Demand and Innovation in Economic Thought

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Abstract

Nick von Tunzelmann has always had a great appreciation for both economic history and the history of economic thought. In his book, *Technology and Industrial Progress*, he distinguished between size, scale, and scope, and connects demand-driven innovation to market demand when the economy is stationary, but maintains that all three become relevant when production is seen to take place in time. The paper explores several episodes in the history of economic thought that emphasize the importance of demand as a driving force in the innovation process, or in some cases neglect it. Our story begins with Adam Smith's idea that an ever more sophisticated division of labour was the main source of productivity growth. It then continues through the classical political economy to the marginalist theory of value and distribution in the context of technical change and technological learning. Schumpeter's economics becomes a good example of how to neglect the demand side of the innovation process. Certain divergences are necessary along the way as the development of Say's Law of Markets and subsequent criticisms by J. M. Keynes illustrate some of the issues that are important in the discussion. The role of time in the production process will also appear prominent, as it is a way to formalize some of the ideas present in Adam Smith. Finally the essay will close with some observations on some contemporary views on the relationship between demand and innovation. The story is interesting because the emergence and dominance of marginalist economic theory has drown much of the research on the relationship between market demand and innovation.

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1. Introduction

Throughout his career, Nick von Tunzelmann has always had a great appreciation for both economic history and the history of economic thought. His book, *Technology and Industrial Progress*, provides a good example of this way of thinking. The importance of demand in the development of new technical knowledge and technological learning was also central to this book and to many of his journal articles published through the years.[1] In the book, von Tunzelmann (1995: 8) relates demand to innovation through the size (the level of output or investment of the firm), scale (the number of processes utilized or the intensity of use of those processes), and scope (the number of products produced) of the market. The size, scale and scope of the market become relevant for his analysis of innovation because production is a process that takes place in time. Time has always been a great challenge for economic theory, sometimes taking on the form of logical time to establish equilibrating tendencies, and other times taking on the form of historical time to demonstrate how certain processes evolve (Robinson, 1980). Virtually every notable economist in the history of economic thought has encountered some difficulty in explaining the passage of time while maintaining equilibrium.

Economists have perceived demand as an important source of technical change and technological learning long before Adam Smith put forward the idea that productive specialization is limited by the extent of the market in his *Lectures on Jurisprudence* (1763) and placed it central to the theory of economic growth in his *Wealth of Nations* (1776). Several predecessors had related population growth with the extent of the market, while others, including Dudley North (1691) and Bernard de Mandeville (1714), had identified the importance of foreign trade in encouraging the division of labour. Adam Smith (1776) began the *Wealth of Nations* by describing how the interaction between market demand and the specialization of tasks drive innovation and economic growth. In the first three chapters he recognized that an increasing division of labour could increase the dexterity of workers, save

[1] The project MACROTEC (Integration of Macroeconomic and S&T Policies for Growth, Employment and Technology) provides a good example of research along these lines. A proposal currently under consideration by the European Commission focuses even more directly on the role of demand and user-driven innovation in the creation and diffusion of new technology.

time lost in switching between different tasks and lead to the invention of new methods of production and types of organization that facilitates work. A growth in market demand, whether coming from domestic or international sources, encourages the further specialization of tasks, which then increases productivity and market demand. Charles Babbage, James Mill and several other classical economists continued the discussion, but few other economists considered specialization as important as Adam Smith. There was a curious paper by Allyn Young (1928) that reasserted the position of Adam Smith after Piero Sraffa (1926) identified some difficulties in including returns to scale in Marshall's economics. This paper became a beacon within economic thought as the emergence and subsequent dominance of marginalist (or neo-classical) economic theory overwhelmed the theory of production and its relationship to market demand in the context of an innovative economy.

Innovation as an economic concept is generally traced back to the work of Joseph Schumpeter (1934), which was first published in German in 1911. This theory, however, is based on marginalist economic theory and is based on Say's Law of Markets, which is to say that the total demand for goods and services will adjust to (or be equal to) total supply during any given time period. Although the entrepreneur is the innovator or agent for change, Schumpeter carries through the logic of the theory to demonstrate that the entrepreneur essentially pushes innovation in a way that is reminiscent of science pushing technology. By contrast, Jacob Schmookler (1962, 1966) found that market forces, and in particular the cyclical trends of market demand, had a significant influence on the rate and direction of innovative activities. He observed that demand was an important source of innovation by finding a correlation between investment demand and the rate of patent applications for related goods. Eric von Hippel (1986) confirmed that market needs are important sources of innovative activity and that lead-users, who have strong market needs, can be a strong driving force in certain product markets.

Numerous episodes in the history of economic thought emphasize the importance of demand as a driving force in the innovation process, or in some cases, completely neglect it. In most instances, they were associated with the economists' view of the production process and the nature of competition. Our story begins with Adam Smith's description of the production process as a division of tasks across different productive activities. While the production process takes place in historical time, Smith and the other classical economists utilized logical time to describe the outcome of the competitive process and explain why the structure of production might change over time. Free competition as a process would take place in historical time. The paper then makes a brief digression into the discussion between David Ricardo, Thomas Robert Malthus and Jean-Baptiste Say on the importance of causality between supply and demand and the relationship between demand and technical change.

The appearance of neoclassical, or more aptly marginalist economics, changed the content of economic theory by defining prices in terms of the scarcity of productive resources with respect to the demand for goods but retained a similar method in the early years. Section five discusses how Leon Walras changed the content of the theory and the way in which Joseph Schumpeter adopted this theory to establish the importance of innovation in the theory. In doing so, Schumpeter's economics becomes a good example of how to neglect the demand side of the innovation process. Alfred Marshall idea of partial equilibrium opened the door to criticism by allowing demand to play a more significant role. Section six tells the story of why free competition is inconsistent with increasing and decreasing returns to scale, the most important source of growth and innovation in Classical growth theory. The paper then makes a second digression in section seven into some criticisms raised by John Maynard Keynes on the causality between supply and demand and what this might mean for innovation. Finally, the essay will close with some observations on some contemporary views on the relationship between demand and innovation.

2. Adam Smith and the significance of market demand for innovation

Market demand, or 'effectual demand', is central to Adam Smith's (1776) theory of economic growth. Productivity growth depended on there being a progressive division of labour, which includes the specialisation and concentration of the workers into certain well defined tasks and the introduction and use of machinery that complemented these tasks. His original example was the variety of tasks in a pin factory, which required eighteen distinct operations according to Diderot's Encyclopédie (1755).[2] One person, or several workers, either with or without the help of machinery, could perform these tasks, but he believed that there was a proper division and combination of their different operations depending on the level of output of pins required. Smith (1776: 17) identified three reasons why labour productivity could increase because of the division of labour:

> This great increase of the quantity of work, which, fin consequence of the division of labour, the same number of people are capable of performing, is owing to three different circumstances; first, to the increase of dexterity in every particular workman; secondly, to the saving of the time which is commonly lost in passing from one species of work to another; and lastly, to the

[2] The idea of the division of labour was not new. It may have first appeared in Plato's Republic, where it is the main source of inequality. William Petty (1683) was one of the first writers to establish its importance for political economy, by using production of clothes, watches and Dutch shipyards to illustrate how entrepreneurs can increase productivity by dividing up individual tasks to different workers. Henry Martyn (1701) used these examples to show how a progressive division of labour can lead to productivity growth. And Smith's mentor, Francis Hutcheson (1747) established the necessity of the division of labour for civilized society.

