

Schumpeter and Goodwin

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Introduction

The long twentieth century has seen a rather strange record of development of economic theory. After the victorious takeover of classical political economy by marginalism (Menger, Jevons, and Walras) starting in 1874 the new standard seemed to provide a more scientific looking framework for economics. The analytical toolbox introduced by Leibniz and Newton after more than hundred years finally had reached the social sciences, theoretical success comparable to the one achieved in engineering was thought to be at the doors. But then the Great Depression hit the world economy. All the theoretical advances made so far – the theoretical body of knowledge taught so skilfully by Keynes teacher Alfred Marshall¹ – broke down like a house of cards when it should prove any practical use to overcome the global crisis. John Maynard Keynes, a brilliant practically oriented advisor of political economy, revolted against Marshall and added a new layer of economic theory: macroeconomics.

With Keynes' macroeconomics a peculiar revival of topics of classical political economy occurred. Economic aggregates - e.g. unemployment, total national expenditure and its components - and corresponding variables concerning more generally held expectations, e.g. interest and expected demand, reappeared on the stage of economic theory. Moreover the importance of the political background (challenged by the Great Depression) was again made explicit: the capitalist state was called to its interventionist arms to secure the working of capital accumulation. It is clear that this whole set of theoretical innovations that the politician Keynes wanted to bring into the picture of economic theory did not fit to the existing mainstream particularly well. Fortunately enough mainstream theory already had started to be stated in a language of mathematics borrowed from 19th century mechanics, so Keynes statements usually were saved by the ambiguous possibilities of interpretation that his use of non-analytic everyday language allowed for. The economic policy proposed by Keynes remained unheard after World War 1 but to some extent supported economic recovery in the United States later. The Great Depression itself was finally overcome by a disastrous employment program: an exploding weapons' industry and worldwide public employment of soldiers.

¹ Keynes is one of the few iconic personalities in the history of economic thought, which had not received the usual contemporary academic education in political economy and thus rather has to be considered as a man of economic practice. This might explain his astonishing ignorance with respect to the works of Karl Marx whom he classified as 'a minor Ricardian' – evidently only knowing some Ricardo-style British interpretations of Marx.

The most remarkable fact for the development of economic theory during World War II perhaps was the movement of the majority of leading economic theorists to the two large Anglo-Saxon countries, Great Britain and the USA. After the war the large group of economists coming from many parts of the world and now working at the great Anglo-Saxon universities tried to construct a more convincing economic theory, which could also include some of the elements that Keynes had introduced. The late 40-ties and 50-ties still can be regarded as one of the most innovative periods for economic theory building of the 20th century. During this period, lasting more or less till the mid-seventies, the recovery of integrated capitalism in the Western hemisphere enabled continuous and increasing cooperation between economists on both sides of the Atlantic – though it also became increasingly evident that the newly emerging mainstream theory² was neither particularly rigorous nor politically applicable.

In the early 80-ties, with the wave of neo-conservative economic policy of the Thatcher-Reagan-Kohl era the divergence between increasing levels of ill-directed mathematical abstraction and obvious practical impotence of mainstream economic theory reached new heights. By including now hyper-rational expectation processes for all micro-entities of the economy (which furthermore were assumed to be identical, i.e. ‘representative agents’) Walras’ notion of *general equilibrium* assumed a new quality: In this universe of rational expectation models issues that went beyond the empty statements ‘There exists an equilibrium.’ or ‘There exists an infinity of equilibria.’ Could only be derived by ex post assumptions on different stochastic disturbances distorting the essential variables. The only general conclusion for economic policy was that state intervention was welfare reducing – though this conclusion never was rigorously theoretically derived³. It is not surprising that this type theoretical impasse was highly acclaimed by conservative policy-makers, and more progressive ‘old Keynesians’ saw no offer, indeed no need for a theoretical alternative as long as the economic seemed to continue.

But during this period of self-immunisation of mainstream economic theory, a period that in retrospect appears as an attempt of scientific suicide, some other processes rapidly were changing the context in which a more useful theory of political economy could emerge.

² Paul Samuelson’s ‘neo-classical synthesis’ merged Keynesian elements into a Walrasian setting. Even the mainstream economist Michio Morishima once explained the success of the Japanese economy by the fact that Japanese politicians simply ignored all advices coming from academic economists.

³ In most RE-models (macroeconomic models of the so-called ‘new classical school’ using rational expectations, see (Sargent, 1979)) the role of the state by assumption is collapsed into a few possible actions in a way that precludes any other conclusion. The policy conclusion that privatisation of state activities is a good thing thus is already part of the model assumptions and the model itself only serves to obscure this by formal technicalities.

First there was a dramatic change in the object of investigation, of society, on its way. The more or less clear class structure of the most advanced European nations of the 19th century was rather quickly dissolving into a **new set of social strata of a global society**. The social institutions that worked as the nodes in this new network had to be included in a new synthesis of the social sciences, a synthesis that in particular needed political science as a major ingredient. Even within the still existing national contexts the importance of the state as a mediator of social change had become only too visible. Despite this call for synthesis the dead weight of the human capital accumulated in academic institutions was too heavy to enable such a start.

Second - and to a considerable extent as a consequence of this change in socioeconomic structure⁴ - a qualitative jump in the workings of **large scale alienation** took place. The phenomenon of 'nationalism' and its transformation into Fascism can only be understood as an emerging dominance of processes in the information sphere over processes solely related to exploitation in the production sphere. The latter, of course, still were indispensable for sustaining the primary metabolism of human societies – the physical constraints of survival never can be ignored – but now the internal model building processes in the minds of human individuals became more connected and substantially more open for manipulation by centralized media in the hands of any group of rulers. The main facilitator for this development was new communication technology starting with telephone and broadcasting. Mainstream economics reflected this process late, and only in a very narrow perspective by introducing simple expectation processes⁵.

The third important change emerging in 20th century capitalism was a decisive shift of the location of the basic capitalist algorithm⁶: away from local material exploitation organizers towards a handful of globally acting financial conglomerates, i.e. towards a stage called '**finance capitalism**' by Rudolf Hilferding [Hilferding, 1908]. During the last decades of the century this produced a kind of **second level alienation** within the ruling classes⁷: global finance versus local exploiters. The mechanisms of global finance reaching not only across different economic branches but also across different continents with drastically different production conditions, these mechanisms appear alien to the local firm owners with their locally bound possibilities. Exchange rate exploitation is a global game

⁴ The other important driver of alienation, of course, was the explosion of technological advances in this field.

⁵ Keynes had started to distinguish between expected and actually needed capital stock, between expectations on real wage changes held by workers vis-à-vis those held by firm owners, and the like. Usually simple adaptive rules were proposed by Keynes' interpreters, e.g. Hicks, to capture these information processes. Only in the 80-ties the school of 'rational expectations' started to introduce full-scale internal model building; though still in a completely oversimplified form by assuming that **everybody** holds the **same true** model.

⁶ A concise formulation of the 'basic capitalist algorithm' is given in [Hanappi, 2013, pp. 262-263].

