the economist’s understanding of the role of accounting data in economic decisions.

G. WHITTINGTON

See also DOUBLE-ENTRY BOOKKEEPING; HISTORICAL COST ACCOUNTING; INFLATION ACCOUNTING; OVERHEAD COSTS.

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accumulation of capital. The accumulation of capital has been analysed by economists in two very different ways. The most common has been to see it as the expansion of the productive potential of an economy with a given technology, which may be improved in the process. But it has also been understood as the outright transformation of the technical and productive organization of the economy. The first approach leads to analyses based on the idea of steady growth, subsuming the concerns of the second under the heading of ‘technical progress’. Such an approach rests on a conception of capital as productive goods or, in more sophisticated versions, as a fund providing command over productive goods. This is not wrong; it is merely inadequate. Capital must also be understood as a way of organizing production and economic activity, so that the accumulation of capital is the extension of this form of organization into areas in which production, exchange and distribution were governed by other rules. This conception of capital emphasizes the importance of organization; so understood, technology and engineering are not abstract science, they are ways of organizing production, and so have an institutional dimension. Accumulation then implies the transformation of institutions as well as production, and steady growth is not applicable (except perhaps as a benchmark).

Besides the distinction between steady state and transformational growth, there is another principal division in the way that economists have thought about accumulation. One side sees it as ‘ploughing back’ part of the surplus arising from production; the other as the process of adjusting a scarce resource to its optimal uses, as determined by the market. According to the classical ‘surplus’ approach, accumulation consists of the productive investment of part of society’s net product – the surplus of output over necessary consumption and the requirements for maintaining capital intact – in order to expand productive capacity to take advantage of new or developing markets. The study of accumulation, therefore, needs to explain both the availability of the surplus and the motivation for ploughing it back, and this can be examined either as steady state expansion or as part of a process of transformation.

The originators of the classical tradition saw accumulation as a transformation of the economy. Smith stressed institutional changes, in particular the development of markets and the removal of state barriers, but his analytics were incomplete and partially incorrect. Ricardo offered only a rudimentary explanation of the surplus, in the ‘iron law of wages’; accumulation, however, he saw as the natural activity of capitalists, although it would be limited by the rise of food prices caused by the extension of cultivation to marginal lands, shifting distribution in favour of rent. Marx located the origin of the surplus in the exploitation of labour and found the cause of the tendency of the rate of profit to fall in the interaction of competition and technological advance rather than in pressure on marginal land. Each offered a picture with a grand sweep, painted in large strokes. Modern ‘surplus’ theory is more circumspect and less interesting.

In most modern work accumulation is studied in the context of steady growth. Growth can be aimed at a specific target, or can continue indefinitely. The first is the subject of ‘turnpike’ studies (so called because to reach a target set of outputs most rapidly the economy first shifts to the balanced growth path – the ‘turnpike’ – and speeds along it, changing to the desired production mix when it reaches the right size), while the latter is analysed by models in which equilibrium paths of perpetual expansion are determined and their properties examined. So, given a system of production, we ask how that system can be
set up so as to grow either over the indefinite future or over some finite stretch of time to reach some target set of outputs. In either case, however, accumulation, the central focus around which other economic questions are grouped, will result from the reinvestment of part of the surplus, and will be analysed either as a case of steady growth or as a deviation from steady growth.

The other approach sees accumulation or decumulation of capital simply as the adjustment of a particular factor of production to its equilibrium level, as determined by supply and demand. In this conception, factor equilibrium is defined in terms of the optimal allocation of scarce resources to competing tasks (in turn defined by the equilibrium final bill of goods, again determined by supply and demand.) The supply of capital may either be taken as given, along with that of land and labour, or it may be seen as governed by saving behaviour, and so responsive to the rate of interest. Demand for capital will be governed by its productivity at the margin, as with the other factors. Equilibrium in a particular sector comes when supply to that sector equals the demand for capital arising in it; equilibrium in general comes when the overall supply of capital equals the overall demand for it. So, according to this conception, accumulation occurs only when the economy is in disequilibrium – it is the movement along the path to equilibrium. The central economic problem is the optimal allocation of scarce resources, and accumulation of capital is a relatively minor matter.

Technical knowledge, however, is itself a scarce resource, and the incentives to produce it and allocate it optimally can be studied by neoclassical methods. Thus the allocation approach can give rise to an account of the long-term transformation of the economy.