> invention of a great number of machines, which facilitate and abridge labour, and enable one man to do the work of many.

Ultimately it would increase the productivity of both labour and capital, provided that the skills of the labour force were coordinated with suitable machinery and equipment.[3]

Smith provides several examples of how machinery increased productivity various places in the *Wealth of Nations*, including the invention of the wind or water mill, the condensing engine. But Smith goes beyond providing simple examples and describes how innovations can be user-driven or science-enabled. Smith (1776: 20) observed that.

> A great part of the machines made use of in those manufactures in which labour is most subdivided, were originally the inventions of common workmen, who, being each of them employed in some very simple operation, naturally turned their thoughts towards finding out easier and readier methods of performing it. Whoever has been much accustomed to visit such manufactures, must frequently have been shewn very pretty machines, which were the inventions of such workmen, in order to facilitate and quicken their own particular part of the work.

Smith then describes how a boy, who wanted to save time, had discovered a way to improve the "communication between the boiler and the cylinder" by finding a way to have the value open automatically. This is an example of a 'user innovation' in the sense of the user of the machine having a strong need for finding a solution to a problem, or might be better understood as learning-by-using.[4] It is also a good example of the nonlinearities present in the innovation process and is similar to the idea of user innovation described by von Hipple (1977) for the semiconductor industry.

Adam Smith does not neglect the role of science and research. In a passage just following the one above he made the point that scientists and engineers can also be an important source of innovation.

> Many improvements have been made by the ingenuity of the makers of the machines, when to make them became the business of a peculiar trade; and some by that of those who are called philosophers or men of speculation, whose trade it is, not to do any thing, but to observe every

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[3] In a modern knowledge-based economy, the division of labour drives the division of knowledge. It is easy to see parallels between Smith's idea of the division of labour and modern growth theory as these activities can be equated with learning by doing, set-up costs, human capital and endogenous technical progress (Lavezzi, 2003).

[4] Kurz and Salvadori (2003) also affirm that Smith's analysis anticipates the concepts of induced and embodied technological change, learning by doing, and learning by using.

> thing; and who, upon that account, are often capable of combining together the powers of the most distant and dissimilar objects.

In this passage innovation appears to be science-driven in the sense that the inventor may continue to improve on the original invention new machine and it could be supply-driven in the sense that the financier may be a major driver of the innovation process by providing necessary capital and reducing the risk. It is the beginning of the idea that a special class of skilled workers performs research and development of new industrial machines and processes.

Smith (1776: 31) begins the third chapter by asserting "this division [of labour] must always be limited by … the extent of the market".[5] While Smith considers the size of the market for a particular commodity to limit or bound the degree of specialization, it also determines the scale of the production process and the resulting productivity improvements. Geography and the population of the area (villages, towns and cities) are the main limiting factors constraining the size of the market. Smith (1776: 31-32) observed that in "small villages, which are scattered about in so desert a country as the Highlands of Scotland, every farmer must be butcher, baker and brewer for his own family." He provides several examples of how technology in the form of different transport systems can overcome the problem by extending the geographical reach of the market, beginning with water transport:

> As by means of water-carriage a more extensive market is opened to every sort of industry than what land-carriage alone can afford it, so it is upon the sea-coast, and along the banks of navigable rivers, that industry of every kind naturally begins to subdivide and improve itself, and it is frequently not till a long time after that those improvements extend themselves to the inland parts of the country.

One of the great advantages of water transport, Smith emphasizes, is that markets can be global. Land transport makes it possible to remote areas, such as the Scottish Highlands, to these global markets.

International trade becomes important in this context because it not only increases the size and growth of the potential market, but as a vent for surplus, it also gives rise to specialization across countries as businesses subdivide tasks into well-defined activities and products. Trade expands the market and provides vent for resources that, in the absence of trade, would remain unemployed or underemployed. By overcoming the size of the domestic market, international trade ensures that the division of labour is carried more fully and

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[5] In his *Lectures on Jurisprudence*, Smith (1763: 63) remarks that the division of labour "is greater or less according to the market."

productivity growth is higher. Smith (1776: 448) provides the example of the discovery of America, and how it was essential for expanding the market:

> By opening a new and inexhaustible market to all the commodities of Europe, it gave occasion to new divisions of labour and improvements of art, which, in the narrow circle of the [ancient] commerce, could never have taken place for want of a market to take off the greater part of their produce.

A country produces products for which it is best suited (i.e., for which its absolute costs are lower) in terms of natural or acquired advantages and exchanges its surplus produce with the produce of other countries for which there is a demand in the home market.

In the first three chapters of the *Wealth of Nations*, Smith establishes that the degree of specialization in a given market depends on the level of demand there was for the specialized product. It follows from this that technical change and technological learning would be a consequence of and an increase in effective demand. An increase in effective demand for a particular product creates an incentive to divide productive operations in more distinct tasks, which facilitates the creation of new differentiated knowledge.[6] Smith was also careful to point out that causality between productivity growth and specialization ran both directions. When the use of machinery facilitated and abridged labour, he pointed out that the accumulation of stock is, in the nature of things, before the division of labour. As specialization became more sophisticated, the incentive to innovate became greater creating a further incentive to invest in new capital equipment. In this context, capital accumulation becomes a progressive cumulative process, whereby the accumulation drives the division of labour while at the same time defining its limits as Young (1928) later pointed out.

Adam Smith had established that technical progress or innovation, which is reflected in a progressive division of labour, is the most important source of productivity growth. It becomes the backbone for the classical theory of endogenous growth (Löwe, 1954; Eltis 1984), which might be more aptly called an endogenous theory of capital accumulation. It the accumulation of capital that Kurz and Salvadori (2003) argue propels the creation of new technical knowledge forward, opens up new markets and enlarges existing ones, increases effectual demand and is thus the main force behind economic and social development. There are no clear and obvious limits to growth other than the extent of the market. The labour force and population growth is endogenous to the theory, which provide the effective demand that

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[6] Loasby (1988) pointed out that the division of labour encourages the development of differentiated knowledge, and therefore of distinctive capabilities, which are 'knowledge how' rather than 'knowledge that'. Hayek (1945) also described the relationship between the division of labour and the division of knowledge.

drive productivity growth and the accumulation of capital, provided that the sustenance available to accommodate the increasing workforce. Investment was also endogenous and determined by the rate of savings (mostly by capitalists). As with modern endogenous growth theory, the growth rate depends on the savings and investment behaviour of entrepreneurs, and the creativity and innovativeness they, and the workforce, come up with given the institutional arrangements and historical conditions in the society.

David Ricardo wrote very little about the beneficial effects that the division of labour had on capital accumulation because he agreed with Smith's analysis, instead concentrating on his view of the long-term trend of profitability as capital accumulates and the relative importance of diminishing returns due the scarcity of land. As Kurz and Salvadori (2003) point out, Ricardo was mainly concerned with issues in Smith that he was not in agreement with, including Smith's belief that diminishing returns due to scarce natural resources were compensated for by the increase in productivity coming from a progressive the division of labour. Growth is also endogenous in Ricardo, but it limited not only by the extent of the market, but also by non-accumulable (natural resources) factors of production. A progressive division of labour, including technical change and technological learning can compensate for the extensive and intensive diminishing returns prevalent in the theory.

