

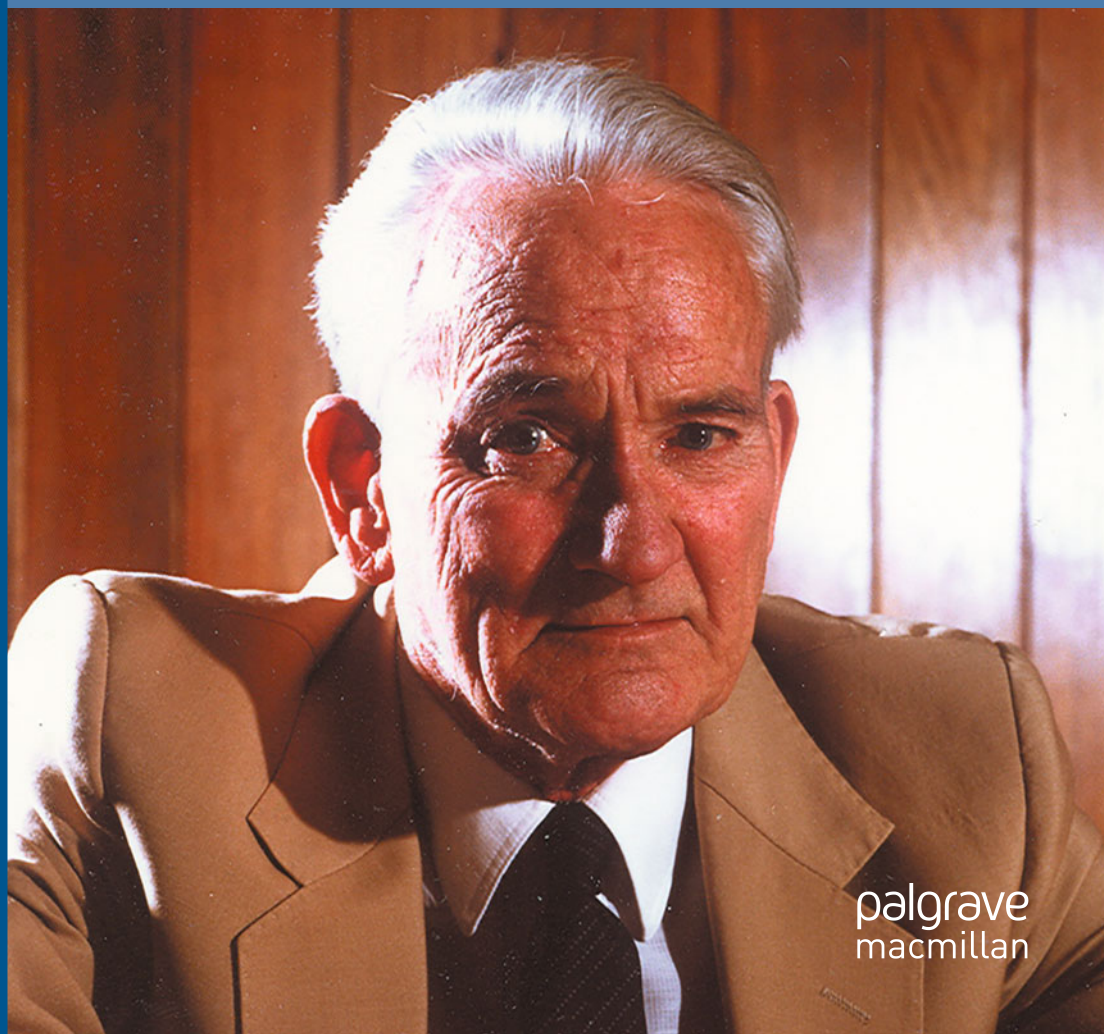


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Trevor Winchester Swan Volume II

Contributions to Economic Theory and Policy

Peter L. Swan



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Peter L. Swan

Trevor Winchester Swan, Volume II

Contributions to Economic Theory and Policy

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Peter L. Swan The Twin Goals of Internal and External Balance

We now come to the first set of papers which made Trevor Swan famous. When Trevor Swan moved to the chair at the ANU he continued to dwell over the problems of internal and external balance which had been concerning him as an advisor to Prime Minister Menzies and even earlier when he was developing his econometric model of the Australian economy. In particular he was concerned that the very rapid immigration programme, and the investment required to equip the newly arriving migrants would lead to excess demand in the economy and so create difficulties for policymakers in their attempts to achieve full employment, low inflation and a satisfactory outcome on the balance of payments (see Swan, 1949, 1950a, 1950c, 1950d).

As early as November 1952, Swan wrote a paper, *Simple Algebra* (1952) which is included in this volume, for a meeting of economists at the Commonwealth (Central) Bank in Sydney addressing the issue of simultaneously achieving three objectives:

1. *Internal Balance*. Taking the labour force and its productivity as given, the objective is a certain volume of national production, corresponding with some definition of “full employment”, and neither greater nor less.

2. *External Balance*. Taking the terms of trade and capital inflow as given, the balance of payments objective is a certain relationship between the respective volumes of imports and exports, i.e., a certain real import surplus (which may be zero or negative)
3. *The Internal Price-Level*. The objective is a certain ‘general level’ of the prices of final goods and services purchased domestically, as measured by some price-index”.