⁷ The first level of alienation, as described by Marx, concerns the working class and its product.

for which local exploiters are just the marionettes on a chess board on which finance capital plays. Needless to say that standard microeconomics with its basic building block of 'the representative firm' has produced no adequate theory of this development, nor did monetary macroeconomics or finance (with its complete neglect of exploitation as the final cause of interest) provide anything useful.

Finally, as fourth big change the **producing class has been split globally too**, partially mirroring the split of the ruling class: Poor workers in third world countries and China live in distinctively different cultural environments, including consumption and working conditions, as do most workers and employees in the leading OECD countries. Though there exist many macro-models of open economies, this opening gap between the circumstances that determine the lives of workers in rich OECD countries and workers in poor countries is almost never addressed.

Taking stock of all the increasing inadequacy and incompetence of mainstream economic theory in the 20th century it suddenly becomes crystal clear that the current deep crisis not only had not been predicted, but even today is not understandable as long as mainstream theory is applied.

At this point the reader might ask: Why is this detour into the economic history of the world economy necessary for a chapter on Schumpeter and Goodwin? The answer is straight forward. Joseph Schumpeter's and Richard Goodwin's lasting contributions to political economy were the works of theoretical mavericks, of theorists who ran counter the mainstream theory while commanding at the same time the apparatus of this theory. Their motivation to do so came from their involvement in actual political economy dynamics. Thus it is mandatory to know the background of these dynamics to understand their departures from the mainstream. Their lives covered the 20th century pretty well: Schumpeter was born in 1883, the same year as Keynes and the year when Karl Marx died. In 1901 he was 18 years old and started his professional career. Richard Goodwin was born in 1913 and died – active scientist till the end – in 1996. Their lives overlapped, Schumpeter died in 1950. More than that, they shared a common time at Harvard University from 1938 onwards⁸. It is tempting to use the two biographies to reconstruct their concrete roles in the evolution of economic thought, but this will not be the path followed in this chapter – many biographical accounts written by better informed experts already exist. In what follows similarities and differences between the two mavericks will be described by the use of the theory elements they

⁸ Still an assistant professor at Harvard, Richard Goodwin in private lessons tried to teach Schumpeter some mathematics. Though Schumpeter was extremely fond of mathematics Richard Goodwin once told me that he was a very untalented pupil. When Goodwin later tried to get tenure at Harvard Schumpeter strongly supported him, but failed – Goodwin left Harvard in 1950 and went to Cambridge.

produced. It is evident that such a task necessarily involves a certain amount of subjective interpretation, which hopefully at least can serve as a thought-provoking starting point for further discussions.

Joseph Alois Schumpeter

The scientist Schumpeter was working along an extremely creative contradiction. On the one hand he was very keen and rather successful to know and to synthesize standard theory better than anybody else, on the other hand he repeatedly produced attacks of the mainstream, true theoretical heresies, which were based on his strong believe that in the end empirically observed facts should guide science⁹. And in this respect mainstream economic theory was an easy prey. Schumpeter's theory building process in 1911 was a sudden innovative push for mainstream economics. It thus resembles the content of his theory! Even with respect to his own lifetime he developed his elaborations in a pulsating manner.

Under the influence of his first teacher Friedrich von Wieser he subscribed to the then fashionable approach of Walrasian economics, which challenged the German historical school prevailing in the German speaking countries. Schumpeter's first book had the extremely aspiring title 'Das Wesen und der Hauptinhalt der theoretischen Nationalökonomie' [Schumpeter, 1970 (1908)]. This book is his first attempt to systematize and to synthesize the new type of economics. Following Wieser in his more temperate attitude concerning mathematical treatment (compared to Walras) and psychological arguments (compared to Jevons) Schumpeter's book offers no surprises¹⁰. The aesthetic appeal of a general equilibrium approach is mainly derived from its mathematical clarity and rigorousness; but Schumpeter as a pupil of classical education in Vienna's Theresianum lacked this mathematical ability¹¹. After having finished it, his restless mind must have been bored with his own achievement – and he soon started to work on a book that pointed in a completely different direction, his 'Theory of Economic Development' [Schumpeter, 1911].

Indeed it is a rather straight forward step to recognize that a system that in the essence (German: das Wesen) is characterized by a set of market equilibria cannot only be described by the forces that drive it back to these equilibria. A vivid thinker like Schumpeter immediately felt that it was necessary to include a description of the countervailing forces that make this return to market equilibrium necessary at all. Even classical mechanics starts by describing countervailing forces.

⁹ As Schumpeter remarks, what he and Karl Marx have in common is to aim on theories derived from 'Tatsachenbeobachtung', from empirically observed facts. Compare [Schumpeter, 1964 (1911), p. 196].

¹⁰ See [Hanappi, 2010] for a more detailed treatment of Schumpeter's position as an Austrian Economist.

¹¹ The Theresianum is an Austrian Gymnasium, which in the 19th century could only be attended by children of the nobility. It provided a classical humanist education and less mathematics. Throughout his life Schumpeter admired the use of mathematics and regretted not to be able to use it adequately. Indeed Schumpeter was just the second pupil without noble descent allowed to attend the Theresianum – after his later teacher Böhm-Bawerk, who was the first.

The simplest solution to this dilemma is to assume that there exists no specific cause at all: The procedure to do so is a well-established theoretical practice since the times of Robert Malthus, who assumed that non-specified 'checks' (wars, natural catastrophes, famines, ...) will lead the number of worker families back to a level that can be sustained by the subsistence wage [Malthus, 1836]. Today students of macroeconomics are taught to test reaction of their models by assuming 'exogenous shocks' in certain variables. Again the specific cause of the shock is omitted, at best the formal characteristic of the change of a variable, transitory or permanent, is considered.

For Schumpeter such plain ignorance was not an option. Moreover he witnessed the enormous surge of economic and political activities that took hold of Europe in the decades just before World War 1. An economic theory that 'in the essence' produced an image of a state of affairs where every single human individual was in rest, at a point in its exchange relations that was optimal, i.e. in equilibrium, such a theory was clearly inadequate to its object of investigation. At the same time young Schumpeter - with his aristocratic education and still fascinated by the scientific touch that Walrasian mathematics gave to the science of economics - was not ready to give up methodological individualism. He had encountered Austro-Marxists, e.g. Otto Bauer, in the seminars at the University of Vienna and felt that an alternative to the class dynamics approach they provided, and which did fit real political dynamics better than Walras' marginalism, was needed. And he evidently did read Karl Marx famous praise of capitalism in the first part of the Communist Manifesto. Grafting this positive (productivity increasing, i.e. less labour time per unit of output) picture of capitalism on single human individuals lead him to a new concept: the entrepreneur.

In [Schumpeter, 1911] according to Schumpeter's innovative theoretical approach entrepreneurs are the *systematic* social force that drives the economy, even the political economy, out of general market equilibrium. Since this force is responsible for the historical mission – and thus legitimization – of capitalism, namely to increase labour productivity of societies, it is at least as important as the countervailing market forces that drag the economy back to equilibrium. With this idea the capitalist system suddenly appeared as an oscillating system governed by two opposing forces. But not only these forces were opposing, they also were different kinds of forces.