But a reallocation process has a natural ending at the equilibrium point, whereas capital accumulation appears to be limitless. Locked into an allocation/disequilibrium framework, the supply and demand approach would be unable to tackle the main questions. It was saved from this fate by the development of the neoclassical growth model, based on the aggregate production function, and thus combining aspects of the traditional ‘surplus’ approach with supply and demand. This model provides an account of ‘steady growth’ over the long run; that is, uniform expansion of all outputs and all inputs, taking place together with regular technical progress. The working of this model, in turn, is based on the traditional theory of competitive factor markets with substitution between labour and capital in the process of production, where both factors are expressed in aggregate terms.

THE KEYNESIAN PROBLEMATIC. The question of substitution initially arose because a simple Keynesian growth model with a given capital–output ratio led to the disturbing conclusion that neither steady growth nor optimal allocation could be achieved. Aggregate demand equals Investment times the multiplier, or I/s, in the simplest case, where s is the average and marginal propensity to save. Aggregate supply, then, is the capital stock times its productivity, or K/v, where v is the capital–output ratio. So the growth rate, \( G = I/K = s/v \). This is the rate which equates supply and demand; hence it is the one that business will find satisfactory. But nothing has been said about the labour force or employment; so the equilibrium growth rate need not be consistent with the growth of the labour force, a condition which cannot be optimal. Nor is that the only problem. When \( I \) is too low, so that \( I/K < s/v \), there will be excess capacity; so businesses will be inclined to reduce \( I \) still further. Similarly, when \( I \) is too large there will appear to be capacity shortage, and businesses will be inclined to increase \( I \) still more. The system gives the wrong signals, and a deviation from steady growth will tend to worsen rather than correct itself.

THE NEOCLASSICAL RESPONSE. Substitution in response to price signals appears to correct this. The neoclassical model determines a path of steady and stable full-employment growth. For instance, when the rate of growth of labour, in efficiency units (the ‘natural’ rate of growth), persists exceeds the rate, \( s/v \), determined by the propensity to save and the capital–output ratio (the rate that will just balance aggregate demand and aggregate supply), the real wage will tend to fall, leading firms to substitute labour for capital. As a result, \( v \), the capital–output ratio will decline, raising the rate of growth, \( s/v \). So long as the production function is ‘well behaved’ (linear and homogeneous, positive first and negative second derivatives, marginal product of capital tends to infinity as \( K/L \) tends to zero, and tends to zero as \( K/L \) to infinity), we will exist a value of \( v \) that will equate \( s/v \) to any natural rate of growth. Technical progress which leaves the \( K/Y \) ratio unchanged (Harrod-neutral) will not affect the steady-growth path; technical progress which leaves the ratio of the marginal products of capital and labour unchanged (Hicks-neutral) will change the path, but the economy should adjust smoothly to the new equilibrium. In the Keynesian case, investment determined savings; here that causality is reversed (and so the instability disappears – by fiat): in the long run, all savings will be invested; persistent excess capacity (resulting from planned saving > planned investment at full employment) would drive down the rate of interest by lowering the return (or raising the risk) on existing securities; the lower rate of interest will then raise investment up to the full-employment level.

OPTIMALITY AND THE GOLDEN RULE. In neoclassical theory, equilibria tend also to be optimal, but in general the steady growth path will not be. An optimal path ought to be one along which per capita consumption is at a maximum. Consumption is output minus investment, and investment must grow at a fixed rate in order to fully employ the growing labour force. Now consider different capital–output ratios: if the marginal product of capital at a certain \( v \) adds more to output than is required to equip the labour force, consumption rises; if it adds less, consumption falls. Hence when the marginal product of capital just equals the additional investment required for the growing labour force, consumption will be at a maximum. But there is no reason to expect this level of the marginal product to be associated with the capital–output ratio that makes \( s/v \) just equal to the rate of growth of the labour force.

