation of capital stock,
5.7	Nominal GDP	AMECO		See 5.4
5.8	Net investment	AMECO		Calculated from gross investment and capital consumption
5.9	Real internal rate of return	PWT	IRR	
5.1	Nonfinancial corporation debt	Haver / IIF	Q110NFP@IIFDATA	
6.1	Short-term interest rate	WEO	fidr	
6.2	Investment and depreciation	AMECO		See 5.4 and 5.7
6.3	Capital services and GDP	PWT		See 5.5
6.4	Real GDP	WEO	ngdp_r	
6.4	Population	WEO	lp	
6.4	Employment	WEO	le	
6.5	Real GDP and unemployment rate	WEO		See 1.2
7.1	Real GDP and potential GDP	WEO		See 1.2 and 1.4

Note: AMECO is the annual macro-economic database of the European Commission's Directorate General for Economic and Financial Affairs (DG ECFIN).
See http://ec.europa.eu/economy_finance/db_indicators/ameco/index_en.htm
PWT: Penn World Tables 9.1.