Market forces actually were just institutionalized rules of (usually different) market mechanisms enforced by a larger political unit, the capitalist state. The 'entrepreneur' was a subset of the set of firm owners, namely those who were able to introduce innovations. Though Schumpeter still has single human individuals in his mind when he writes about 'the entrepreneur', he nevertheless treats them like a class when it comes to the description of social dynamics. Like Karl Marx, who (in the second preface to 'Das Kapital', [Marx, (1857)]) disentangles 'the capitalist' as a character mask from its human individual carrier, Schumpeter actually uses his concept of 'the entrepreneur' to describe

an algorithm that a subset of the set of firm owners performs. In this context the individual physical person is of no importance, Schumpeter just enhances class analysis of the capitalist class!

It is not surprising that with this new theoretical vista on capitalism a considerable amount of new theoretical problems emerged. But this is exactly the role that creative mavericks have to play: to provoke unconventional new answers by inventing new perspectives.

The first set of questions concerned innovation itself. How does it work? It becomes necessary to distinguish between *invention*, which is the job of the researcher/scientist, and *innovation*, which is a second stage of activity that glues together existing, previously invented 'old elements' to form a 'new combination' that then is put to the test in a broader social environment¹². In this respect Schumpeter's theoretical innovation certainly has provoked an extremely fruitful development of a scientific community studying the emergence and distribution of knowledge that only blossomed decades after his death.

A second set of questions concerned the swarming of innovations. Why do innovations occur in the form of a pulsation and not as a smooth and continuous flow? This question forced economists to take a closer look at the historically observed reasons for the swarming processes. Collective experiences, communication processes and expectation formation became a scientific focus. Schumpeter himself, proposed to link the different frequencies of innovative swarming to different types of causes. For high frequency cycles (named Kitchin cycles) the achievement of desired inventory levels might be important. For medium frequency cycles (named Juglar cycles) it might be that the characteristic time necessary to transfer capital from one branch of activity to a new, extra-profit promising branch is responsible. And for the long cycle (called Kondratieff cycle) a special type of innovation, namely basic innovations (e.g. steam power, electricity ...) that only occur about every half centuries are responsible. Needless to say that all these suggested fields of investigation are at the core of today's most relevant economic research.

Third, with innovation being closely linked to the finance needed to develop and to test new products and processes in a market environment - and eventually to fail – a theory of finance came into focus. Is there a positive correlation between size of firms, their financial possibilities, and thus in the end their innovative power? This type of questions leads to the study of oligopolization and further on to the role of independent financial intermediaries that are detached from innovative firms. The current global crisis has at its root the mismatch between global welfare gains (achieved by innovations and redistribution of wealth and income) and the profit rates promised by Wall Street investment bankers. The topic launched by Schumpeter never was more acute than today.

¹² Note that this is similar to the way in which Schumpeter glued together Marx' and Walras' older ideas (inventions) to produce his theoretical innovation. See [Hanappi and Hanappi-Egger, 2004] for a detailed look on the innovation process.

It is obvious that this list of newly emerging questions is not exhaustive, many other items could be added. Schumpeter himself was aware of this and he spent the next decades to reconcile and to synthesize the many loose ends his attack on the mainstream in 1911 had unearthed. The necessity to lead such a multidisciplinary theoretical discourse was overlaid by a second type of cycle: Schumpeter's personal to and fro between theory production and economic and political practice. In the early 20-ties he seemed to have failed in both respects. In economic theory the star of John Maynard Keynes was rising, a brilliant writer and political commentator who dominated economic heresy in his London circles. Schumpeter's articles were dispersed over a variety of publication media, he could not get a position at the University of Vienna¹³ and was not able to gather followers to form an economic school. With respect to practice he for a short period became (conservative) minister of finance of Austria in a coalition government (March to October 1919), which broke down after a year. Then he founded a bank that went bankrupt¹⁴. Even as an applied political economist he cannot be said to have had success; in an article published in 1929 - still in Bonn - he denied that there is a severe destabilizing development in the German population: 'In keinem Sinn, auf keinem Gebiet, in keiner Richtung sind daher starke Ausschläge, Aufschwünge oder Katastrophen (in Deutschland, H.H.) wahrscheinlich.', he concludes at the end of the article. (In no meaning, in no area, in no direction strong disturbances, booms or catastrophes (in Germany) are likely to happen.) [Schumpeter, 1929].

From 1925 onwards¹⁵ this second layer of a first dive into economic practice ended and Schumpeter concentrated again on synthesizing existing theoretical knowledge. This renewed intellectual effort certainly was supported by the scientific exchange that his appointment as professor at Harvard University enabled. There he could finally publish his two volume book 'Business Cycles', which has the significant subtitle 'A Theoretical, Historical and Statistical Analysis of the Capitalist Process' [Schumpeter, 1939]. Theory, history and empirical observation of the entire social process should be integrated and made comprehensive as oscillatory movements, as business cycles. But while the aspiring polymath Schumpeter appears to be extremely ambitious his texts still remain scattered over many topics and sub-disciplines, missing the grand unifying golden thread that runs through them. This is the reason why several of his colleagues considered his contributions just as 'pleasant after dinner talk'¹⁶ and not as serious economics. Schumpeter, the 'footnote economist' (Harold

¹³ In Vienna Böhm-Bawerk had turned against him and Schumpeter got his first position (1909-1911) only at the University of Czernowitz far in the East of the Austrian-Hungarian Empire.

¹⁴ Since 1911 he had been university professor in Graz (Styria, Austria), a position he laid down for this short intermezzo as a CEO of a private bank. In 1925 he returned to academic life as professor in Bonn.

¹⁵ A main reason probably was the tragic death of his second wife and their common child in this year.

¹⁶ Of course, such innocent looking after dinner talks surely are to be preferred to the silence that exchange of sterile models lacking economic interpretation produces.

Robbins¹⁷). But, as mentioned before, Schumpeter lived this creative contradiction; and a handful of influential admirers in the academic world enabled him to continue his academic career despite his non-conventional style. The contradiction between holistic aspiration and rather eclectic selection of topics across the different sub-disciplines is symptomatic for a special type of outstanding scholars of the social sciences, from Thorstein Veblen to Herbert Simon. In my view this is what allows to classify a social scientist to be part of the group that does evolutionary political economics: his or her own research pattern is self-similar to the object of investigation (see [Hanappi, 2014a]).