The proposition that consumption per head is maximised when the rate of profit equals the rate of growth is sometimes called the ‘Golden Rule of Growth’. Under constant returns, it has another disconcerting implication for neoclassical theory. In the stationary state, a positive rate of profit implies that the choice of technique (of the capital–output ratio) is suboptimal. In the stationary state (the normal assumption underlying textbook price theory) only a zero rate of profit is consistent with optimal technique. But a zero rate of profit implies that the Labour Theory of Value governs long-run prices! Either long-run prices are determined by growth theory, or they reflect labour values, or the techniques in use are sub-optimal. (Non-constant returns make this more complicated, but the heart of the problem remains: allocation theory cannot determine long-run prices and optimal techniques independently of growth theory, and therefore of the ‘surplus approach’.)
TECHNICAL PROGRESS. Treating technical progress as a shift of one kind or another in the production function limits the field of study to changes in method, overlooking the introduction of new products and, indeed, whole new sectors. Treating it as autonomous or as a function of time, even, as in 'learning-by-doing', time on the job, ignores the important influence of demand pressures. Neo-Keynesians, by contrast, treat technical progress as primarily occurring in manufacturing as a response to the growth of demand, so that the rate of technical progress depends on the relative size of manufacturing and on the rate of growth of demand, a relationship known as Verdoorn's Law, which has been widely confirmed.

CAPITAL THEORY. The standard version of neoclassical theory treats capital as a factor of production, on a par with labour and land, where factors are understood in broad terms and are supplied by households and demanded by firms. (The activity analysis version treats each capital good and each form of land or labour separately, determining its marginal product as a shadow price, thereby avoiding difficulties over capital-in-general, but for that very reason cannot easily analyse the forces that bear on capital as a whole; for instance, saving and investment and their relation to the rate of interest.) The 'surplus' approach of the classics, especially as developed by Marx, conceives capital as an institution: it is a way of organizing production by means of control over produced means of production, which permits processes of production to be valued so they can be bought and sold. These two approaches are obviously different, but are they necessarily incompatible? The capital theory controversy developed over the neoclassical attempt to show that the aggregate production function's implied ordering of techniques (according to an inverse relationship between profitability and capital-intensity) could be constructed in a disaggregated classical or 'surplus' model.

Each point on a neoclassical production function (whether aggregate or not) represents the adoption of a method of production: the firm or the economy as a whole has fully adjusted its plant and equipment. Moving from one point on a production function to another thus means scrapping old plant and replacing it with new, which implies a burst of exceptionally high activity in the capital-goods sector. This will normally be compatible with continuous full employment in the neoclassical framework only if the consumption goods sector is the more capital-intensive, a condition for which there is no economic rationale (Uzawa, 1961), or if certain other special conditions are met (Solow, 1962). But once we step outside the neoclassical framework the problem of 'traverse' (moving from one growth path to another), even with a given technique, can be shown to simply capacity surplus or shortages in one or more sectors, normally accompanied by temporary overall unemployment (Hicks, 1965; Lowe, 1975).

In marginal productivity theory a technique is thus uniquely designated by (K/Y, K/L); moreover, each K/Y is uniquely paired to its corresponding K/L, and as a direct consequence, each K/L is uniquely associated with a marginal product of capital. But suppose a technique were most profitable at one rate of profit (marginal product of capital) and then also proved the most profitable at another level of the profit rate. If this could happen, the neoclassical production function would not uniquely determine the choice of method of production. Yet the general possibility of this phenomenon ('rewitching') is easily demonstrated. (Not only the neoclassical approach is at risk here; the Marxian doctrine of the falling rate of profit is likewise rendered suspect: Okishio, 1962).

Neoclassical production theory, whether aggregate or not, postulates diminishing marginal output as the amount used of a factor is varied in relation to other factors. If factors are paid the value of their marginal products, as the theory of competitive behaviour asserts, then factor reward (e.g. the rate of profit) should fall as the amount of the Factor (capital) increases in relation to labour. (If reswitching occurs, it can be demonstrated that at least one of the switches will show a positive relation between capital per worker and the rate of profit.) Once we step outside the conventional approach, this inverse relationship is not intuitively plausible: increasing the amount of capital employed in a production process is a more complex matter than employing more labour. Capital consists of all the various means of production; it is a set of inputs. In fact, it is more (and more complicated) than that: at the beginning of production the capital of an enterprise consists of its plant and equipment, its inventory of materials and its wage fund (minus various obligations). A little later it consists of somewhat depreciated plant and equipment, together with the worked-up inventory of marketable goods, while the materials and wage fund have disappeared. But (allowing for changes in indebtedness during production, etc.) although the actual goods in which its capital is embodied are different in the two situations, the business will sell for the same price — it has the same capital value. To vary the amount of capital is to change the size or the nature of the entire process, and it is not at all obvious what effect this will have on the rate of profit.