The idea of the division of labour reappeared in several times in the economic discourse after Adam Smith, but it was almost exclusively in classical theory, except in Alfred Marshall and in some recent endogenous growth models. In his commentary on the *Wealth of Nations*, Edward Gibbon Wakefield (1835: 26) asserts that the division of labour depends on cooperation between workers, and that this cooperation can be of two different kinds:

> First, such co-operation as takes place when several persons help each other in the same employment; secondly such co-operation as takes place when several persons help each other in different employments. These may be termed simple co-operation, and complex co-operation. It will be seen presently, that, until men help each other in simple operations, they cannot well each other in operations, which consist of several parts.

Scazzieri (1993) pointed out that John Stewart Mill believed that this idea of the combination of labour was a more general principle behind the division of labour, arguing that it made more sense in the context of large-scale production.

Charles Babbage (1835: 175-176) also found that the different skills of labour could be associated with the division of labour, which he termed the 'division of mental labours':

> The master manufacturer, by dividing the work to be executed into different processes, each requiring different degrees of skill or of force, can purchase exactly that precise quantity of both which is necessary for each process; whereas, if the whole work were executed by one workman, that person must possess sufficient skill to perform the most difficult, and sufficient strength to execute the most laborious, of the operations into which the art is divided.

Babbage's view of the division of labour provided a way to economize on the total payment of wages by employing a mixture of skilled and unskilled labourers. One implication of this idea, as Nick von Tunzelmann (1995) pointed out, is that wages based on the time-rate became easer to manage, giving birth to what later became known as scientific management. Babbage (1835: 213) believed that technological change was endogenous and responded to the relative process of factor inputs, he maintained that demand was essential for the further division of labour and innovation: "The inducement to contrive machines for any process of manufacture increases with the demand for the article." Rosenberg (1994) claims that Babbage may be the "the first observer of the events of the industrial revolution to call attention in an explicit way to the causal links between economic forces and inventive activity."

Karl Marx (1844) also understood the technical necessity of the division of labour, but described it a form of alienation where workers become increasingly specialised and the work repetitious in the *Economic and Philosophic Manuscripts of 1844*.

> The accumulation of capital increases the division of labour, and the division of labour increases the number of workers. Conversely, the number of workers increases the division of labour, just as the division of labour increases the accumulation of capital. With this division of labour on the one hand and the accumulation of capital on the other, the worker becomes ever more exclusively dependent on labour, and on a particular, very one-sided, machine-like labour. [They become] depressed spiritually and physically to the condition of a machine.

When referring to Adam Smith, Marx only made a passing reference to market demand and argued "the division of labour had to be conceived as a major driving force in the production of wealth as soon as labour was recognized as the essence of private property." In *Das Kapital,* Marx (1867) focused his analysis on self-expanding reproduction and accumulation:

> Capital therefore has an immanent drive, and a constant tendency, towards increasing the productivity of labour, in order to cheapen commodities and, by cheapening commodities, to cheapen the worker himself'

Effective demand is not an intrinsic problem in Marx's theory of capital accumulation, as pointed out by Anwar Shaikh (1978: 231), even if the economy goes into periodic crisis. As Marx (1894) put it, "The real barrier of capitalist production is capital itself".

3. The classical theory of value and distribution and the problem of technology

The theory of value and distribution is the core of economic theory and applied economic analysis (Robbins, 1932). While Adam Smith began his analysis of the *Wealth of Nations* from the point of view of market growth and specialization, the remaining part of book one was devoted to the theory of value and distribution in a competitive economy. Competition plays an important role in the theory both in providing entrepreneurs the incentive to recognize, develop and use the immeasurable opportunities provided by the economies of scale and specialization described in the first three chapters (Richardson, 1975). Smith saw competition as a rivalry between the multitude of independent individuals and firms, all pursing their own self-interest, but resulting in the common good of society as a whole as if they were guided by the invisible hand. Its importance lies within the dynamism that appears in the circular flow and in the generation of a physical real surplus, that promotes consumption, growth and international trade.

Garegnani (1984) and Kurz and Salvadori (1995) identified four data that the classical economists (including Adam Smith, David Ricardo and Piero Sraffa) and Karl Marx typically start from to derive the prices of production: (1) the technical conditions of production; (2) the size and composition of social output; and (3) either the wage rate(s) or rate of profit; and (4) The quantities of available natural resources. In this theory, wages and profits represent a fundamental asymmetry or equilibrium condition, which means that these data are sufficient to determine either the rate of profit or wage rate and the relative prices underlying the cost-minimizing system of production, given the levels of output. In short, the classical economists assume that entrepreneurs follow a cost-minimizing behaviour, but that this behaviour can include many different strategies.

The prices of production in classical theory reflect the conditions of reproduction of the economy as a whole, that is, the cost of production plus profits at the 'ordinary' or 'average' rate of return. They were not purely theoretical; but also 'centres of gravitation' around which market prices fluctuated in a way analogous to Newton's gravitational forces. The rate of profit could appear very different across firms and industries in the economy at any moment in time, which meant that the uniform rate of profit described the outcome of the competitive behaviour of many different entrepreneurs, or undertakers as Smith called them, all of whom are striving to minimize the cost of production.

In the classical theory of value and distribution, equilibrium prices are 'centres of gravitation' or 'attractors' of market prices. As attractors, they imply that self-interested individuals search for the most profitable opportunities and minimize the costs of production. The outcome of this process of competition and selection is a cost-minimizing system with a uniform rate of profit and uniform rates of remuneration for each particular kind of input in the process of production, such as the different kinds of labour and materials used in production (Kurz and Salvadori, 1995). This process of search and selection explains movements of capital and labour across industries in the absence of significant barriers to entry and exit. The classical economists saw these 'natural' or 'normal' prices as the result of the actions of profit-seeking producers concerned with minimizing production costs under a system of perfect liberty. In other words, 'normal' prices or prices of production describe the forces that governing the competitive economic system whereas market prices reflect influences that are accidental or temporary.

The object of the theory is to describe how higher than average profits in one industry would act as an attractor of capital and labour from other industries. Adam Smith described a process where individuals reallocate their land, labour and capital to uses that are more profitable. David Ricardo (1817: 91) described this process as being driven by:

> the desire, which every capitalist has, of diverting his funds from a less to a more profitable employment. [This was because] it is this competition, which so adjusts the exchangeable value of commodities, that after paying… [wages and the other costs of production], the remaining value or overplus will in each trade be in proportion to the value of the capital employed.

In other words, finance capital moves to those sectors with a higher than average rate of profits, which over time allows the physical capital to become mobile through the process of investment and depreciation. Adam Smith (1776: 131-132) also observed that the emergence of new industries can also lead to prolonged period of higher than average profits:

> The establishment of any new manufacture, of any new branch of commerce, or of any new practice in agriculture, is always a speculation, from which the projector promises himself extraordinary profits. These profits sometimes are very great, and sometimes, more frequently, perhaps, they are quite otherwise; but in general they bear no regular proportion to those of other old trades in the neighbourhood. If the project succeeds, they are commonly at first very high. When the trade or practice becomes thoroughly established and well known, the competition reduces them to the level of other trades.

This story fits very well with the idea of technology long waves developed by Freeman and Parez (1988). The important point is that the classical economists were mainly interested in the inter-industry flows of finance capital, where financiers gain profits by minimizing costs.

The theory, described in logical time, explains why entrepreneurs and enterprise enter and exist a particular market in historical time.