The final turn in Schumpeter's work, an oscillation back to practice, came with his role as a teacher at Harvard University. Putting his extremely broad and diversified knowledge to the practice of educating a whole generation of American economists¹⁸ certainly was a final triumph for Joseph Schumpeter's work style. Some of these economists took Schumpeter's synthesizing efforts to a more advanced mathematical level that seemed to allow to reconcile old Walrasian thought with modern Keynesian macroeconomics, e.g. Paul Samuelson in his outstanding PhD thesis, [Samuelson, 1979 (1947)] that initiated the 'Neoclassical Synthesis', the canon of post-war economics¹⁹. Others, like James Galbraith, oriented their research more towards questions concerning democratic governance and how politics can be related to economics in a way that supports a peaceful future trajectory²⁰. Though James Tobin usually is classified as a left-wing Keynesian, his proposals for economic policy also still carry a dash of Schumpeter style. And finally the small group of those economists, like Paul Sweezy, [Sweezy and Baran, 1966] and Richard Goodwin, who were interested in a revival of Marx' ideas has to be mentioned. Schumpeter himself had studied Marx in detail, as he was already involved in Böhm-Bawerk's critique of Marx during his study days in Vienna. With the emergence of the Soviet Union as a global power Schumpeter's interest in Marx' original ideas increased again (see [Catephores, 1994]). No surprise that he hired Sweezy, a Marxist interested in the adaption of Marx to contemporary analysis, as a teaching assistant at Harvard. Richard Goodwin came with a similar leftist image to Schumpeter at Harvard. But contrary to the history-oriented Sweezy, his special competence was in mathematics. As Richard Goodwin once told me²¹, he

¹⁷ Robbins was aware of Schumpeter's very emotional double image: 'It is clear that that the spectacle of much contemporary Keynesianism inspired in Schumpeter a distaste that must have been almost physical. ... The reaction to the man himself, too, was very ambivalent; there seems to have been something in Keynes that alternately attracted and repelled him.' [Robbins, 1970]

¹⁸ To name just a few: Paul Samuelson, James Tobin, Richard Musgrave, Abram Bergson, Erich Schneider, Paul Sweezy, John Kenneth Galbraith – and Richard Goodwin.

¹⁹ Samuelson's style of writing (and in particular of giving talks) reflected Schumpeter's style: vivid, sharp, to the point, and always with a hint on a broader context. Just the superior mathematical skills of Samuelson differed markedly from Schumpeter's possibilities.

²⁰ It is little known that Schumpeter was an active peace activist during World War 1, see the documents in the highly informative Schumpeter archive: www.schumpeter.info .

²¹ I met Richard Goodwin several times, first as a student in a seminar Goodwin gave as visiting professor in Vienna in 1985 and later at workshops and conferences in Siena.

provided private lessons in mathematics for Schumpeter – but Schumpeter was not a very talented pupil in that respect.

From the perspective of evolutionary theory what Schumpeter produced with these pupils at Harvard was diversity²². A diversity which necessarily blocked the emergence of a school of Schumpeterian Economics during the 50-ties and 60-ties, Schumpeter remained a maverick of economic thought. In the after-war period Samuelson was the first to stand the test of time. Later – with the slow collapse of capitalism and the rapid collapse of the Soviet Union – the other heirs of his thought gained ground. It might well turn out that in the long-run Richard Goodwin was the most important follower of Schumpeter.

Richard Goodwin

The scientist Goodwin was working along an extremely creative contradiction. In his case the contradiction concerned mainly his talent and interest in formal techniques on the one hand, and his strong commitment to communism, his believe in socialist goals, on the other hand. Of course, it first has to be explained why this is can be a contradiction at all.

To understand this issue a look back to the introductory section of this chapter, the general development of economics in the first half of the 20th century, is necessary. During this time, when the internal value system of young Richard Goodwin was formed – the period when he was socialized – there was an enormous gap between the highly prestigious activities of ‘science’ (understood as consisting only of the natural sciences) and the dirty subject of business, understood as an object of investigation for which a scientific approach just had started to be in the making. This is particularly true for the United States (Goodwin was born in 1913 in Indiana). Economics, the new science in the making, often was perceived as being split into two different fields: One type of scientific approach was directed to support businessmen; first in their individual profit-seeking decisions, second from the perspective of the design and policing of market mechanisms²³. Another type of scientific approach was the older school of classical political economy. Here the most prestigious personality – the culmination of this approach - was Karl Marx and he propagated a theory of class struggle dynamics.

²² For the general political climate in the United States during these years Schumpeter’s drive to diversity was already suspicious: As much later was discovered, the Secret Service had a close watch on Schumpeter and spied out and documented each move, each letter he wrote or received.

²³ When Goodwin was 16 years old the Great Depression was throwing the United States into a crisis that made any equilibrium-oriented economic theory look ridiculous. The necessity of a revolution or at least a fundamental redesign of market mechanisms that went far beyond Roosevelt’s block-busting efforts was evident.

Both approaches offered no serious mathematical treatment providing a general and clear model of their core statements²⁴. Goodwin's decision to devote his work to the study of the language of science (natural sciences) was to be combined with a subscription to one of the two believe systems in political economy – and he decided to go with the workers' agenda as outlined by Marx. But scientific research and believe in an exogenously given system are opposites. For the single researcher they create the need to conquer the believe system and to transform it into a scientific area, eventually deleting parts of the old believe system. Goodwin just had graduated in Harvard.

He went to Cambridge to join Keynes and his circle where he discovered a third believe system: Keynesianism. Keynes, like Schumpeter, was only producing prose text, though in a precise and convincing style that fascinated everybody. For a unique translation into a mathematical framework – an idea very dear to Richard Goodwin – these texts were much too open to interpretation²⁵. The canonical mathematical form of Keynesianism still taught in today's universities finally was provided by John Hicks, though a plethora of competing interpretations, from Kalecki to today's bastard-Keynesians and post-Keynesians, has emerged. Right from the start of this race for the true interpretation Richard Goodwin, the mathematician, was not impressed. In the discussions in Keynes' circle he kept his double image: As long as believe systems were concerned he was Marxist and usually joined Joan Robinson's left-leaning arguments. As Geoff Harcourt reports, he agreed, when she criticised Keynes system as being only a static framework; but Richard Goodwin – now the mathematician - corrected Robinson by concluding that for a useful dynamic theory a mathematical framework is indispensable [Harcourt, 1992]. Goodwin's first contributions to Keynesianism therefore were dynamic reformulations of the investment function; work on a 'dynamic multiplier' [Goodwin, 1947]. An 'independent' investment function was generally considered to be the pivotal element of Keynes' theory. This function was an assumption about the aggregate investment behaviour of firms: What they expect as demand at the beginning of the year, when investment is decided, could be different from what turns out to have been demand at the end of the year. Expectations thus are to some extent independent of what the interdependencies in the material world produce.

But these first amendments to Keynesianism were just some baby steps for the mathematician Richard Goodwin. He felt that the simple linear models based on Keynes' accounting framework and some crude assumptions on the constancy of socio-psychological propensities (to consume, to invest, etc.) were leading to linear first-order difference equations that only could describe much too simple

²⁴ The first approach the work of Paul Samuelson, Schumpeter's other assistant, set out to provide exactly that [Samuelson, 1942].

²⁵ Note that an imprecise description can be more adequate to an ,imprecise' (still mostly unknown) object of investigation than a precise description that despite its concise form shares nothing with the object of investigation.

dynamics were inadequate. The mathematics used by the first generation of Keynesians rather resembled what Newton had used for physics 200 years ago; this language was way too primitive for a complicated object of investigation like human society. The most important mathematician of the 20th century, John von Neumann, had a similar impression when he first met the Hungarian economist Nicholas Kaldor, who told him about the models Keynesian macro-economists use²⁶. Typically such models, e.g. Hicks' business cycle model, had to use exogenously assumed barriers to be able to describe cyclical movements. One of Richard Goodwin's next goals was to overcome this deficiency in mathematical elegance. And as for many trained mathematicians aesthetics and elegance played an important role for Goodwin.