A second problem concerns influences running the other direction, from the rate of profit to the amount of capital. When the rate of profit changes, competition requires prices to change. (Suppose, ceteris paribus, that the real wage rose, requiring the general rate of profit to fall; to keep the rate uniform, so capital will not tend to migrate to the relatively high-profit industries, the prices of labour-intensive products will have to rise relative to capital-intensive ones.) But if the prices of produced means of production change, then the 'amount of capital' embodied in unchanged plant and equipment can vary, and this can come about because of variation in the rate of profit. Moreover, the amount of capital embodied in unchanged equipment can vary in either direction when the rate of profit changes, since the direction of relative price changes depends only on relative capital-intensity, about which no general rules can be given. The neoclassical ranking of techniques according to capital-intensity and the rate of return has to be considered an inadequate representation of the real complexities involved in choosing techniques and using capital in production. So the neoclassical answer to the Keynesian problem is not sufficient.

NEO-KYNESSIAN THEORY. An alternative to the neoclassical theory of steady growth, however, provides a similar answer by way of a different conception of price adjustments, while still remaining within the conception of accumulation as the expansion, rather than the transformation, of a given system. The overall saving ratio is considered the weighted average of saving out of wages and profits, the weights being the respective income shares. Here the propensity to save out of profits is assumed to be relatively high, and that out of wages to be low. Then, if the natural rate of growth > s/v, eventually the money wage rate would tend to fall, and this, ceteris paribus, would raise the profitability of investment. As a result the overall saving ratio would rise, bringing s/v up to the full-employment level. If s/v is greater than the natural rate, on the other hand, the resulting excess capacity would lower profitability and tend to bring s/v down. Thus it is not necessary to assume easy and unrealistic substitution; the
capital/output ratio can remain fixed, and yet market adjustments will direct the system towards the full employment growth path. Like the neoclassical, this scenario sees the natural rate of growth as the centre of gravitation towards which the system adjusts. But it has sometimes been given another, more Keynesian interpretation. If, at the level of normal capacity utilization, investment demand were to exceed savings, multiplier pressure would drive up prices — since output could not be (easily) increased. Money wages, on the other hand, would not be driven up, since employment could not be (easily) increased either, for when plant and equipment is operating at full capacity there are no more places on the assembly lines — the full complement of workers has already been hired. Thus the excess demand for goods will not translate into excess demand for labour, and prices will be driven up relative to money wages: a Profit Inflation. Thus the overall saving ratio will rise, until the pressure of excess demand is eased. So in the long run as well as in the short, savings adjust to investment. Understood in this way, the second scenario contradicts the neoclassical one rather than complementing it.

**Investment and the Accelerator.** But this is still not fully Keynesian, or at least not Harrodian, for the emergence of excess or shortage of capacity must be allowed to influence investment plans — the ‘accelerator’, or capital-stock adjustment principle. When \( s/v > \) actual or current \( I/K \), there will be a slump; when \( s/v < I/K \) prices will be bid up relative to money wages. Money wages, in turn, will tend to rise or fall according to whether the actual rate of growth lies above or below the natural. If the actual rate lies above the natural, this will tend to raise the natural and lower the actual. There are thus three rates of growth: the actual, \( I/K \), the warranted, \( s/v \), and the natural, and six possible permutations of these. It can be shown that in only two cases is there an unambiguous tendency for all three rates to converge; in two others, plausible additional assumptions will bring a tendency to converge. But in two cases there seems to be no convergence at all: quite the opposite (Nell, 1982). So the Keynesian approach suggests that the full-employment (or, indeed, any) steady growth path should not be treated as a centre of gravitation; it may or may not be what the market tends to bring about.

**Capital Value and Profit.** Ironically, this neo-Keynesian approach runs afoul of the same problems that plague the neoclassical standard version. For once we leave the one-sector framework, the neo-Keynesian theory implies that excess aggregate demand will bid up, not the price level in general, but the relative price of capital goods — for the excess demand is entirely concentrated in the investment goods sector, and there is no discussion of how this could be transmitted to the consumer-goods sector. Moreover, if both prices did rise relative to money wages, consumer-goods demand would fall. But this would not indicate a possible equilibrium, for it leaves the profit rate unequal in the two sectors. Thus the neo-Keynesian claim must be that a bidding up of the relative price of capital goods will raise the rate of profit, leading to higher savings, etc., but in a two-sector model it is easily seen that this will only be the case when the capital-goods sector is the more capital-intensive. So the validity of the approach depends on an arbitrary condition (which becomes even more arbitrary as the number of sectors increases).