An increase in demand, seen as an increase in the extent of the market, can also result in above average prices and profits for a period of time, which helps encourage specialization as well as finance investment in new machinery:

> The increase of demand, besides, though in the beginning it may sometimes raise the price of goods, never fails to lower it in the long run. It encourages production, and thereby increases the competition of the producers, who, in order to undersell one another, have recourse to new divisions of labour and new improvements of art, which might never otherwise have been thought of. (Smith 1776: 748)

Because of these economies of scale, profit-seeking entrepreneurs can minimize the cost of production through the accumulation of differentiated knowledge. Since firms that accumulate this kind of knowledge often see rising profit rates, entrepreneurs will move their finance capital to these sectors. Thus, the uniform rate of profit as a tendency explains why technical change and technological learning takes place. Profit-seeking entrepreneurs minimize the cost of production by generating new and differentiated knowledge that would appear in the market as new products and processes. Smith recognized this type of competition in fifth book of the Wealth of Nations (1776: 706) when he stated that "the competition of producers who, in order to undersell one another, have recourse to new divisions of labour, and new improvements of art, which might never otherwise have been thought of."

Karl Marx (1867) had a similar theory about how inter-industry competition results in investment flows, bringing about a tendency for the rate of profit to equalize across industries, but he was more explicit about how intra-industry competition aims at enlarging the market share and improving the profitability of enterprises through innovation. In chapter 13 of the first volume of *Das Kapital*, Marx (1867) argues that capitalists search for ways to increase profitability and market share by introducing new products and processes. By lowering (and minimizing) the cost of production, individual entrepreneurs have higher than average profits until the new technique becomes widespread. Although the new technology allows the innovating firm to have above average profits temporarily, it plays a crucial role in the competitive process by contributing to the continuous change of the productive structure. The determination of production prices in each industry and the tendency towards a uniform rate of profit lead to continuous investments in the innovating industry as well as the diffusion of technology across industries.

The objective of an entrepreneur or enterprise is to increase the surplus value or profit contained in the commodity provides the rationale for technological accumulation, but it ultimately depends on the interaction between knowledge and the learning process acquired from production experiences. In volume three of *Das Capital*, Marx (1894) made an important distinction between perfecting and inventing new machines (or radical and incremental process innovations), engendered by the division of labour, and the introduction of new machinery that depends on other factors (Giammanco, 2002).[7] One of these factors is the dependence of science on labour, which implies that some time must elapse before the firm integrates an invention into the production process (Rosenberg, 1974). Another factor is the interdependence of industries, which implies that innovations in one industry can be the cause of innovation in others.

Although independent of the equilibrium conditions, technological diversity is an important driver of economic growth and knowledge accumulation in the classical economists and Marx. Both, however, had significant theoretical difficulties because they considered labour as a measure of value. The heterogeneity if labour across firms and products made it difficult to make interspatial and intertemporal comparisons without an invariable measure of value, which eluded these economists until Sraffa (1960) proposed the standard commodity. With the standard commodity, Sraffa was able to demonstrate the equilibrium conditions necessary for obtaining the prices of production, and to provide the foundations for a theory of capital accumulation, technical change and economic growth.

Demand plays a negligible role in the simple single-product processes of production because the technology is linear, consumption choices only concern luxury commodities, and there is no joint production (Walsh, 1992). John Stewart Mill (1848: 564-571) and later William Stanley Jevons (1871) were interested in joint production because it formed the general rule. Kurz and Salvadori (1995: 240) point out that Adam Smith was well aware of the possibility that the demand for products that are jointly produced did not coincide with their demand. The reason was that when joint production enters the theory, whether it is classical or neoclassical theory, demand factors would play an important role in the determination of value. Following Sraffa (1960), Kurz and Salvadori (1995) investigate different possibilities to include joint production into the classical theory of value and distribution. One important example they present is the problem of jointly utilized machines, which first described by Babbage (1832) in the context of the sophisticated division of labour and division of skills.

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[7] Both Marx and Schumpeter perceived knowledge accumulation as endogenous to the growth process. They also observed that technological competition is important for innovation and the diffusion of technology.

4. A digression on Say's Law of Markets and deficient aggregate demand

Longer-run imbalances, especially those related to labour saving innovations, could engender long-term unemployment, or what is often called technological unemployment. This became a hot topic in the early nineteenth century, as several important economists, including David Ricardo and Thomas Robert Malthus debated whether unemployment created by innovation would persist. Adam Smith (1776) believed that machines and workers were complementary to each other, and when specialization is more fully worked out or a new machine is introduced, workers will not be displaced. David Ricardo (1817) initially argued his *Principles of Political Economy* that workers displaced from labour-saving machines would be reabsorbed somewhere the economy, but in his chapter 'on machinery', which was added in 1821, he suggested that these workers might not be reabsorbed in the economy very quickly. This would require an increase in the rate of capital accumulation, and produce a downward pressure on wages and income. He points out, however, that there is no guarantee that this will happen, as profits and savings tend to decline over time.

Thomas Robert Malthus (1820, 1827) alo embraced the classical theory of value and distribution, but he maintained that excess savings led to deficient demand unless landowners increased their unproductive spending.[8] He believed that economic crises were characterized by a general excess supply caused by insufficient consumption. Malthus (1827: 62-63) argued in *Definitions in Political Economy* that:

> The question of a glut is exclusively whether it may be general, as well as particular, and not whether it may be permanent as well as temporary...[The] tendency, in the natural course of things, to cure a glut or scarcity, is no more a proof that such evils have never existed, than the tendency of the healing processes of nature to cure some disorders without assistance from man, is a proof that such disorders never existed.

The correspondence between Malthus and Ricardo highlight some of the differences in their methodology. Malthus was more concerned with the dynamics of economic development and in particular the possibility of demand-led growth, which made more sense in historical time. By contrast Ricardo was more concerned with value and distribution, and the consequences that general gluts might have on the theory of production in logical time (Sowell, 1963). The main point of Malthus, as Nick von Tunzelmann (1995: 47) points out, is that demand factors explain whether displaced labour would be reabsorbed in the economy, and whether the employment is temporary or persistent. These demand factors include how well suited the

[8] Jean Charles Léonard de Sismondi (1819) made a similar argument, maintaining that foreign markets are were an important outlet for domestic overproduction, could increase international conflict as if deficient demand becomes a global problem.

new innovations are "to the tastes of each social group and to the structure of the society as a whole." Von Tunzelmann (1991) also suggests that the arguments made by Malthus "remains one of the most complete demand-side explanations of economic growth in existence", which would make him the 'first Cambridge economist' as Eltis (1984) suggests.

The 'machinery question' relates closely to the origin of Say's Law of Markets and hence the way that technology and innovation are perceived in economic thought. Jean-Baptiste Say (1803: 153) and he was concerned with how the production of commodities led to the acquisition of other commodities or that 'products are paid for with products'. From Say's (1803: 138) point of view "a product is no sooner created, than it, from that instant, affords a market for other products to the full extent of its own value" and that "a glut can take place only when there are too many means of production applied to one kind of product and not enough to another" (1803: 178-9). Over a given time period, the total supply of goods and services in a market economy was seen to equal the total demand, which precluded the possibility of deficient demand in the economy as a whole. James Mill (1808) in *Commerce Defended* restated Say's Law of Markets as "production of commodities creates, and is the one and universal cause which creates a market for the commodities produced." John Maynard Keynes summarized Say's Law of markets simply as "supply creates its own demand."

It is also understandable why Keynes (1936: 32) sided with Malthus,

> Malthus was unable to explain clearly (apart from an appeal to the facts of common observation) how and why effective demand could be deficient or excessive, he failed to furnish an alternative construction; and Ricardo conquered England as completely as the Holy Inquisition conquered Spain. Not only was his theory accepted by the city, by statesmen and by the academic world. But controversy ceased; the other point of view completely disappeared; it ceased to be discussed. The great puzzle of Effective Demand with which Malthus had wrestled vanished from economic literature.