He then proposed an assignment of three instruments to these three targets:

“Suppose there are three authorities (which may be market mechanisms) effectively controlling the volume of domestic demand, the money wage-level, and the external price-level (in domestic currency) respectively. They may be called, for short, the Treasury, the Court, and the Bank. Let instructions be given as follows:

- a. The Treasury is to expand or contract the volume of demand according to whether employment is less than or more than “full”.
- b. The Court is to raise or reduce money wages according to whether the import surplus needs to be increased or diminished.
- c. The Bank is to raise or reduce the external price-level according to whether the internal price-level is falling or rising”.

The title of this paper is “Simple Algebra”. But even though the title of the paper indicates algebra, there is no algebra, only an English summary of some algebra which clearly already exists. He mentions that this paper owes its outline to Meade (1951), but there is an important innovation in the argument of this paper, even though it is only implicit. Given that Australia is a small country economically, it is reasonable to assume that Australia cannot affect its terms of trade between the prices of its export and imported goods. The exchange rate, together with the level of money wages determined by the Arbitration Court, determines the “real” exchange rate between foreign traded goods made up of imports and exports, and domestic goods, that is, between traded and non-traded goods, an idea that Swan had taken from Wilson (1931).¹ The approach

¹ Metaxas and Weber (2016, 5–8, 30) provide an excellent account of Wilson’s important (1931) contribution.

by James Meade (1951) had largely relied on changes in the terms of trade to exposit the equilibration in the external economy but, as Swan (1960, 54) argued, this was not at all necessary.

In 1953 he circulated an additional paper on policy instruments and targets that this time included the algebra. It is potentially confusing that this paper was not published until 1960 (Swan, 1960), but it was presented at a seminar in 1953, soon after the appearance of the Simple Algebra paper. By inference from a dialogue from James Mill (1773–1836), the father of John Stuart Mill (1806–1873), Swan (1960, 51) was developing economic theory as a “commanding view of the vast combination of agents and operations engaged in producing, for the use of man, the whole of things which he enjoys and consumes”. Once again, he mentions Meade (1951) but is specific this time that the terms of trade between import and export prices are fixed and that almost all of Meade’s (1951) exposition is based on terms of trade effects which are not a necessary requirement, as all Meade required was that the exchange rate affect the relative prices of imports and exports. The three targets were full employment, price stability and balance of payments equilibrium and the three instruments, domestic demand to be managed via fiscal policy, money wages to be managed by the Arbitration Court and the exchange rate. Swan does not consider the interest rate and monetary policy. Trevor also helpfully produces a diagrammatic treatment. But since this is three-target, three-instrument problem, two diagrams are required, because it is a three-dimensional problem.

A revised version with a far simpler diagrammatic presentation was given as the Giblin Lecture at the 1955 ANZAAS conference, and to a meeting of central bank economists with minor variations at much the same time. Again, rather confusingly this was not published until 1963 (Swan, 1963). It solved in diagrammatic terms the problem of simultaneously achieving both internal balance, that is full employment without inflation, and external balance, that is a satisfactory outcome on the current account of the balance of payments. The instruments of policy were now taken to be the level of demand—as in the earlier paper—and the real exchange rate, which policy could manipulate either by changing the money wage or by changing the nominal exchange rate. This had thus become a two-targets-two-instruments problem, a simpler setup than that set out in the Simple Algebra paper. As in Swan (1960) an important simplification was made by assuming that a small open country like Australia cannot affect its terms of trade. The cost ratio of external

to internal prices could thereby be represented on the vertical axis as simply the ratio of the nominal exchange rate to the money wage rate. He also abstracted from interest and monetary policy, unlike Mundell's subsequent work which I will describe below. Many years later, Rüdiger Dornbusch (1973b, 876) (1942–2002), and see also Dornbusch (1973a, 1974), clarified the mechanism by which the price of non-traded goods, here represented by the money wage, must fall within a monetary model with a devaluation which: "cause the relative price of home goods to decline at home and to rise abroad".²

In Swan (1960) he employs the same three objectives as in Swan (1952), namely "Simple Algebra", and the same three instruments, but now he supplies the algebra. He stresses the role that changes in real wages must play in the maintenance of external balance. With "sticky" money wages, changes in the exchange rate can bring about the necessary changes in the real wage. A theme is adopted which Swan persists with over his lifetime: while a devaluation raises domestic prices, revaluation lowers them.

We now come to arguably Swan's most famous paper dubbed by others as the "Swan Diagram" which is shown in Fig. 1.1.

The horizontal axis of this diagram shows real domestic expenditure made up of total domestic investment and consumption (private and public) at constant prices, and on the vertical axis the real exchange rate which is the price of imported and exported goods (*i.e.* all kinds of traded goods) relative to the price of domestic goods as represented by local wage costs. Domestic expenditure policies, exchange-rate policy and domestic wage rates set via the Arbitration Court (now the Fair Work Commission) now jointly determine both internal and external balance. The four zones of economic unhappiness described on the diagram show what is wrong with the economy when one is not on either of the lines. For example, in Zone I there is over-full employment (*i.e.* inflationary pressure) and a balance of trade surplus. Anthony Waterman (1966), when a student supervised by Swan and Noel Butlin, extended Swan's (1963) analysis by adding in Bill Phillips (1958) empirical Phillips curve relationship between the rate of inflation and the level of unemployment. Ivor Pearce (1961) published an excellent mathematical treatment of the problem when a member of Swan's department. His treatment was very

² As an aside, Rüdiger and I were colleagues at the University of Chicago in 1974 and we discussed Trevor Swan's contribution to Dornbusch's own work.