A most important influence during his first period in London was his friendship with British Marxists, mostly history professors, e.g. Eric Hobsbawm. Goodwin's believe system finally became rooted in a highly educated anti-fascist community. He became a member of the Communist Party of Great Britain²⁷. Nevertheless this clear political positioning was not really reflected in his theoretical work. Unlike Schumpeter, who was raised in a context where the controversy on Marx work was vivid and all participants knew it very well – and in German language, Goodwin encountered Marx first by personal hardship in the Great Depression and later by the exchanges with Marxist historians in their anti-fascist activities. For him Marxism was not a genuine economic topic, it remained something a bit outside the theoretical economic discourse. This might also have been the case due to the fact that British Marxists of that time, e.g. Maurice Dobb, by and large had subscribed to the neo-Ricardian and Sraffian interpretations of Marx' work. The Hegelian roots, which were so visible in German editions, had disappeared and the corresponding dialogue on dialectics – with its methodological consequences – simply did not exist in this interpretation. In the end it only contained an exercise in input-output modelling, a technique imported to the Anglo-Saxon communities by the (Marx knowing) Russian economist Leontief. And Goodwin indeed jumped on this methodological train as many of his later papers on sectorial models show. So Marxism had only a very indirect influence on his work.

Schumpeter had searched for an appropriate academic environment in Europe and finally found it by crossing the Atlantic to go to Harvard. Goodwin went to and fro: First (after he graduated) from Harvard to London, then back to Harvard as an assistant of Schumpeter. Finally, when not given

²⁶ As an answer to this dilemma John von Neumann and Oskar Morgenstern later invented the theory of strategic games as a new language for the social sciences [Neumann and Morgenstern, 1944]. Unfortunately enough their original motivation soon was forgotten by the next generation of game theorists, game theory degenerated to a sterile branch of pure mathematics (see [Hanappi, 2013]). Only in the last two decades evolutionary political economy incorporates game theory in a way that revives the original goals, see [Hanappi, 2014b].

²⁷ In private chats he sometimes remembered how he and Eric Hobsbawm were celebrating the defeat of Hitler in 1945. Later he left the communist party. But lifelong Goodwin considered himself to be a ‚deviant Marxist‘, signaling that he thought that this label is not sufficiently defined.

tenure in Harvard, back to Britain – and finally (after retirement in Cambridge) to Siena (Italy). Like the maverick Schumpeter, Goodwin also had to rely on personal contacts (Schumpeter, Stern, some colleagues in Siena) to get appointments in an academic environment that in general was very hostile to new thoughts²⁸. Well-established professors of economics usually had a hard time to acquire the human capital that in the end secured them tenure. Once they have a position that enables them to defend their own human capital (even if it is outdated) against newcomers and mavericks, it is evident that they will do so. And the institutional mechanisms that might hinder this sclerotic tendency till today are missing in the academic world – in particular in economic theory departments. This, by the way, is one of the main reasons why personalities like Schumpeter and Goodwin are so important for the advance of a science. Their similarity with respect to changes of location thus has a deeper reason. And another similarity concerns their most influential period: Like Schumpeter, Goodwin has had his greatest impact when he influenced a large group of younger economists²⁹ in his role as a teacher. There is no Goodwin School of economic thought, but the seed of his theoretical innovations permeates a large diversity of economic approaches.

Back in Harvard, with his congenial counterpart Schumpeter, Goodwin's creativity blossomed. He brought non-linear macro-dynamic modelling to the profession³⁰. Giving lectures in physics as well as in advanced dynamic macroeconomics enabled him to develop a teaching style that his pupils admire till today (compare [Goodwin et al, 1984]). Of course, he was teaching model-building, i.e. a special kind of mathematics. But with the models now also came an economic interpretation that undoubtedly was inseminated by Schumpeter's broad knowledge of economics and economic history³¹. His masterpiece (after several forerunners published earlier) was his famous growth cycle model [Goodwin, 1967]. In this dynamic macroeconomic model consisting only of seven equations Goodwin was able to combine structurally (though not dynamically) stable oscillations, i.e. limit cycles, around a Harrod (knife-edge) growth path with a continuous growth of essential macroeconomic variables. The small size of this model shows Goodwin's typical aesthetic aspirations:

²⁸ In Goodwin's case the tag 'Marxist' amplified this hostility. He once told me that the only appointments in the United States that were offered to him were teaching banking in universities in the Mid-West, because 'with this dry subject even a Marxist can do no harm in the Mid-West'. Goodwin laughed and added: 'They didn't know.'. Nevertheless this never happened.

²⁹ The one closest to him probably was Vela Vellupillai, see Velupillai's obituary of Schumpeter [Velupillai, 1996].

³⁰ As Nathan Rosenberg highlighted (see [Rosenberg, 1994]), Schumpeter wanted to provide a picture of capitalism that Goodwin now with his modelling capabilities promised to build: 'I felt very strongly that ... there was a source of energy within the economic system which would of itself disrupt any equilibrium that might be attained. If this is so, then there must be a purely economic theory of economic change which does not merely rely on external factors propelling the economic system from one equilibrium to another. It is such a theory that I have tried to build ...' (Schumpeter cited in Rosenberg[1994, p.42])

³¹ When Schumpeter towards the end of his life was asked which of the parts of his holistic approach he considers to be the most important one, he had a clear preference: economic history.

it certainly took him a lot of time to pack so many issues in such a small (the beauty known as ‘Ockham’s razor’) jewel of model-building. Here are some secrets of his success:

- i. *Draw a hard and clear borderline on what the model speaks about, and on what it is silent.*
He assumes: an exogenous constant growth of labour productivity (1) and labour supply (2), an output that only depends on (homogeneous and non-specific) labour and capital (3), inflation plays no role (all variables are real) (4), all wages are consumed and all profits are invested (5). These assumptions are nailed down in the first five equations of a differential equation system (i.e. using continuous time).
- ii. *Surprise the connoisseur of the history of economic thought by modestly putting major themes into innocent looking small, but strong statements.* Goodwin writes that these borderlines are drawn ‘for convenience’, but some of them clearly carry the heavy weight to set an end to conflicting economic views. They exclude Schumpeter’s pulsating character of technological progress; they exclude a Malthusian reaction function of labour supply; they exclude the Marxian reduction problem (how to reduce complicated labour to simple labour) as well as all models of vintage capital; they stick to short-term (Hicks’) Keynesian macroeconomics in assuming that all variables are real and price expectation errors are excluded; and they subscribe to Say’s Law that holds that not only a strict division between consuming worker households and investing firms is upheld, but that there also is no possibility to change corresponding stock variables, i.e. all profits are immediately (continuous time!) invested; and – contrary to Keynes view - there is no state. Richard Goodwin, a decent British gentleman, knows all these debates – but prefers to let his reader make up his mind without his comments.
- iii. *Provide some leeway for possible extensions by adding ‘more empirical and disputable’ assumptions.*

First of all this characterizes the first five assumptions as less disputable, which means that they define the scope of the model, they rest in the world of model-building and do not reside in the empirically observed dynamics. The first additional assumption is a constant capital-output ratio (6), the second is a positive (linear) relationship between employment and real wage (7). Again both assumptions are short-cutting long debates in economics. How capital and output are related had been at the centre of Austrian Economics and the empirically observed Phillipps Curve had been a hot topic since the beginning of the century – though the latter used a constant mark-up over nominal wages instead of real wages³².