Malthus was more concerned income flows and cyclical variations. Von Tunzelman (1995: 47) also points out, decisions to consume and to produce, and to save and invest are distinctly different from each other, though described in a different way than in Keynes. This would explain why imbalances could arise in the short period. Ricardo, on the other hand, identifies savings with investment, which means the decision to save does not involve a reduction in effective demand for consumption goods, but rather a change from 'unproductive' to 'reproductive consumption' (Gehrke and Kurz, 2001). This would mean there could never be a 'general glut' of commodities as was maintained by Malthus. It may be for that reason that Malthus (1820: 413) believed that growth was essentially demand-led:

> The three great causes most favourable to production are, accumulation of capital, fertility of soil, and inventions to save labour. They all act in the same direction; and they all tend to facilitate supply, without reference to demand, it is not probable that they should either separately or conjointly afford an adequate stimulus to the continued increase of wealth, which can only be kept up by a continued increase of the demand for commodities.

5. Innovation in the Walrasian theory of value and distribution

Leon Walras (1874) described the competitive process in a similar way as the classical economists, but changed the content of the theory by defining prices in terms of the scarcity of productive resources with respect to the demand for goods. Excess profits, that is, profits above the interest rate, vanished when there was free competition. This difference had an important influence on how the meaning of competition changed in the twentieth century. In contrast to the classical theory, Walras, and other early marginalist economists determined prices through the scarcity of productive resources with respect to the demand for goods. They started from a very different set of data (Garegnani, 1984): (1) the initial endowments of the economy; (2) the preferences of consumers; and (3) the set of technical alternatives from which cost-minimizing producers can choose. Thus, given the technology, endowments, the prices of all factors of production are determined simultaneous and symmetrically through the intersection of the supply and demand, or what is described as general equilibrium. Individuals are endowed with factors and demand produced goods and enterprises demand factors and produce goods with a fixed coefficients production technology.

In his book *Éléments d'Économie Pure*, Walras (1874) stressed "value in exchange, when left to itself, arises spontaneously in the market as the result of competition." In doing so, he used the analogy of an auction to symbolize the market, and the competitive bidding process that goes on in such a market. Nevertheless, he also introduced the concept of perfect competition, but only for logical and mathematical convenience, considering it analogous to 'perfectly frictionless' machines. This assumption was made for mathematical convenience and to support the idea of tâtonnement, which he used to describe the process of discovering the equilibrium price. Nevertheless, the mathematical requirements of the theory pushed subsequent contributions toward merging the concepts of competition and the market so that the market became an idealized state, which meant that the market lost all of its institutional characteristics (Stigler, 1957). Subsequent developments in the idea of perfect competition by Knight (1921) anticipate the change from the long-period method used by Walras to the temporary method pioneered by Arrow and Debreu. Debreu (1959) provided the most complete break with the long-period method by using the concept of perfect competition to compress the futures markets into the present and insure that all markets clear simultaneously.

This change in method circumvented Walras' analysis of the production and reproduction of capital goods, which is important for technical change and technological learning.[9]

Joseph Schumpeter adopted the Walrasian theory of value and distribution in his analysis of economic development and provides perhaps the best illustration of what the marginalist theory of value and distribution can explain. Schumpeter was trained in the Austrian tradition pioneered by Carl Menger (1871) and was a student of Eugen von Böhm-Bawerk. Böhm-Bawerk (1889: 82) emphasized the importance of time in the production process, but while Schumpeter (1954: 439) recognized his contribution to production theory, he was more interested in the dynamic model of Walras. The Austrian approach to the marginalist theory of value and distribution may have had some influence on Schumpeter as it differed from Walras in emphasizing subjective value, the spontaneous evolution of institutions, and disequilibrium. By focusing on the subjective nature of knowledge, Schumpeter, as well as Hayek, described competition as a process of discovery, where entrepreneurs would gain higher than average profits by producing new goods, or producing existing goods in new ways – an idea reminiscent of Adam Smith's division of labour and Marx's linkage between competition and technological change (Eatwell and Milgate, 1994: 84).[10]

Schumpeter (1954: 795) believed that Walras was the 'greatest of all economists' and that 'his system of equilibrium' was 'the best theoretical work of our time'. Following in his footsteps, Schumpeter (1934, 1939) began his analysis by considering technology, endowments and preferences as given and then describes how equilibrium prices of all factors of production and their distribution across different industries are determined simultaneously and symmetrically when marginal revenue equals marginal costs under the presumption of free competition. Profits are maximized in equilibrium, since there would be no economic profits remaining in the economic system. Schumpeter (1934:62) was clear that equilibrium prices, including uniform rates of remuneration for each particular kind of input (including labour and other material inputs) in the production process, results from the actions of competitive profit-seeking producers concerned with minimizing production costs. This

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[9] The new method also could not explain why capital moved between different industries and enterprises, or what is now called structural change and economic dynamics. Arrow (1962) is a curious addition to the literature as it focuses on technological learning (learning-by-doing), but it is rare example.

[10] Hayek (1945: 94) viewed competition not a state that assumes "the data for the different individuals are fully adjusted to each other" but a process that "necessarily involves continuous changes in the data for the different individuals." At the same time, he asserted that equilibrium is an outcome of the formation of a spontaneous order through individual actions, that is, the economy is both self-organizing and self-reproducing.

process of search and selection by profit-seeking producers explains how capital and labour moves between enterprises in the absence of significant barriers to entry and exit. Innovation appears as spontaneous (or discontinuous) changes to the technical alternatives available to the enterprise, or what is more commonly called the production function in economic theory (Schumpeter, 1939).

In *The Theory of Economic Development* and *Business Cycles,* Schumpeter (1934, 1939) extended the Walrasian theory of value and distribution to include changing technical alternatives from which cost-minimizing producers can choose, but maintained the initial endowments and the preferences of consumers as constant. He adopted the long-period method with the production and reproduction of capital goods being explicit, but he was most interested in changes in method of production that lead to changes in the production function, or what he defined as innovation. Schumpeter (1934:66) identified innovation as a distinct internal factor that is independent of other business behaviours, including invention. He defined it as carrying out 'new combinations' of available materials and resources that appear discontinuously through time. Development is synonymous with innovation and novelty, and can occur in five ways: (1) the introduction of a new good or service or an improvement in the quality of a good or service; (2) the introduction of a new method of production, or way of handling a commodity commercially, that is new to the industry; (3) the opening of a new market; (4) success in obtaining new materials and other inputs in the production process; and (5) the introduction of new forms of market organization. Schumpeter (1939: 84-85) described innovation as 'the setting up of a new production function' and maintained that these factors offset Ricardo's Law of Diminishing returns by 'jumping' to a new method of production. The consequence of the change in the method of production is that the marginal cost curve will also change immediately for the enterprise introducing the innovation and over time as the technology diffuses through the economy.