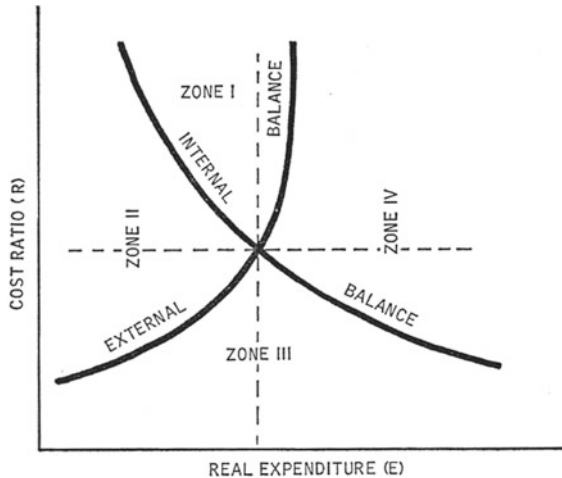


Fig. 1.1 Trevor Swan's model of internal and external balance, 1955

much along the lines of the small country assumption of Wilson (1931), Swan (1952, 1960, 1963) and Salter (1959) when Pearce (1961, 28) concludes: "It may be that the success of exchange depreciation as a policy rests more upon its power to reduce the price of non-traded goods relative to those traded than upon its power to affect the real terms of trade". The strange thing about this contribution is that it made no reference to the long history of Australian involvement in Ivor Pearce's approach. This failing was extensively commented on by Heinz Arndt's (1976) survey of the Australian contribution to the balance of payments literature, which is the first paper to be included in this volume.

Some years later, at the Reserve Bank of Australia Port Stephens Symposium on International Monetary Issues in 1976, Swan explained how the real wage was the key to his diagram: "what some called the 'Swan Diagram' was completely misunderstood if the axes were mislabelled. The diagram's axes were labelled with the level of effective real demand and the cost ratio of wages, i.e., another real variable and not the exchange rate. One might as well use the level of real wages on that axis. He agreed that shifts between traded and non-traded goods took a long time. If such shifts were to be brought about, relative prices had to be shifted first. And relative prices could only be shifted if changes the ratios

of real wages could be brought about (apart from effects due to shifts in indirect taxes and other minor factors). Hence the entire discussion about price and quantity effects depended on whether or not the real wage was endogenous to the system and could be affected by exchange-rate policy. If the real wage was not affected, exchange-rate policy would have no effect on the allocation of production to domestic and overseas demand. It could only be seen as a variable affecting the price level”.

In essence, by constructing a Keynesian economic model relevant to a small trading nation Swan could now articulate complex economic policies to a large audience in a very simple and understandable way. Two other well-known Australian economists, Wilf Salter (1959) and Max Corden (1960), appear to extend Trevor’s diagrammatic approach. A closer examination of Max Corden’s (1960, p. 4) Figure II reveals that it does not include Swan’s external cost ratio for traded and non-traded goods and thus its workings remain obscure and not directly related to Swan’s contribution. Salter’s contribution is based squarely on the dichotomy between traded and non-traded goods and thus follows directly from Swan’s contribution. It is included in this volume, as is that by Heinz Arndt (1976) which provides an excellent introduction to Trevor Swan’s contribution. Salter (1959, 226) explains why what became known as the ‘Australian model’ of the exchange rate is justified: “Whatever may be the case in economies playing a major role in world trade, in a dependent economy such as Australia no great damage is done if secondary terms of trade effects are neglected. Variations in the terms of trade - although frequent and often disastrous - are determined almost exclusively by conditions abroad; while the effects of Australian policies on the terms of trade are generally thought to be small”.

A limitation of Swan-Salter approach to simultaneously achieving internal and external balance was that their approach was largely diagrammatic without the backing of a dynamic micro-founded general equilibrium modelling foundation which has recently been supplied by Schmitt-Grohé and Uribe (2021). Their main finding is to “show that the internal and the external balance schedules of the Salter-Swan policy framework continue to exist in a micro-founded general equilibrium version of the nontradable and tradable goods model”. They explain that the crucial insights from the Swan-Salter model continue to hold:

Employment, which is the internal target of the government, is affected by both, the exchange rate and government spending. Devaluations stimulate labor demand by lowering real wages, and public consumption has an effect on the labor market through an expansion in the demand for nontradables. Since both devaluations and public spending raise the demand for labor, a government that aims to avoid both unemployment and overheating will, all other things equal, move these two instruments in opposite directions. The resulting negative relationship between the nominal exchange rate and government spending captures the internal balance schedule of the Salter-Swan policy framework. (Schmitt-Grohé and Uribe, 2021, 2).

After Swan's diagram was included in the Arndt and Corden (1963) volume of readings, many Australian secondary school economic students in the 1960s and 1970s, not to mention most undergraduate students, including myself, were brought up on the Swan diagram and the four zones of economic unhappiness. It was a little ironic since Swan and, for that matter, Colin Clark, saying that economics should not be taught in schools. It was also reproduced in an appendix in the Australian version of Samuelson's best-selling text, Samuelson, Hancock and Wallace (1970).