³² While Austrian Economics is bluntly ignored by (6), assumption (7) (like the original Phillipps Curve) has a flavor of Marxian Economics, since it implicitly assumes that an organized labor movement is able to get higher real wages by central wage bargaining in a situation with less unemployment.

- iv. *Find an analytically solvable non-linear model that can be used to transport your main issue.*
- This certainly was the hardest part of his work. It meant that the seven assumptions can be transformed into a system that is known to imply a certain type of dynamics, in that case 'limit cycles'. What looks like a surprising property to the reader must have been the result of tedious construction work for the model-builder. The Lotka-Volterra system Goodwin uses has been the ideal candidate for that purpose.

At the end of his paper Goodwin reveals a few more background ingredients of his interpretation. He seems to aim at modelling a stalemate in class struggle that nevertheless produces cycles. In a sense this is close to Keynes intentions of a stabilized capitalism – though without state intervention. But it also is reflecting Schumpeter's view of a stable, pulsating capitalist economy – though without innovation induced cycles. Surprisingly, the largest intellectual distance of his model is to Marx' approach to political economy³³. The Marxist Richard Goodwin still was acting on a different terrain than the mathematical economist Goodwin. Nevertheless his formal innovations have paved the way not only for econophysics and evolutionary political economics, but also for many young progressive followers in a Marxian tradition.

When he published this paper Goodwin was already back in Cambridge. There he was an underground celebrity (having known Keynes and Schumpeter directly) and in contact with many colleagues and students – the roaring sixties had started to turn London upside down. Established academia was no exception, and Goodwin always has had an affinity to fun and arts³⁴, he was painting and was a famous wine connoisseur. When after his retirement from Cambridge he followed an invitation to the Tuscany this latter side of the great economist had more room to flourish.

But this did not mean that in Siena he was not productive in theory building any more, quite the opposite happened. Typically for a creative contradiction the increased possibilities of relaxation spurred his energy for theory production: He acquired programming skills, he conquered the newly emerging field of chaos theory (and even wrote a book on it), and he amended his cycle model by adding a third equation to the Lotka-Volterra system that now represented pulsating technological advance, see [Goodwin, 1990a]. Together with Lionello Punzo he produced a seminal book on the dynamics of a capitalist economy, see [Goodwin and Punzo, 1987], in which they extend the cycle model to an input-output framework and provide rich links to the methods used in modern physics.

³³ Goodwin writes: „By contrast the profit rate is equal to $1-u$ (u is the share of wages, H.H.) and therefore tends to constancy. We may look at this as standing Ricardo (and Marx) on his head. ... Hence it (labor, H.H.) is the sole ultimate beneficiary from technical progress. By now there would, I suppose, be considerable agreement that what happened in history is: wage rates went up, profit rates stayed down. It is to the explanation of this that the present paper is addressed.’ [Goodwin, 1967]

³⁴ This attitude, namely to have the side of a bon-vivant, is also a feature he shared with Joseph Schumpeter; though they cultivated different tastes.

Richard Goodwin still was the unstoppable, unconventional mathematical economist now giving seminars at the University of Siena.

When he died in 1996 there already was a large community of admirers and pupils who were busy in amending and modifying his famous models. Like Schumpeter's, his lifetime had been devoted to spread interesting new ideas and interpretations – and he succeeded³⁵.

Schumpeterian Elements in Goodwin's Theories

The transformation of some of Schumpeter's ideas into Goodwin's formalized model worlds in many respects is of eminent importance. On the *first level* of a *comparison of languages used in political economy* this transformation is an example of the comparative advantages of more or less mathematics involved³⁶. More precisely, it is an example of the translation from a language in which precision is incorporated in the adequate ambiguity of statements in prose text referring to an ambiguous dynamics in the real economic world, i.e. Schumpeter's language, into a language in which precision is already incorporated in its grammar, i.e. Goodwin's mathematical models. There are outstanding examples of this exercise, of translating and then re-interpreting classics of political economy, e.g. Richard Day's work on Malthus [Day, 1999, pp. 157-324] and John Roemer's excellent work on Marx [Roemer, 1981]. But most of these examples link authors that did not have a chance to share a part of their lives. It is remarkable that Goodwin's most Schumpeter-oriented work, the book 'The dynamics of a capitalist economy: A multisectoral approach', was only written many years after Schumpeter's death in 1950. There seems to be the necessity of a longer period of digestion to develop appropriate formalisms that are able to catch some essential ideas of great political economists. A *second level* with which a study of the transformation from Schumpeter's work to Goodwin's work has to be concerned is the transformation of the *survival and modification of core issues*, of content. It is evident that both levels of investigation are far from being independent from each other. In what follows the first level thus will be used as a guide through the transformation process, while the second level will be integrated into this tour wherever it seems to be particularly important.

At their common time at Harvard the complementary expertise of Schumpeter and Goodwin shaped their cooperation. In a revealing paragraph written by Richard Goodwin much later their relationship is implicitly visible:

³⁵ In the only book that Nobel-Prize winner Paul Krugman devoted to evolutionary economics, [Krugman, 1996], he emphasizes the importance of Goodwin and regrets that these non-linear dynamic approaches to macroeconomics have not been further developed since.

³⁶ This, of course, is a topic which is hotly debated since more than hundred years (see e.g. [Weintraub, 2002] or [Hendry, 1980]).

*'The greatest mistake in my career occurred when Schumpeter came to me in 1938 or 39 and asked me to report on a very important new publication – the von Neumann paper given at the Menger seminar, a repetition of the one he had given in Princeton in 1932. When I got as far as realizing that he was including all remaining plant and equipment in annual output, I rashly judged it to be totally unrealistic, and I still do, though in retrospect I realize the immense simplifying power of the method. In any case, I, alas, reported back to Schumpeter that it was no more than a piece of mathematical ingenuity, failing to see that it contained two aspects close to Schumpeter's heart – a rigorous solution to Walras's central problem and a demonstration that the rate of profit arose from growth, **not** quantity of capital. When I came to edit his papers for the final section of his **History**, I found no references to what now appears to me to be one of the great, seminal works of this century, the omission being possibly the result of my own blindness.'* [Goodwin, 1989 (1985), p. 125].