Innovation gives rise to new production functions that 'incessantly shift existing cost curves', generates disequilibria and intensifies competitive behaviour (Schumpeter, 1939: 88). Competition in this context is not a state of the market, but a process that resembles the one advocated by the Austrian economists. At the same time he noted the importance of product differentiation, as described in Chamberlin's (1933) theory of monopolistic competition. Schumpeter (1939: 99) stressed that 'disturbances of equilibrium arising from innovation' must be large enough to 'disrupt the existing system and enforce a distinct process of adaptation'. Diffusion does not play a prominent role in Schumpeter's theory and only appears as a process by which firms copy, imitate and gradually improve on the original innovation, or what he described as 'induced innovations'. They are innovations in the sense that it changed the production function of the follower firm. Large disturbances occur

spontaneously, often in clusters, concentrating in a particular branch of industry, which makes it difficult for the economic system to absorb these changes quickly.

Schumpeter departs from Walras by defining the function of the entrepreneur as innovator and the function of the manager as financier.[11] Walras (and Pareto) envisioned the entrepreneur as the competitive profit-seeking agent, whose main function was to bring about dynamic market adjustments that would eventually result in the elimination of any excess profits above the interest rate. They may follow many different strategies, but they create the tendency toward equilibrium by choosing relatively more profitable investments over less profitable ones. While the entrepreneur provides some dynamics in the equilibrium analysis being an agent of change, Schumpeter argued that dynamic equilibrium conceals the process of economic change or evolution and masks the source of 'true profits'. In Schumpeter (1934; 1939), the main function of the manager is to search for the most profitable opportunities and minimize the costs of production, whereas the main function of the entrepreneur is to carry out 'new combinations' of 'materials and forces within their reach'.

The Walasian tâtonnement process implies that trading occurs only at equilibrium prices, that there is a tendency for all factors of production (labour and capital) to gravitate toward full employment and for all product markets to clear. Schumpeter (1954: 472) considered Walras as the true successor of J.B. Say recognized that Walras and also observed (p. 589) that there are many different meaning of Say's law in the literature. One curious issue raised by Schumpeter (1954: 1083) is that Say's Law may not be relevant when time is included into he production process, as suggested by Wicksell's (1898) renunciation of Say's law in the context of monetary equilibrium. Nevertheless Schumpeter appears to embrace Say's Law, particularly in the context of Walasian theory of value and distribution, and then defines innovation as an activity of the entrepreneur. It is possible that the entrepreneur could be a lead user in the sense that they have strong needs in the market, but this is not considered by Schumpeter. Consumer needs, expressed as the preferences of consumers, are taken as given as is in all marginalist theories of value and distribution. Schumpeter also had the opportunity to explore demand-driven innovation in the context of induced-innovation, but he was not interested in the diffusion process, but only on how entrepreneurs could utilize the technical alternatives available to them. Finally, there is strong evidence that Schumpeter disliked Keynes' principle of effective demand and the policies that he advocated.

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[11] Schumpeter (1939:82) maintained that innovation should be considered endogenous "because the turning of existing factors of production into new uses is a purely economic process" and that it "is a distinct internal factor because it is not implied in, nor a mere consequence of, any other." However, his introduction of the entrepreneur simply shifted the explanation of innovation to another exogenous factor.

6. Marshall's theory of value and distribution and the demand for technology

Alfred Marshall (1890) also adopted essentially the same method as the classical economists, but changed the content of the theory by determined both the market and normal prices through the relationship between demand and supply. Competition remained rivalrous in Marshall (1890: 448) as he did "not assume that competition was perfect" because it "requires a perfect knowledge of the state of the market." One important difference from the Walrasian theory of value and distribution is that he distinguishes between short-period normal prices that refer to less than year and long-period normal prices that refer to several years and include capital goods, which corresponds to the prices described by Walras (1874). In short, he introduces a short-period equilibrium of an industry in which the capital stocks and productive capacities of firms are considered as given and a long-period equilibrium in which firms can adjust the size of their capital stocks and productive capacities. But Marshall had some difficulties in reconciling some of the ideas of the classical economists with those of the marginalist approach.

Marshall (1890: 323) presents his theory of value and distribution in Book V of *Principles of Economics,* in which he draws a mechanical analogy between the 'equilibrium of a stone hanging by an elastic string' and the 'general relations of demand, supply and value'. This book is set essentially in logical time. Marshall (1890: 240) introduces his ideas on industrial organization in chapter 7 of Book IV by drawing a biological analogy between the social and industrial organization and the physical organization of the higher animals. This book is set essentially in historical time. Youngson (1956) pointed out, Marshall had a very similar view as Adam Smith on the importance of the division of labour and the role it played in innovation and the development of new machinery and equipment, but he also recognized that the economy in his time was more highly organized and technological advanced than in the time of Smith. He also had similar views on the importance of international trade, but differed from Smith in that international markets would expand by lowering transportation costs and not by colonial expansion. The increase in the scale of production, brought about by the increasing division of labour, led market to distinguish between internal and external economies of scale. Marshall (1890: 266) defined internal economies as "dependent on resources of the individual houses of business engaged in it, on their organization and the efficiency of their management", and external economies as "those dependent on the general development of industry." At the end of Book IV, Marshall (1890: 318-319) defines the law of increasing return:

> An increase of labour and capital leads generally to improved organization, which increases the efficiency of the work of labour and capital. . . . Increasing Return is a relation between a quantity of effort and sacrifice on the one hand, and a quantity of product on the other. The

> quantities cannot be taken out exactly, because changing methods of production call for machinery, and for unskilled and skilled labour of new kinds and in new proportions.

Being a relation of quantities, Marshall considered the law of increasing return to connect logical and historical time.[12]

In Book V, Marshall (1890) introduced the idea of partial equilibrium analysis and the representative firm to make the notion of short-period normal prices more applicable to concrete issues and focus the analysis on a particular industry. Partial equilibrium analysis focused on the determination of prices and quantities in a specific market, independent of the effect that this market might have on supply and demand, and hence prices in other markets. To deal with economies external to firms, Marshall introduced the representative firm, defining it as 'an average firm' with 'access to the economies, external and internal economies, which belong to the aggregate volume of production'. He considered it essential to his discussion of normal value in relation to supply and demand, but he also claimed that he used the concept to simplify problems that were relevant to the long-period equilibrium. It was particularly important for issues related to the growth of firms (internal economies) and growth of knowledge (external economies), but it meant that the long-run costs of a firm should be equal to the industry.

Marshall's theory, however, contained an inconsistency, which made variable costs, including increasing and decreasing returns to scale, incompatible with free or perfect competition. The problem with the theory was that whatever happened in one market or industry had no effect on the prices of goods in other markets. One could accept this argument if the division of labour could be contained within the industry being investigated, but Piero Sraffa (1925, 1930) argued that this was contrary to the facts. This issue was the main topic of a debate that took place during the late 1920s in *The Economic Journal* (see Robertson et al., 1930). Starting from the point of view that diminishing returns (rising costs) and increasing returns (falling costs) originate from different causes, Sraffa (1926) showed that when variable costs are external to an industry, they would change the costs of firms in the other industries affected. This incompatibility of economies external to the firm with economies internal to the industry violates the assumptions that underlie Marshall's partial equilibrium analysis because it is not possible to establish the supply curve for the firm. This meant that Marshall's view of partial equilibrium and the representative firm were untenable. One way to avoid this problem is assume that all variable costs are internal to the firm, but this would mean that the firm would be a monopolist, in a non-competitive environment.

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[12] Kenneth Arrow (in Arthur, 1984) pointed out that Cournot (1838) concluded that declining marginal costs for the individual firm, or increasing returns, were incompatible with free competition.