When James Meade visited Swan's department in 1955 he published his version of Swan's internal-external balance model in the *Economic Record*, Meade (1955). Meade seems to have been convinced by Swan to adopt Roland Wilson's (1931) small country assumption to the exchange rate as he states: "Now a depreciation of the exchange rate and a cut in wage-rates are best regarded as alternative means of raising the price of imports and exports relatively to the price of other products in the Australian economy" (Meade, 1955, 244). Meade goes even further to recommend that Australia consider a fully floating exchange rate (Meade, 1955, 254–255):

[A]s the value of the Australian pound fell, more and more speculators would stop selling and would start buying Australian pounds, until a point was reached at which a temporary deficit on the balance of payment was being financed by an inflow of speculative funds. Thereafter, the rate of exchange would rise or fall from month to month as events helped to show the true seriousness of the initial disturbance or as new disturbances, favourable and unfavourable, occurred and demanded new estimates of Australia's long-run prospects.

In the early 1960s Robert Mundell published a number of articles on exchange rates and internal and external balance. In Mundell (1961) he produced a diagrammatic approach to internal and external balance like Swan's (1955) approach, except that he has output, rather than domestic expenditure as in Swan's diagram on the horizontal axis and the monetary exchange rate on the vertical axis, rather than Swan's real exchange rate (price of traded to non-traded goods). With a flexible (floating) exchange rate, a budget deficit creates an excess demand for home goods which is corrected by an increase in output or by a fall in the foreign exchange rate. With a stable configuration, he has the slope of the internal balance line steeper than the slope of the external balance line, whereas in Swan's formulation shown in the picture above, one-line slopes upwards and the other slopes downwards.

In Mundell's formulation, monetary policy is used to lower interest rates, but this cannot happen in Swan's formulation as he takes the interest rate as given.³ Such a reduction in interest rates increases the demand for home goods, including investment goods, and reduces capital inflows (raises capital outflows). Mundell's main point is that monetary policy provides a greater Keynesian multiplier impact on the economy than does fiscal policy as the reduced capital inflow lowers the exchange rate, thereby stimulating exports and reducing imports and so raising aggregate demand. Mundell also argues that commercial policy, e.g. Swan's import controls, must be deflationary with a flexible exchange rate after considering changes in the terms of trade. By contrast, Trevor Swan's "small country" assumption rules out changes in the terms of trade. Of course, with a flexible exchange rate which was not achieved in Australia until 1983, it would not be necessary to impose import controls to achieve balance of payments equilibrium as adjustments to the exchange rate would automatically achieve balance. Mundell (1962) examines the formation of internal and external balance when policy makers do not wish to change the exchange rate or impose exchange controls. This contrasts with the Australian Government which adopted a policy of a fixed exchange rate and frequently imposed severe import restrictions. Mundell assumes that capital inflow responds positively to a higher interest rate differential. With a fixed exchange rate, Mundell argues that a higher interest rate will create a balance of payments surplus

³ In the earlier unpublished version of the model he had not proceeded in this way, but he decided that it was appropriate to do so in the final version of the model.

due to higher capital inflows and this can only be corrected by a reduction in the budget surplus. With this system in place, he argues that if monetary policy were used to obtain internal balance and fiscal policy, external balance, the resulting outcome would be unstable. Hence, Mundell assigns fiscal policy to the internal balance objective and monetary policy to the external balance objective. As noted above, this is precisely what the Australian Government and the Reserve Bank attempted to do in 1960 when faced with a looming balance of payments crisis but the monetary policy proved entirely ineffective with a sizeable expansion in the money supply taking place and no tightening of interest rates.

The apotheosis of Trevor Swan's policy contribution came with the floating of the dollar in 1982 at the urgings of Trevor Swan and the Reserve Bank as introducing a market for the exchange rate meant



Fig. 1.2 Geoff Pryor Cartoon Right through primary school I had a desk next to a boy who was far more interested in drawing splendid sketches than in lessons. This was Geoff Pryor who sums up the Hawke-Keating reforms in a magnificent cartoon. The Geoff Pryor cartoon depicting (from left): Paul Keating, Bob Hawke imposing a free market for the Australian dollar on the Opposition Leader Andrew Peacock and his deputy, John Howard. National Library of Australia obj-156519017. <https://www.nma.gov.au/defining-moments/resources/australian-dollar-floated>

that the market now took care of the exchange rate—not politicians. By adopting the major Campbell Committee reforms that introduced competition to the banks, floating the dollar, lowering tariffs and abolishing import restrictions, the Hawke/Keating Government essentially unwound the Federation compact and created a dynamic competitive economy for the first time since Federation. As a consequence, the incomes of Australians have grown immeasurably in the last 40 years (Fig. 1.2).

In recent decades, Trevor Swan's model has been promoted in the *op ed* pages of the *New York Times* by Nobel Laureate and columnist, Paul Krugman (1998, 2010), who applied the model to Latin America's problems, and to China's exchange rate, arguing that the Yuan was undervalued in 2010. But Jeffrey Frankel, another MIT colleague of Krugman, argued that the Yuan was now overvalued, <https://seekingalpha.com/article/195725-china-a-tale-of-three-swan-songs>, rather than undervalued.