Even worse, suppose that the capital-goods sector is the more capital-intensive, and consider a small rise in the growth rate to a new equilibrium level, requiring an increased production of capital goods (alternatively, a fall in the actual rate below the equilibrium). The corresponding new overall capital–labour ratio will be higher than the initial one; but to maintain full employment there will have to be a diversion of resources to the industry with the lower capital–labour ratio. To preserve full employment the capital-goods sector would have to be contracted; but to increase the growth rate it has to expand. (A similar argument holds for a decline in the equilibrium growth rate.) In the case where a rise in the price of capital goods would increase the rate of profit, permitting the neo-Keynesian mechanism to work, the system could not adjust to the new steady growth path, since the two conditions for adjustment contradict one another.

In fact, adjustment from one steady growth path to another turns out to be difficult in general, even without changes in technique. A change in the growth rate requires changes in the relative sizes of sectors, which means shifting labour and resources; but these are normally used in different proportions or in different combinations. And some can only be used in certain sectors and not in others. The ‘traverse’ from one steady path to another will normally involve both unemployment and shortages, and it may be difficult to actually reach a new path before the conditions determining it change. The ‘steady growth’ approach to accumulation may face insurmountable problems.

**The Significance of Steady Growth.** But, what then is the importance of the steady growth path? For the neoclassical approach it is an extension of the concept of equilibrium to the case of expansion over time; for some neo-Keynesians it represented a centre of gravitation, a point towards which the system would move, or around which it would oscillate. For others it may simply be a point of reference — how the system would work if certain contrary-to-fact assumptions held. Real processes will normally be different and can be classified by their distance from such a point of reference.

Following Joan Robinson, steady growth with continuous full employment has been termed a ‘golden age’; desired capital accumulation equals the natural rate of growth. But a low desired rate, well below the initial natural rate, might create a large reserve army of unemployed, forcing down real wages and lowering the birth rate, so that the natural rate would fall to the depressed desired rate — a ‘leader age’. A desired rate above the natural rate may bid up real wages enough to lower the rate of profit until the desired rate fails to the natural — a ‘restrained golden age’. A ‘bastard golden age’ occurs when the desired rate cannot be achieved because the real wage cannot be driven down sufficiently, the attempt resulting in inflation. Other possibilities can be envisioned, depending on the adjustment mechanisms postulated. For example, when the initial stock of capital is not appropriate to the desired rate of accumulation, it will have first to be adjusted, but the part of the capital-goods sector that produces capital goods for its own use may be too large or too small for easy adjustment to the desired rate, giving rise to ‘platinum age’ patterns of accumulation. The catalogue is endless, but its value is limited.

Steady growth, in fact, appears to be best analysed as a supply-side concept. Its most elaborate development, in fact, is strictly supply-side — as the von Neumann ray, or in Sraffa’s terms, the Standard Commodity, where the industry sizes of the system have been so adjusted that the net product of the economy as a whole consists of the same commodities in the same ratios as its aggregate means of production. The warranted rate of growth, by contrast, balances supply and demand. But it is an imperfect growth concept, for it balances aggregate supply and aggregate demand at a moment of time; it
does not balance the growth of supply with the growth of demand. The von Neumann ray is an analysis of the growth of supply—but so far there is no comparably detailed analysis of the growth of demand.

ACCUMULATION AND TECHNICAL CHANGE. This not only brings to light a defect in the theory of steady growth, it also raises the question of the relation of steady growth to the accumulation of capital. For the best-established empirical proposition in the study of consumer behaviour states that as income increases, consumer demand will increase non-proportionally—it will shift in a characteristic manner. Hence there is little point in trying to complete the theory of steady growth with an account of steady growth in demand; it doesn’t happen.

In actual fact, steady growth has never taken place. The history of capitalism is a history of successive booms and slumps, but perhaps even more striking, of slow but persistent long-term shifts in crucial relationships. For two centuries labour shifted out of agriculture and migrated to the cities to work in manufacturing industry. For over half a century now labour has shifted into services, first from agriculture and then, later, from manufacturing as well. For almost a century the relative size of the government sector has been rising, whether measured by share of GNP or by share of employment.