Allyn Young (1928) provided additional support to Sraffa's argument by drawing from Adam Smith's idea of the division of labour. But he considered specialization not only an issue within a single enterprise, but that can include many different enterprises involved in the production of a single commodity (industrial stratification). The increasing returns generated though specialization was 'progressive and propagates itself in a cumulative way', which implies that variable costs are always external to the industry. Despite the best efforts by D. H. Robertson and G. F. Shove to defend Marshall's partial equilibrium analysis, Sraffa (1930) demonstrated once more that increasing returns are inconsistent with internal economies and that as a consequence the representative firm would change position within the industry as new firms would enter and others leave (Robertson et al., 1930). After the debate, Sraffa (1960) chose to return to the classical theory of value and distribution and develop a more systematic approach to the theory, but he also suggested that the introduction of imperfect competition into Marshall's partial equilibrium approach could be an alternative solution to the problem.

Joan Robinson (1933) and Edward Chamberlin (1933) arrived at a similar solution to Marshall's problem that decoupled prices and competition, but used different methodologies. By decoupling prices and competition, the solution also provided an alternative way to look at the relationship between demand and innovation. Using the term 'monopolistic competition', Chamberlin (1933) included all market situations that lie between perfect competition and monopoly to provide a more general view of competition. The theory considers all individual firms as independent and there is free entry and exit to and from the market as in free competition, but postulates that that the goods produced by the various firms are differentiated but there are many close substitutes. Chamberlin (1933: 56) defined product differentiation as the "characteristics of the product itself, such as exclusive patented features; trade marks; trade names; peculiarities of the package or container, if any; or singularity in quantity, design, colour or style [as well as] the conditions surrounding its sale." He believed that monopolistic competition would lead to excess variety, but as pointed out by Saviotti, product variety may be an essential part of product and process innovation. In this context firms

Robinson (1933) introduced Cournot's (1838) concept of marginal revenue into the theory of the firm and assumes that it is downward sloping. Although less general, Robinson gets around the problem of aggregating heterogeneous commodities at the industry level and she showed that it was not possible to pay labour their marginal product if perfect competition does not exist. Recognizing much of the criticism in *The Economic Journal* discussion, Robinson also moved away from Marshall's representative firm, instead adopting Pigou's (1928) idea of the equilibrium firm. This idea allowed her to assume that all firms within an industry were identical as in Marshall's theory, but because they were in equilibrium all firms

were ‘representative’. Robinson identified several different forms of competition that did not rely on price, including product innovation, product differentiation, packing and design, availability of credit, advertising, and marketing, all of which would generate behavioural heterogeneity in the economy. In both theories of imperfect competition, the enterprise will be facing an inelastic demand curve, which decoupled prices and competition.

7. A digression on Keynes’ principle of effective demand and innovation

The relationship between savings and investment is at the core of virtually every growth theory, which implies that Keynes’ principle of effective demand would be relevant to the theory of production and innovation. In the *General Theory of Employment, Interest and Money*, Keynes focused on the investment decision and its consequences for output and employment rather than on savings and the accumulation of capital and its consequences for economic growth. He sought to distinguish his theory form classical and neoclassical theory in the first two chapters by arguing that Say's Law only holds if increases in individual savings exactly match an increase in aggregate investment. In the third chapter, Keynes (1936: 32) singled out Ricardo’s contention “that it was impossible for effective demand to be deficient” and Malthus’ inability to provide an “to explain clearly (apart from an appeal to the facts of common observation) how and why effective demand could be deficient or excessive.” Keynes (1937: 250) argued “it is not the rate of interest, but the level of incomes which insures equality between savings and investment.”[13] A central message in the *General Theory* was that savings adjusted to investment, rather than the other way around, because investors and consumers have different behaviours.

This shift in away from the idea that supply creates its own demand and aggregate saving funds investment spending to one where consumption and investment spending determine savings and the volume of employment also shifted the focus of economic theory away from the accumulation of capital and toward the investment decision. For Keynes, the composition of the capital stock simply reflected the investment patterns and not some optimal decision made beforehand. This essentially meant that issues related to technology and innovation disappeared from the discussion, and were instead replaced by discussions of uncertainty, expectations and financial frugality. The re-emergence of growth theory attempted to bring the issue of capital accumulation back into the analysis and Garegnani (1978) asserted that it was possible integrate the classical theory of value and distribution

[13] From a strictly causal perspective, the principle of effective demand says that for any autonomously determined level of investment (or any other component of aggregate demand), there exists an equilibrium level of income and savings.

with Keynes' theory of effective demand because it does not rely on the causal mechanisms identified by Keynes.

Keynes was aware that technology was essential for economic growth. In *Economic Possibilities for our Grandchildren*, Keynes (1931: 19-20) pointed out that "the accumulation of capital which began in the sixteenth century", and that "the growth of capital has been on a scale which is far beyond a hundredfold of what any previous age had known." A rise in prices and profits triggered this growth, but he emphasized that:

> From the sixteenth century, with a cumulative crescendo after the eighteenth, the great age of science and technical inventions began, which since the beginning of the nineteenth century has been in full flood--coal, steam, electricity, petrol, steel, rubber, cotton, the chemical industries, automatic machinery and the methods of mass production, wireless, printing, Newton, Darwin, and Einstein, and thousands of other things and men too famous and familiar to catalogue.

On year earlier, in the second volume of *A Treatise on Money*, Keynes (1930: 85-86) wrote that Schumpeter's theory that innovation, described in his *Theory of Economic Development*, is the most important explanation for why the rate of investment fluctuates over time.[14]

> Entrepreneurs are induced to embark on the production of fixed capital or deterred from doing so by their expectations of the profit to be made. Apart from the many minor reasons why these should fluctuate in a changing world, Professor Schumpeter's explanation of the major movements may be unreservedly accepted.[15]

A Treatise on Money contains many of the ideas contained the *General Theory*, but presented in from a more dynamic, long-period perspective (Seccareccia, 2004). In the *Treatise*, Keynes demonstrates how an initial investment decision normally gives rise to a set of expectations that may trigger further changes in investment over several periods. As pointed out by Sccareccia (2004) expectations were endogenous to the wavelike pattern of behaviour inherent to the logic of the Credit Cycle. One criticism raised against the *Treatise*, however, was that it failed to provide a theory of the determination of output and employment as a whole. The *General Theory* provided the theory, but this book was basically concerned with Marshallian short-period static analysis, with expectations based on the idea of the marginal

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[14] Ironically, Schumpeter's (1936) criticism of Keynes' General Theory and especially the role given to expectations, including the marginal propensity to consume, marginal efficiency of capital, and liquidity preferences, because it did not take into account the source of innovation (exogenous) or the diffusion of innovation (endogenous). Schumpeter believed these were essential to capitalism itself. (see Freeman and Louçã, 2001)

[15] Keynes cites Wesley C. Mitchell (1927: 20-21), and not Joseph Schumpeter, because the *Theory of Economic Development* was only available in German at the time.

efficiency of capital. And when Keynes dealt with expectations, they were arbitrary he does While the *General Theory* asserted the independent role of demand in determining growth and cycles, the dynamics of the system, including long-term expectations and innovation, were not considered.

Harrod (1939, 1948) developed the first growth models by combining the accelerator principle with the Keynesian multiplier. His model was inherently unstable, because when the 'actual' rate of growth of effective demand was faster than the 'warranted' or equilibrium rate of growth, enterprises would increase investment, which would then increase effective demand and the desire to invest even more.[16] Similarly, when the 'actual' rate of growth of effective demand was slower than the 'warranted' or equilibrium rate of growth, enterprises would decrease investment, which would then decrease effective demand and create the incentive to invest even less. With demand independent of supply, the economy will either grow or collapse indefinitely. The instability principle became known as a 'knife-edge', but Harrod (1970: 740) thought the movement to be more gradual and likely to encounter many different kinds of frictions:

> the amount of friction depends on built-in procedures, degree of conservatism, sensitivity to current changes day-by-day, uncertainties about the future, sensitivity to changes of expectations, the kind of phenomena that affect expectations, etc.