Peter L. Swan: The Theory of Economic Growth

Having solved the problem of internal and external balance, using a Keynesian kind of model, Swan was able to turn to problems of long-run growth. Amongst Swan's major theory accomplishments was the independent development of the world's first significant theoretical "growth model" at about the same time as Robert (Bob) Solow (1956) made his contribution which could be, and is, used to analyse the way resources such as labour and capital are combined over time to produce real increases in living standards. This paper was produced in the mid-1950s, after the work on internal and external balance had been basically completed and it was published in 1956 (Swan, 1956). As Swan says in the first paragraph of that paper "[w]hen Keynes solved the great puzzle of effective demand he made it possible for economists to once more study the progress of society in long run... terms".

As a young boy, Peter Swan recalled his father labouring over this paper: "He took over the entire lounge room and dining table for days if not weeks at a time, close on 24 hours a day. Numerous pages of paper filled with algebra and diagrams were stacked up on the table. It was not possible to enter the room as it was filled with tobacco smoke from either his pipe or Benson & Hedges cigarettes". With an austere upbringing and few toys, his son constructed fiendish contraptions with the hundreds of gold-coloured tin boxes which the cigarettes came in. Nothing went

to waste. When Peter Swan had the temerity to ask his father why he chain-smoked back came the prophetic but very naive response: “I prefer a quick ending from cancer!” He was proved precisely correct as he died from throat cancer, doubtless related to pipe smoking in earlier days.

More than a thousand books and articles have built upon or utilized this path-breaking model independently produced at about the same time by Robert Solow (1956). Today, Trevor Swan’s 1956 article remains the most highly cited article ever to appear in *The Economic Record* with 7,714 Google Scholar citations to February 2023. It helped expose Australian economics to a world-wide audience. Swan’s model together with the now more famous contribution by Robert Solow (1956, 1957) (see Dimand and Spencer, 2009, reproduced in this volume) is known as the Solow-Swan Growth Model. Robert Solow was awarded the Nobel Prize for Economics in 1987 for his work relating to the economic theory of growth and technical change. It is helpful to compare the two presentations of the model.

In his paper, Swan skilfully shows how his model can be collapsed onto a two-dimensional diagram which is shown in Fig. 2.1 He puts growth rates on the vertical axis, and the ratio of output to capital, Y/K , on the horizontal axis. Swan does this because he wants to display the effect of different rates of (Hicks-) neutral (i.e. TFP) technical change on his diagram and this is only possible with the output to capital ratio displayed on the horizontal axis and so long as he continued with his assumption of the unitary elasticity Cobb-Douglas production function. Four years later, in his 1960 Gamagori paper (not published until 1964) he proved that in general Hicks-neutral technical change is not possible in a steadily growing (Golden Age) economy as technical change is confined to the Harrod-neutral, i.e. purely a labour saving or augmenting, type. Fortunately, his 1956 diagram is still valid as with his Cobb-Douglas production function Hicks and Harrod-neutrality coincide. There is a second advantage as well. Swan wanted to be able to extend his diagram to examine the Ricardian assumption of diminishing returns to scale and Malthusian population issues and this is only possible with his expository structure. The exogenous growth rate of the labour force, n , is shown as a horizontal line. Swan assumes a value of 1% for n . The growth rate of capital g_K is an upward-sloping line through the origin, $g_K = s(Y/K)$. Swan assumes that s is equal to 10%. Swan only makes this constant-returns assumption initially, and I will return to this issue below. Swan, like Solow, also initially ignores technical progress. His Cobb-Douglas assumption means

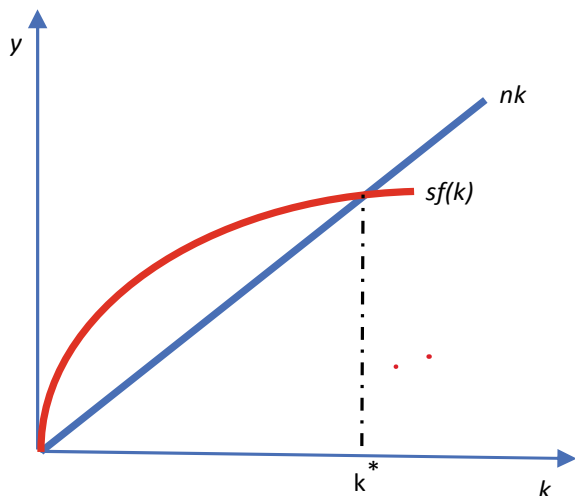


Fig. 2.2 Solution to Solow's version of the growth model (Solow, 1956)

I. WHY DID SOLOW (1956) BECOME MORE POPULAR THAN SWAN (1956)?

Just as we compared Swan's sophisticated and rigorous diagram for his econometric model, shown in Volume I, Picture 5, with Samuelson's simpler model of the Keynesian system shown Fig. 6, it is worth comparing Swan's Fig. 2.1 with the simpler diagram produced by Robert Solow, which is shown as Fig. 2.2. This picture comes from Solow's (1956) paper and is now reproduced in many undergraduate textbooks.