These points lead to a major criticism of the treatment of technical progress in accumulation: whether it is presented as shifting the production function, as learning by doing, or in a ‘technical progress’ function, and whether conceived as embodied or disembodied, it has been treated as leading to the extraction of greater output from given resources, in the context of steady growth. But technical progress introduces new products as well as new processes, and together these change the forms of social life. This is reflected in the changing importance of the major sectors of the economy, in the changing class structure and in the changing patterns and nature of work. None of these points seems to be captured by the current analyses, in part because of the preoccupation with steady growth, based on an overly simplified concept of capital as productive goods. When capital is understood as also being a form of organization, then the link between accumulation and the transformation of institutions can be forged. Another reason, perhaps, may be that technical progress has been approached too timidly, and without understanding its dual nature. None of these points seems to be captured by the current analyses, in part because of the preoccupation with steady growth, based on an overly simplified concept of capital as productive goods. When capital is understood as also being a form of organization, then the link between accumulation and the transformation of institutions can be forged. Another reason, perhaps, may be that technical progress has been approached too timidly, and without understanding its dual relation to the growth of demand. For technical progress both stimulates the growth of demand and responds to it.

STEADY GROWTH VERSUS TRANSFORMATIONAL GROWTH. In practice, steady growth is an impossibility for at least three reasons. First, land and natural resources are limited, and high-grade ores and high-fertility lands are the first to be used. As they are used up over time, productivity falls unless and until technical progress offsets the decline—but such technical progress will have to involve new products. Second, as mentioned, Engel curves imply that consumption patterns will be changing. And finally, if propensities to save differ in the different social classes (and it workers receive interest on their savings, and capitalists salaries for managing capital), then the relative wealth of the classes will be changing over time, leading to changes in the composition of demand. The first point implies that costs will tend to rise; the second two, that demand for consumer goods will tend to rise more slowly as time passes. All three therefore point to long-term stagnation in the absence of major technological changes.

This does not simply mean increasing the productivity of currently employed processes; it means the development of new processes and new products—both for consumers and for industry. It means electrification, or the internal combustion engine, the aeroplane or, perhaps, the computer. The changes must be of sufficient importance to lead to an investment boom resulting from widespread scrapping of present plant and equipment, as well as the development, concurrently, of large-scale new markets, as consumers introduce the new products into their living patterns. And as new plants are built, economies of scale can be realized, making it possible to lower prices, so as to reach new markets in lower levels of the income distribution. Capital organizes markets and marketing as well as production.

New household products have emerged because a way has been found to perform some normal daily activity better or more cheaply by, in effect, shifting it from the household to industry, capitalizing it. New-industrial processes, usually involving new products as well, have emerged as the result of mechanizing activities formerly performed by workers, enabling them to be done better, or more cheaply, or more reliably. Mass-production goods have replaced home crafts; the mechanization of agriculture, in conjunction with Engel’s Law, has displaced farm labour; the rise of manufacturing, to build the factories and then to supply the new goods, has provided employment for the displaced labour—but at greatly reduced hours of work per week, providing more hours to spend on consuming.

The rise of mass production and the consequent urbanization have created new problems; among others, periodic mass unemployment, which in turn had to be dealt with by an expanded government. And today traditional mass production is being transformed by the computer and the chip, with consequences we cannot yet fully foresee.

The interlocking emergence of new products and new processes, creating new markets and new industries, can be termed ‘transformational growth’, in contrast to steady growth. It is here that the true story of the accumulation of capital, and the causes of the wealth of nations, will be found, but to date this study has been left the province of economic historians.

EDWARD J. NELL

See also CLASSICAL GROWTH MODELS; NEOCLASSICAL GROWTH MODELS.

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Acyclicity. Acyclicity is a consistency property of preferences and other binary relations. It requires that the asymmetric part \( P \) of the relation (e.g. the subrelation of strict preference) contain no cycles; that is, for no sequence of alternatives \( x_1, x_2, ..., x_n \) is it true that \( x_1 P x_2, x_2 P x_3, ..., x_n P x_1 \). The study of cyclic preferences dates at least to Condorcet's (1785) treatment of the paradox of voting, in which transitive individual voters generate cyclic majority preferences.