Technological change and innovation could also be a friction, as was suggested in some of the endogenous growth models.

Kaldor (1957) and Kaldor and Mirrles (1962) developed a semi-endogenous growth model that anticipates the *AK* technology and differential learning rates in the open economy before the appearance of the neoclassical endogenous growth theory. Like in the other endogenous models, Kaldor (1957) rejected the standard neoclassical assumption of decreasing returns, arguing that increasing returns characterize the manufacturing sector. These positive feedbacks explain why diverging patterns of knowledge accumulation (and learning rates) appear instead of the simple stabilizing forces found in neoclassical growth models. The model replaced the production function with a technological progress function that interrelated investment with technical change and technological learning and incorporates it into the theory of growth and distribution developed as a solution to the instability problem in Harrod. Although formally identical to the *AK* model, causality runs form distribution to the profit rate instead of the technology to the profit rate (Kurz and Salvadori, 1998). Kaldor

[16] Solow (1956) developed a growth model using the standard neoclassical assumptions to demonstrate that competitive markets (with substitution and flexible wages) result in the full employment of labour and capital and not the escalating unemployment as suggested by Harrod.

maintained the endogenous rate of profit by allowing capital accumulation to adjust to changes in the technological capabilities.

Kaldor (1966) also applied Veblen's (1898) notion of cumulative causation to Verdoorn's (1949) idea that economies of scale depend on the structure of industry in a demand-driven, but drew particular attention to the dynamic and macro nature of increasing returns and knowledge accumulation as described by Young (1928). In his empirical analysis, Kaldor (1966) focused on differences in productivity growth across countries, arguing that these differences are best explained by changes in the growth of effective demand.[17] Kaldor (1978, 1989) also showed that growing domestic and international markets engender a process of cumulative causation in which manufacturing growth generates new types of knowledge through various learning activities and hence a higher rate of productivity growth and GDP growth for the economy as a whole. This implies that the process of technical change and technological learning is endogenous as output increases through the foreign trade and investment multipliers. Sustainable growth and structural adjustment therefore depend on national and regional technological and organizational capabilities. McCombie and Thirlwall (1994, 1997) extended this idea to explain the diverging patterns of technological accumulation in terms of high export growth and low import penetration.

8. Contemporary analysis of the role of demand in innovation.

Demand is important in at least two ways in the history of economic thought. In micro-economics it reflects the needs, wants and preferences of individual consumers of both intermediate inputs and final outputs. If there is no good or service that can fulfil a specific need or want, then one option is to find a solution to the problem by making the good or service. In macroeconomics, increasing effective demand makes it possible for increased specialization, technical change and technological learning. In adopting the Walrasian theory of value and distribution, Schumpeter described the innovation process as science-driven. If he had also considered changing needs, wants and preferences of individual consumers, he might have been able to extend his idea of innovation to also be science-enabling.

At a conference sponsored by National Bureau for Economic Research in the early 1960s on The Rate and Direction of Inventive Activity, included an interesting discussion on whether innovation was determined primarily by the supply of inventions or market demand. Jacob Schmookler (1962) was the main proponent for supporting the idea that demand essential to the innovation process. Schmookler (1966) established that the greater the

[17] Cornwall (1977) elaborated further on how demand can engender differences in growth rates.

demand for technology, the more creative groups and individuals were drawn to work on an unsolved problem and more patentable inventions they generated. Various non-linear models of innovation were later introduced that emphasized the interactive nature of learning, particular between science-driven research and demand-driven innovation. Schmookler was important in not only reasserting the importance of market incentives for innovation but also inspired the development of user and user-driven innovation by Eric von Hippel.

In the context of specific industries and markets, the technological choices of individual innovators and users shape the search for novelties, but the rate of diffusion and economic impact of innovation is closely related to the emerging demand for new products and processes. Schmookler's (1966) analysis emphasized the importance of demand dynamics in influencing investment and the direction of innovative efforts across different products and industries. He claimed that demand conditions crucially influence the desirability and realization of inventions and that the existence of an expected profitability and the expansion of market demand represent the key stimulus to which inventive activities react.

Rosenberg (1974), Mowery and Rosenberg (1979), Scherer (1982a), and Kleinknecht and Verspagen (1990) criticized Schmookler on conceptual and empirical grounds, but the lively discussion resulted in a number of important case studies, including Walsh (1984), Malerba, (1985), Howells (1997), and den Ende and Dolfsma (2005), as well as a number of econometric analyses, including Wyatt (1987), Parker (1992), Geroski and Walters (1995), Kleinknecht (1996), and Brouwer and Kleinknecht (1999). Von Hippel (1988), and Saviotti, (2001) also found demand important for the emerging technologies and in the generation of variety in new products. At the industry and macroeconomic level demand patterns have been considered as important determinants of structural change, without however linking them to the associated changes in technology; demand conditions have rarely been included as determinants of innovative performances.

Metcalfe (2001), Andersen (2001) and Saviotti (2001) that have proposed evolutionary models where consumption is investigated in its effects on innovation, economic structures, and growth, bringing into considerations income and time constraints, behaviours and utilities, satiation and preferences for variety. Sylos Labini (1969) took a more macroeconomic perspective on demand and innovation when he combined technological factors with market structures and demand conditions. He found that the rate and type of innovation was driven by the expansion of demand in oligopolistic markets. Pasinetti (1981, 1993) identified demand as the sources of structural change, inspiring a stream of studies where attention has been mainly devoted to the dynamics of productivity growth. A stream of research inspired by Lundvall (1988) also investigated the relevance of user-producer interactions in European systems of innovation.

Important insights have emerged from input-output analysis, which has its intellectual roots in classical theory. Using the approach, Mohnen (1997) and Los and Verspagen (2002) studied the interaction between producers and users of innovative or R&D intensive goods, helping to identify the sources of innovation and productivity growth. Studies in this direction include research by Brown and Conrad (1967) and Terleckyj (1974, 1980), as well as Momigliano and Siniscalco (1984) and Marengo and Sterlacchini (1990). A different stream of research, pioneered by Scherer (1982b, 2003), DeBresson (1996), Evenson and Johnson (1997), Verspagen (1997) and Los (2001) has mapped the flows of technological knowledge across sectors of the economy. Different methods and data (including R&D and patents) have been used to build such matrices in order to identify sources and effects of inter-industry technology flows and estimate R&D spillovers.

Users have often been the originators of commercially important product and process innovations in many different industries ranging from scientific instruments to sports equipment. Von Hippel (1986, 2005) shows that user innovation is not a rare phenomenon, a considerable amount of users (around 25 percent on average) report that they had already innovated for themselves. Valuable user innovation activity, however, seems to be unequally spread over the bulk of users: According to lead user theory, specifically those users who (1) already face needs today that the entire market place will only experience in the future (being ahead of an important trend in a market place under study) and (2) expect high benefits from a solution that addresses their advanced needs are likely to come up with the most attractive innovations. Urban and von Hippel (1988) showed that in the field of printed circuit CAD software concepts developed by lead users were more attractive to the market place than concepts developed by more traditional marketing research methods.

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