Solow puts capital per worker, $k = K/L$, on the horizontal axis and output per worker $y = Y/L$ on the vertical axis, where L is the labour force.¹ This allows us to represent the model with just two curves. The upward-sloping straight line shows the investment per worker which is necessary to ensure that capital keeps pace with the growing labour force. This line has a positive gradient of n . The second line shows savings per

¹ In Solow (1956, 69) it is actually the change in the rate of capital deepening, which is on the vertical axis, where the rate of capital deepening is defined as $\dot{r}/r = \dot{K}/K - \dot{L}/L$ and the change in capital deepening is $\dot{r} = sF(r, 1) - nr$. My treatment in the text relies on far simpler textbook explanations.

worker, $sf(k)$, where $f(k)$ shows output per man as a function of capital per man. This also has a positive slope, but one which gradually falls as capital per worker increases, because of diminishing returns to capital.² Thus, subject to some obvious conditions, the two lines necessarily intersect, at $k = k^*$. At this point, the capital per worker ratio is at an equilibrium value. When the ratio is above this equilibrium value, it is falling, and vice versa, so the equilibrium is stable (Fig. 2.2).

When the savings rate falls, as in Swan's thought experiment, the savings curve moves down, and capital per worker starts falling. It gradually falls to a lower equilibrium level. This reduction in the long-run level of capital per worker corresponds to what Swan's picture shows, which is that the long-run level of the capital to output ratio is lower (i.e. the output/capital ratio in the diagram is higher). And we can see from the vertical axis that output per person is also lower. This last fact is clear from Solow's diagram, in which variables are expressed in levels, but it is not directly represented in Swan's diagram which shows growth rates of the variables.

Swan uses his diagram to show how technical progress can lead to steady increases in output per person and thus can cause a continuing rise in living standards. To do this, he supposes that what he calls neutral technical change, essentially total factor productivity (TFP), increases at some positive rate but this form of technical change which has come to be known as Hicks-neutral change is the same as Harrod-neutral with

² Initially, Solow does not make any restrictions on the form of the production function, as long as it has diminishing returns to each factor and constant returns to scale. Constant returns to scale is required in order for his diagrammatic treatment to work, since only then can one write the production function in the form $y = f(k)$. However, when Solow goes on to discuss the effects of a form of technical change which equally augments labour and capital—i.e. one which causes increases in total factor productivity (TFP)—he is forced to work with the more restrictive Cobb-Douglas function, just like Swan. That is because, as explained below, his diagram can only display an outcome with equilibrium growth in the presence of technical progress if that technical progress is labour saving. And simple algebra shows that one can only correctly represent the effect of progress in TFP as if it is labour-saving technical progress if the production function takes the Cobb-Douglas form. We saw above that Swan (1956) also needed to assume a Cobb-Douglas production function in order for his diagrammatic treatment to work. But initially, in Swan (1982) but written relatively early in 1956, he both solved his model, and depicted it diagrammatically, with an unrestricted form of production function, like that used initially by Solow. Note that, as Swan (1964) demonstrated, only with the labour-saving technical progress does there exist a steady-state solution in which the wage rate is rising at the same rate as technical progress.

the Cobb-Douglas production function. This shifts up the output growth line in the Figure to the line y_3 as labour and capital are both being augmented. Such a change would mean that when Y/K was equal to 0.1, output would be growing faster than capital due to the higher marginal product of capital and that both output and capital would be growing faster than labour. As a result, the growth rate of the economy would steadily increase. But diminishing returns to labour would mean that eventually an equilibrium would be reached. This is shown as point 3 in the diagram, at which point capital and output are both growing at the same rate with a constant output to capital ratio. The key then to Swan's model and diagram is that the output to capital ratio is constant along the equilibrium growth path even with technical progress. But both would be growing faster than the labour force, and so output per worker would be rising. Since, as explained above, equilibrium on the Solow diagram requires a constant capital to labour ratio, such a diagram cannot be used to display the effects of technical change.

The way textbooks get around this problem is to redefine labour units in Solow's diagram with capital per *effective worker* on the horizontal axis and output per *effective worker* on the vertical axis. The upward-sloping straight line now shows the investment per effective worker which is necessary to ensure that capital per effective worker keeps pace with the growth in the effective labour force. Hence the slope of the straight line increases from n to $n + g$ if the effectiveness of labour is growing at rate g . The second line now shows savings per effective worker, and has exactly the same slope as before, again because of the assumption of constant returns. This means that, if one were to begin at the point k^* shown in Fig. 2.1, the initial outcome, after this happens, would be a situation in which savings per effective worker were no longer sufficient to keep capital per effective worker constant. So, capital per effective worker would begin to fall. But capital per effective worker will eventually fall to a lower level at which equilibrium is regained. In this new equilibrium position, although output per effective worker is lower, output per worker is now growing at the rate g , by assumption, and so real incomes are increasing. Of course, the problem for the reader is to understand that in terms of actual workers, capital per worker is continuing to rise as the economy becomes more capital intensive and output per actual worker continues to rise as well. In fact, if the real wage were to fail to keep pace with the productivity rise, the economy becomes entirely dominated by

capital.³ But this cannot happen in a “golden age” with uniform steady-state growth. In the Swan diagram, the rising per capital income is visible because it displays rates of change, but this is not the case in the Solow diagram which is in terms of levels.