Whenever a feasible set \( S \) contains more than two alternatives, some principle is needed to generate choices \( C(S) \) from the pairwise comparisons summarized by the preference relation; one natural candidate is the set of undominated alternatives. Acyclicity is necessary and sufficient for the existence of a non-empty set of undominated elements in any finite feasible subset \( S \) of the universal set of alternatives. In addition, defining the choice set as the undominated alternatives according to an acyclic relation guarantees that choices will exhibit a desirable consistency property: if \( S \) is a subset of \( T \) and if \( x \) belongs both to \( S \) and to \( C(T) \), then \( x \) must belong to \( C(S) \). In Sen's (1970) example, if the world champion is a Pakistani, then he must be champion of Pakistan as well. This property is attractive in piecemeal decision mechanisms in which choices are made from unions of choices over subsets. If an alternative fails to be chosen in some subset, it need not be reconsidered later, since the contrapositive of this property ensures that the alternative will not be among the final choices.

Acyclicity is a significantly weaker consistency property than transitivity; it permits intransitivities both of the strict preference relation \( P \) and the symmetric subrelation of indifference \( I \). For example, the preferences \( xPy, yPz, \) and \( xIz \) are acyclic; so too are the preferences \( xIy, xIz, \) and \( xPz \).

Acyclicity arises in several contexts in economics. Consumer theory's Strong Axiom of Revealed Preference (see Houthakker, 1950; Ville, 1951–2), for example, is an axiom asserting that a particular revealed preference relation is acyclic. It arose as well early in the development of game theory; the acyclicity of dominance relations is closely linked to the uniqueness of the von Neumann-Morgenstern (1947, ch. XII) solution.

Acyclicity has been studied most intensively, however, in connection with Arrow's (1951) Impossibility Theorem. The proposition concerns constitutions, which aggregate sets of individuals' preference orderings into social preferences. Arrow showed that the only constitutions satisfying two reasonable axioms and yielding transitive social preferences are dictatorial. Several writers have attempted to circumvent this conclusion by relaxing transitivity to the more defensible requirement of acyclicity. Non-dictatorial acyclic constitutions do exist, but they turn out to be hardly more attractive than dictatorships. Blair and Pollak (1982) review this literature and show that such constitutions must endow at least one voter with extensive veto power over strict social preferences opposite his or her own. If egalitarian concerns force the vesting of such power in many such voters, the constitution will be highly indecisive, that is, frequently yield judgements of indifference between alternatives.

DOUGLAS BLAIR

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Adams, Henry Carter (1851–1921). Adams was born on 31 December 1851 in Davenport, Iowa, and died in Ann Arbor, Michigan, on 11 August 1921. In many respects typical of the new generation of late 19th-century American social scientists, Adams became a professional economist only after considering a career in the church or in reform political journalism. After graduating from Iowa (later Grinnell) College in 1874, he spent one year as a school teacher and another studying at Andover Theological Seminary before obtaining a fellowship at the newly founded Johns Hopkins University, where he received its first PhD, in 1878. At Hopkins, Francis Walker steered him towards public finance, a field to which Adams subsequently made major pioneering contributions. But he was no narrow specialist, and two years' further study in Europe, mainly at Berlin and Heidelberg, laid the foundations for the breadth of interest, historical perspective, and philosophical insight that characterized his later writings.

On returning to the USA Adams, like many of his contemporaries, found difficulty in obtaining a satisfactory permanent academic post and was obliged to spend several years in temporary or part-time employment before obtaining a permanent position at the University of Michigan in 1886, where he spent the remainder of his career. The frank and revealing correspondence between Adams and President Angell immediately prior to this appointment is a notable contribution to the chequered history of academic freedom in America (cf. Dorfman, 1954, editor's introduction; Coats, 1968), for Adams had only recently been dismissed from Cornell for having publicly expressed support for labour unions during the outcry over the Haymarket bomb incident. At Ann Arbor, Adams built up a distinguished department (Brazier, 1982) and achieved national recognition for his nearly two decades of service as Chief Statistician to the Interstate Commerce Commission, where by constructing and implementing a system of uniform railway accounts he made a lasting contribution to the development of public regulation.

A co-founder and staunch supporter of the American Economic Association, of which he was President in 1896–7, Adams endeavoured to bring the best elements in European