These sentences show that despite the complementary capacities the relationship was hierarchical. Professor Schumpeter, at this stage already dubbed the 'Sage' by McCraw [McCraw, 2007, pp. 247-494], was asking his assistant Goodwin to check the validity of a paper that was difficult to understand. This wish is fully accepted by Goodwin, and he even after years still feels guilty for his misjudgement. As a side-issue it is remarkable that Schumpeter never checked the correctness of Goodwin's advice, showing Schumpeter's complete trust in his expertise. Another interesting aspect is Goodwin's description of the source of his mistake: He stopped reading the paper, when he thought that its economic content is unrealistic, which means that his judgement was based on the degree of economic adequacy of the model and not on its mathematical elegance. But what was to be considered as economically adequate, as 'realistic', for Goodwin at the time would fitted well into Keynes macroeconomic thought! Short-run economic flow accounting still was the world in which the trained Keynesian Richard Goodwin did evaluate papers in 1938. When he reconsidered the case in 1985 (published later in 1989) he reassessed the core economic tenets of his master Schumpeter, namely to reconcile the countervailing forces of equilibrating (Walrasian) markets and equilibrium destroying growth, relating the growth rate to profit rates (in principle a Marxian theme). One year later, in 1986, a similar paper appeared in which Goodwin uses a seemingly unrelated pair of famous economic models, the same von Neumann model³⁷ [Neumann, 1945] and Piero Sraffa's model [Sraffa, 1960], to discuss the same question again [Goodwin, 1986]. And he again starts from

³⁷ The first version of John von Neumann's model was published in 1938 in German with the title „Über ein ökonomisches Gleichungssystem und eine Verallgemeinerung des Brouwer'schen Fixpunktsatzes“. It is included in a volume called „Ergebnisse eines mathematischen Seminars“ edited by Karl Menger (Vienna, 1938).

core issues of economic content without reference to the rather exotic difference of style of the two authors³⁸.

'Although at first sight the economics of Piero Sraffa and John von Neumann seem almost totally unrelated, I shall attempt to indicate that there exists a kind of asymmetric affinity, so that they mutually illuminate their respective virtues and shortcomings which, in suitable combination, prove fruitful.' [Goodwin, 1986, p. 203]

This introductory sentence immediately shows that Goodwin has left his Keynesian framing behind and has started to take Schumpeter's perspective on innovation serious - innovation in the area of economic theory, of course: Take two already approved older elements of theory and create a fruitful new combination! The more surprising the choice of the pair of seemingly antagonistic elements is, the greater the chance of exploring new territory will be. And Goodwin plays with these contradictory elements:

'A striking contrast between the two men arises from their relation to Marxism. ... there is no evidence of any knowledge of, or interest in, Marxian concepts, or more generally social problems (of John von Neumann, H.H.). That he arrived at an analysis which is in some respects close to Marx is, to my mind, a testimony to the extraordinary power of his logic and, at the same time, a confirmation of some aspects of Marxian thought. ... He (Piero Sraffa, H.H.) became a close friend and supporter of the distinguished Marxist Gramsci ... Nonetheless his (Sraffa's, H.H.) one book contains no substantive reference to Marx: its conclusions can be regarded as ... a devastating attack on orthodox economics as a prelude to a restructuring of Marxian theory.' [Goodwin, 1986, p. 203]

'The contrast between the two systems could not be greater: with a given real wage rate, von Neumann determines a surplus all of which is accumulated resulting in a constant growth rate of output without limit. Sraffa considers only a given, constant output and shows that profit rate and share of wages can be arbitrarily chosen within defined limits. Both analyses are unsatisfactory.' [Goodwin, 1986, p. 204]

It is not too surprising that the new synthesis that Goodwin constructs by using elements from both authors is a non-linear differential equation system resembling his Lotka-Volterra model of 1967 (amended by the distinction of different sectors of the economy). But now this model comes in full Schumpeterean swing:

'... the resulting system ... in the long-run ... generates one particular case of disequilibrium growth. In economics ... the problem of instability is not very serious. The economy is bounded on the high side by given resources, particularly labour, and on the low side by a variety of rigidities in expenditure, particularly unemployment benefits. Though illuminating the nature of the problem, the multiplier-

³⁸ Von Neumann in his short paper mostly remains in the domain of advanced analytical mathematics, while Sraffa in his book uses an extreme form of a highly structured sequence of 96 statements (evidently resembling Wittgenstein's Tractatus). The formal difference could hardly be stronger.

accelerator combination has one fatal defect: the accelerator ceases to function when output is below capacity, which is the case for a large part of time. A depression consists essentially of excess capacity and excess labour supply. Schumpeter, in his original cycle theory (an elaboration of an aspect of Marx), provides a solution; the cycle is simply the form growth takes; innovational investment leads to expansion, the accelerator to over-expansion and collapse, thus converting a fairly smooth flow into a fluctuation.' [Goodwin, 1986, p. 209]

To enrich Schumpeter's central insights by formal models mimicking the essential dynamics comes under a cover story of bridging seemingly disparate economic doctrines. This project of Richard Goodwin culminated in his book 'The dynamics of a capitalist economy: A multisectoral approach' [Goodwin and Punzo, 1987]. In this majestic work, which unfortunately still is ignored by the majority of mainstream economists, he takes on board not only Schumpeter's idea that growth of labour productivity – which following Marx for him is the historical mission of capitalism – is to be understood as a disequilibrium process initiated by entrepreneurial activity, Goodwin also considers now Schumpeter's further specification, namely that productivity enhancing innovation takes place in a (historically changing) subset of economic sectors only. This latter insight forces the model builder Richard Goodwin to combine the non-linear swings induced by the pair of countervailing forces (dis-equilibrating entrepreneurial activity and equilibrating market forces) with a sector model of the economy, e.g. a dynamic input-output model, or von Neumann's growth model. And this is what he and Lionello Punzo achieve in this book.

In the following years Goodwin goes even one step further: Deeply impressed by the possibilities opened up by computer simulation and several new mathematical tools (like René Thom's *catastrophe theory*, [Thom and Zeeman, 1975] and Edward Lorenz's *chaos theory*, [Lorenz, 1963]) he started to acquire the new toolboxes. At the age of 77 years (!) he publishes his book 'Chaotic Economic Dynamics' [Goodwin, 1990b]³⁹. It is in this last book that Goodwin not only shows how important formalization using the most recent tools can be, but also reveals that in his old age he repeats Schumpeter's turn to the history of economic ideas⁴⁰: From chapter 4 onwards this book in parallel develops the historical debate between the great economists of the 20th century. And this debate always revolves around Schumpeter's central ideas. It might be not exaggerated to state that Goodwin thus takes most of Schumpeter's essential ideas to the next, to the formalized, level.

³⁹ Goodwin's youthful verve during his last years in Siena impressed us all. One could see him driving his sports car, a cabriole, with his long white hair waving on his way from the university of Siena through the vineyards of the Tuscany towards his picturesque home, where he spent his life with oil painting, economic theory building, and wine tasting.

⁴⁰ Schumpeter could not publish the fruits of his last years of research. His 'History of Economic Analysis' was published by his wife after his death only [Schumpeter, 1982 (1954)].