It is true that Solow’s version of the model has proved more popular, although many still refer to the Solow-Swan model and Swan’s citation count for the *Economic Record* remains the highest for any Australian economist. Many years later Solow himself asked, “Trevor Swan—who was a splendid macroeconomist—also published a paper on growth theory in 1956 (Swan, 1956). In that article you can find the essentials of the basic neoclassical model of economic growth. Why did the version in my paper become the standard, and attract most of the attention?” (Solow, 2007, 3). Others have wondered the same thing (e.g. Robert Dimand and Barbara Spencer (nee Swan) (2009). Solow provides three answers: (i) Swan’s use of the simple Cobb-Douglas form of the production function, (ii) the focus on Joan Robinson and her issues with an aggregate production function, which I discuss below, and (iii) “Swan was an Australian writing in the *Economic Record*, and I was an American writing in the *Quarterly Journal of Economics*”. Solow’s first explanation is implausible. In fact, the first version of Swan’s model, Swan (1982), was quite general and Solow (1956, 85) was forced to rely exclusively on the Cobb-Douglas functional form to consider technological change as his model can only handle Harrod-neutral purely labour-saving technical change.⁴ With Cobb-Douglas, Hicks (TFP technology) and Harrod-neutrality are the same. The second explanation is also implausible as the treatment of Joan Robinson was largely confined to the Appendix and Swan’s paper demolished much of the Cambridge (England) case against the aggregate production function and thus supported Solow’s position. Hence, we are left with Solow’s third explanation which makes a great deal of sense. The *Quarterly Journal of Economics* is by far the world’s most highly cited economics journal, far exceeding the impact of the *Economic Record* with the patriotic Swan wishing to support the home-grown product.

³ Peter Swan (1976) showed that Harrod-neutral technical change in the nineteenth-century textile industry resulted in capital dominance because of the failure of wages to keep pace with the high rate of technological improvement.

⁴ Naturally, Solow’s followers must confine textbook presentations to pure labour-saving technological progress, but Solow’s (1957) famous empirical paper also assumes neutral (TFP) productivity growth, not Harrod-neutral.

Dimand and Spencer (2009) discuss Solow's three explanations at greater length and find some element of plausibility in all three explanations. Their contribution is included in this volume.

Vines and Wills (2020) put forward a fourth explanation, namely that, the apparent greater simplicity of the Solow diagram was helpful in ensuring that the Solow version of the model became popular. But they also argue that this simplification was a significant limitation. What they say builds on the fact that Trevor's paper was a lot more than the co-first neoclassical growth model. It also explores classical Ricardian and Malthusian issues, in a way which Solow did not do at all. In part, this was because Swan was interested in Ricardian and Malthusian population concerns, that is to explaining the classical economists. But what he modelled was also directly related to Australian policy concerns. The question Swan (1956, 339) asked, which Solow did not ask, was: "what is the maximum rate of labour growth consistent with the maintenance of a given standard of output per head". Although not mentioned here, labour growth was (and is) a policy instrument due to Australia's commitment to a very high rate of immigration. Swan had already written a number of papers on the problem of absorbing Australia's incredibly high rate of immigration, Swan (1949, 1950a, 1950c and 1950d) and in the following year, 1957, he gave the Presidential Address to Section G of ANZAAS on population growth and immigration. Only Heinz Arndt's Notes (1957) on Swan's speech have survived and I have included this summary in the current volume.

In this speech Swan recognizes the Malthusian concern regarding immigration with a fixed supply of land and diminishing returns. A high level of savings is required to equip immigrants with sufficient capital. However, he also expresses considerable optimism once the skills of immigrants are brought into the picture, together with economies of scale from a larger population. Today, many economists argue that the vast immigration programme that was temporarily halted during the COVID-19 pandemic should not be resumed due to a lack of infrastructure and low or negative growth in real wages. Were Swan alive today he would point to China's aggression and the need to have a sizeable population to ward off China's threats with better defence preparedness from a more sizeable tax base, while drawing attention to the larger market created by immigration and the importance of scale economies. Swan's (1956) solution depended on sufficient technical improvement to offset the effects of diminishing returns from the fixed supply of land. He thus does not

consider economies of scale with respect to the population size. To discuss this case he therefore required a version of the model in which the production function displayed diminishing returns to scale. But that is not possible for the Solow diagram, since it can only be drawn if one assumes that there is constant returns to scale. Hence, Vines and Wills (2020) are correct that Swan (1956) needed to use a more complex (and sophisticated) diagram than Solow (1956) as he had a far more extensive agenda in which he also needed to display the benefit of technological change in a far more attractive manner than can be done with Solow's approach. Does the greater complexity of Swan's diagram explain Solow's relative success? I personally don't think so. Solow's market power hypothesis, his point (iii), is far more powerful and arguably Solow's impact would have been even greater had he adopted Swan's diagrammatic approach.