Epilogue

Both men, Joseph Alois Schumpeter and Richard Murphy Goodwin, have challenged the economic mainstream that prevailed in the 20th century – if it is justified to identify such a mainstream in this turbulent century at all. Till today their work is rarely included in the curricula of mainstream economics at universities, which is quite understandable given their innovative role for the advance of political economy. Both were political men, acting also outside the ivory tower of high-browed science – though their political initiation had completely different roots. At the beginning of the 21st century it is very clear that their theory fragments are extremely valuable gems, by far more useful than the ruins of a general equilibrium theory that is only held together by relicts and rituals of the academic industry of journal production. As role models these two scholars cannot be used, each maverick is unique by definition. What can be learned by the next generation of political economists is that a common reference to facts (Schumpeter's and Marx' 'Tatsachenbeobachtung') is central, and that then it only needs good education and a considerable amount of courage ...

References

- Catephores G., 1994, **The Imperious Austrian: Schumpeter as Bourgeois Marxist**, New Left Review 1/205, May-June 1995.
- Day R., 1999, **Complex Economic Dynamics**. An Introduction to Macroeconomic Dynamics, MIT Press, Cambridge (MA) and London (UK).
- Dore , Chakravarty, and Goodwin, 1989, **John von Neumann and Modern Economics**, Clarendon Press – Oxford.
- Goodwin R., 1947, **Dynamical Coupling with Especial Reference to Markets Having Production Lags**, *Econometrica*.
- Goodwin R., 1967, **A Growth Cycle**, in: C.H. Feinstein (ed.), *Socialism, Capitalism and Economic Growth: Essays Presented to Maurice Dobb*. Cambridge University Press, Cambridge, pp. 54-58.
- Goodwin R., 1986, **Swinging along the turnpike with von Neumann and Sraffa**, *Cambridge Journal of Economics*, vol. 10, pp. 203-210.
- Goodwin R., 1989 (1985), **Swinging Along the Autostrada: Cyclical Fluctuations along the von Neumann Ray**, in: [Dore, Chakravarty, and Goodwin, 1989, pp. 125-140].
- Goodwin R., 1990a, **Schumpeter, Keynes and the Theory of Economic Evolution**, *Economia e Banca, Annali Scientifici*, 3, pp. 69-94.
- Goodwin R., 1990b, **Chaotic Economic Dynamics**, Clarendon Press, Oxford.
- Goodwin R., Krüger M., and Vercelli A., 1984, **Nonlinear Models of Fluctuating Growth**, Springer Verlag.
- Goodwin R. and Punzo L., 1987, **The dynamics of a capitalist economy: A multisectoral approach**, Westview Press, Boulder, and Basil Blackwell, Oxford.

- Hanappi H., 2003, **Wie österreichisch ist Schumpeters Innovationstheorie?** , in: Pichler Rupert (ed.), Innovationsmuster in der österreichischen Wirtschaftsgeschichte, Studienverlag, Innsbruck, 2003.
- Hanappi H., 2013, **The Neumann-Morgenstern Project**, in: H. Hanappi (ed.), Game Theory Relaunch, InTech Publishers, pp. 4-25.
- Hanappi H., 2014a, **Evolutionary Political Economy in Crisis Mode**, Journal of Economics and Statistics, vol. 234/2+3 (2014), pp. 422-440.
- Hanappi H., 2014b, **Bridges to Babylon: critical economic policy- from Keynesian macroeconomics to evolutionary macroeconomic simulation models**, in: Lukasz Mamica and Pasquale Tridico (eds.), Economic policy and the Financial Crisis, Routledge Publishers.
- Hanappi H., Hanappi-Egger E., 2004, **New Combinations. Taking Schumpeter's concept serious**, paper presented at the International Schumpeter Society Conference 2004 in Milano (I), June 9-12, Bocconi University, 2004. Published as [MPRA Paper No. 28396](#).
- Harcourt G., 1992, **Post-Keynesian Essays in Biography. Portraits of Twentieth-Century Political Economists**, Palgrave Macmillan.
- Hendry D., 1980, **Econometrics - Alchemy or Science?**, *Economica*, New Series, Vol. 47, No. 188 (Nov., 1980), pp. 387-406.
- Krugman P., 1996, **The Self-organizing Economy**, Blackwell Publishers.
- Lorenz E., 1963, **Deterministic Nonperiodic Flow**, *Journal of Atmospheric Sciences*, vol. 20, issue 2.
- Malthus R., 1964 (1836), **Principles of Political Economy**, Augustus M. Kelley, New York.
- Manning E. (ed.), 1975, **Dynamical Systems – Warwick 1974**, Lecture Notes in Mathematics 468, Springer, Berlin & New York.
- McCraw T., 2007, **Prophet of Innovation. Joseph Schumpeter and Creative Destruction**, Belknap Press at Harvard University Press.
- Neumann J., 1945 (1938), **A Model of General Economic Equilibrium**, *The Review of Economic Studies*, vol. 13, no. 1, pp. 1-9.
- Neumann J. and Morgenstern O., 1944, **Theory of Games and Economic Behavior**, Princeton University Press, Princeton.
- Robbins H., 1970, **The Evolution of Modern Economic Theory**, MacMillan Press Ltd.
- Roemer J., 1981, **Analytical Foundations of Marxian economic theory**, Cambridge University Press.
- Rosenberg N., 1994, **Joseph Schumpeter: Radical Economist**, in: [Shionoya and Perlman, 1994, pp. 41-57]
- Samuelson P., 1979 (1947), **Foundations of Economic Analysis**, Atheneum and Harvard University Press, New York.
- Schumpeter J., 1970 (1908), **Das Wesen und der Hauptinhalt der theoretischen Nationalökonomie.** , Duncker & Humboldt, Berlin.
- Schumpeter J., 1964 (1911), **Theorie der wirtschaftlichen Entwicklung**, Duncker & Humboldt, Berlin.
- Schumpeter J., 1929, **Das soziale Antlitz des Deutschen Reiches**, *Bonner Mitteilungen* Nr.1, 1929.
- Schumpeter J., 1939, **Business Cycles**. McGraw Hill, New York.
- Schumpeter J., 1942, **Capitalism, Socialism and Democracy**, Harper and Row, New York.
- Schumpeter J., 1982 (1954), **History of Economic Analysis**, Allen & Unwin, London.

- Shionoya Y. and Perlman M., 1994, **Schumpeter in the History of Ideas**, University of Michigan Press, Ann Arbor.
- Sraffa P., 1960, **Production of Commodities by Means of Commodities**. Prelude to a Critique of Economic Theory, Vora & Co. publishers, PVT. Ltd., Bombay (India).
- Sweezy and Baran, 1966, **Monopoly Capital: An Essay on the American Economic and Social Order**, Monthly Review Press, New York.
- Thom R. and Zeeman E., 1975, **Catastrophe Theory: Its Present State and Future Perspectives**, in: [Manning, 1975, pp. 366-401].
- Velupillai V., 1996, **Obituary: Professor Richard Goodwin**, in: The Independent, 09 August 1996.
- Weintraub E.R., 2002, **How Economics Became a Mathematical Science**, Science and Cultural Theory, Duke University Press.