In this regard, one might well ask why did not Solow place the output to capital ratio on the horizontal axis like Swan? Swan did so because of the constancy of this ratio when subject to technological change and such an approach would have enabled Solow to display technological change on his diagram. The reason Solow did not do so was due to an error. Dixon (2003), included in this volume, points out that Solow (1956, 85–87) incorrectly claims that the capital-output ratio is increasing in the steady state as a consequence of (Hicks-neutral) TFP-type technological change. By contrast, Swan (1956) shows that the constancy of this ratio is a defining characteristic of the growth equilibrium. Dixon (2003, 490) goes on to say: "With the aid of his diagram (which features the output-capital ratio on the horizontal axis) Swan was able to arrive not only at the key neoclassical growth 'proposition' that the equilibrium rate of growth is independent of the savings rate, but he was also able to correctly solve for the equilibrium growth rate of output in the presence of technical progress". It is clear then that not only are there no errors in Swan's exposition and diagrams, but there is an error when Solow attempts to extend his model to incorporate technological change.⁵ Perhaps this is what Swan was warning against in his preliminary analysis, Swan (2002, 375) when he stated: "Warning: Solow's article is in several respects misleading". It would be wrong to conclude that Solow's error was serious in the scheme

⁵ Of course, both authors at the time also thought incorrectly that general TFP technology, i.e. Hicks-neutral technical change, was consistent with both a steadily growing state and a general production function.

of things as textbooks soon corrected the error. It is only important in so far as it denied Solow a better diagram.

Swan's paper is a lot more than the co-first neoclassical growth model. As already mentioned, it explores the classical Ricardian and Malthusian paths but it also provides a series of insights into a number of puzzles connected with Joan Robinson's *Accumulation of Capital* (1956), the Wicksell Effect, and Akerman's problem.⁶ While Solow (2007, 4) dismisses these topics in Swan (1956) as "a blind alley" and much of the "Two Cambridges debate" which Solow lived through in person as a Cambridge (England) visitor, as "one interminable and pointless hassle with Joan Robinson", Swan regarded his Appendix in which these topics were discussed as being far more important than the main body of the article.⁷ What if Swan had not addressed these topics and Joan Robinson and Cambridge England had won the debate? Solow would not have been able to dismiss Joan Robinson so easily. In his Nobel Prize Lecture,⁸ Solow (1987) complains: "I was already trapped in the famous 'Cambridge controversy'. I use the word 'trapped' because that whole episode now seems to me to have been a waste of time, a playing-out of ideological games in the language of analytical economics".

Mordecai Kurz (1963) created an interesting extension of Swan's model by splitting the production of capital and consumption goods into two sectors. A new result which is also true in Swan's single sector model is that when the economy is not on its terminal path, the more undeveloped an economy is, the higher the rate of growth it is capable of attaining. This is important in understanding the rapid historical growth

⁶ Anthony Waterman (2020), who was supervised by Swan and Noel Butlin, had previously studied under Joan Robinson in Cambridge and was exceedingly impressed: "With one exception, Joan Robertson was the most intelligent person I have ever met. She instantly grasped the implications of a set of assumptions, followed them through to a degree of complexity far beyond the grasp of any ordinary mind, saw at once the weakness in any line of argument: and was incapable of understanding why the rest of us were unable to follow. But I was a lazy and incompetent student, and my weekly essays were pretty feeble. She patiently tried to help me, but I had never really grasped what economics is all about".

⁷ Swan's correspondence indicates that he was greatly concerned that he may have accidentally approved the reproduction of the main article without the inclusion of the Appendix.

⁸ It is notable that in his Nobel Prize Lecture, Solow (1987) fails to credit Trevor Swan as the independent co-discoverer of the neoclassical growth model.

rate of Japan and the current high growth rate of China (prior to the latest drastic attempts to halt COVID by draconian lockdowns that were once so familiar to Victoria). Another interesting finding is that when the savings ratio equals the relative capital shares then the interest rate is equal to the growth rate of income.

Wicksell's work on the treatment of durable goods in his analysis of Akerman's problem is the starting point for my work, and that of others, on the economics of durable goods (see, for example, Peter Swan, 1970). See Geoff Harcourt (1972) for a discussion of Trevor's contribution to the debate between Joan Robinson and other Cambridge (England) economists and the Cambridge Mass. Economists, the so-called "Two Cambridges" debate. See the work of economists such as Robert Solow and Paul Samuelson at MIT; Steve Dowrick and Mark Rogers⁹ (2002), Robert Dixon (2003) and Mark Rogers (2003) from Australia; and David Romer (2019) from Berkeley, for surveys of some of the vast literature that has been spawned by the model.

Much of the Two Cambridges debate concerned the claim made by Joan Robinson (1953) that it was impossible to measure aggregate capital to explain the marginal product of capital and the distribution of income in a way which did not involve prices and interest rates—the very things that the theory was supposed to explain. Labour and land could be measured in terms of their own technical units to explain their marginal products whereas it was claimed that capital was heterogeneous and needed to be defined in value terms, making it impossible to explain profits, the interest rate and the share of income going to capital, labour and land (Harcourt, 1972, 4). While Joan Robinson believed that one could construct a measure of capital in relation to the amount of labour required to construct it, this made it useless to explain the distribution of income. To overcome this indeterminacy, Swan resorted to what were popular children's toys at the time: "the device of using a primary unit, namely, a one all-purpose commodity – his famous Meccano set"¹⁰

⁹ Mark Rogers was an English economist who undertook his PhD at ANU and later returned to Oxford. Tragically, both Steve Dowrick and Mark Rogers died at relatively young ages from brain tumours.

¹⁰ Peter Swan reminisces: "Yes, at one stage I possessed a small number of Meccano Set pieces, but I was not over-endowed with toys other than the fantastical contraptions I constructed from Benson & Hedges cigarette tins. On Trevor's frequent overseas trips, he would return with exotic toys not available in Australia. One such toy nearly resulted in