

ECONOMIC DEVELOPMENT AND DEVELOPMENT OF FORMAL SCIENCE: THE IMPORTANCE OF MANUFACTURING-LED INVENTIONS

Satya Prasad Padhi*

What the paper suggests is that the scientific development (and the academic research) that targets and capable of continuous technological improvement is an outcome of a particular economic development process. For instance, the development process that is based on specializations, and allows for continuous changes in specializations, provides the incentive and scope for such scientific development. Therefore, the effectiveness of the education – for technological improvements - depends on such development process.

Key Words : *Endogenous Growth, Inventions*

INTRODUCTION

In the economic development literature, the specificity of developed status in education, allowing for scientific discoveries, is controversial. One point of view (i.e., the orthodox one) maintains that the formal science, imbued with a scientific temper, creates innovations that in turn define more productive investment opportunities, leading to higher economic developed status. The challenge comes from another point of view (i.e., the historical one) that suggests that new investment opportunities, guided by higher profits expectations, embody new challenges – both economic and technical – that in turn induces inventions and the role of independent scientific discoveries are negligible. Further, according to the latter perspective, if scientific discoveries are important, the new investment opportunities-led higher development processes are responsible for them.

The present paper is organized as follows. Section I reviews the controversy, highlighting the orthodox positions and policies and the need of an alternative. It also highlights that mere alternative perspective is not enough. The scope for alternative policy perspective depends on an alternative understanding of the growth process, and the role of investment, that permits the growth of science, as the effect. Section II in this context adds to the contributions of Young (1928) to show that the Youngian endogenous growth theory has an in-built support for the endogenous growth of inventions, as an alternative to the orthodox positions. Section III concludes on the policy focus.

The Controversy

To start with, in recent years, it has become increasingly fashionable to emphasize a literature that highlights the impact of formal scientific education in narrow specializations (the formal science) on economic development. In this perspective, the primacy is given to the formal education (or the 'formal' human capital formation in narrow specialized lines) that generates scientific knowledge and facilitates innovations (or, fundamental changes in the production function). The origin of this interest can be traced to a modern growth theory that emphasized that technological progress based on new scientific knowledge (and innovations) drives economic growth and facilitates continuous developed status (for example, Solow, 1957).

In this perspective, the growth of scientific knowledge, amounting to new discoveries, is

* Professor, Department of Economics, Panjab University, Chandigarh

exogenous and is not effected by the actual production conditions, which confirms to the neo classical reduplication principle. That is, investment adjusts to such discoveries and is not the cause. As Scott (1989, pp. 133-5) noted, the related literature (Kuznets, 1930; Salter, 1960) assumes the principle of reduplication where the adjustment (of investment) does not create further discoveries. The empirical assumption therefore is that the incidence of technological progress derives its strength mainly from 'exogenous' academic research (say, Mansfield, 1991; 1998).

The policy implication therefore is that the current globalization process and the phenomenal growth in the communication technology permit many countries to participate in such growth process. The entire policy focus therefore is on facilitating such education through tax incentives (or subsidies) and/or on the concentration of such higher education in few countries (with the presumption that it as a public good facilitates the development process of all).

This has generated a debate in the literature dealing with economic development. The immediate provocation could be that, even if 'education'/'academic research' has no doubt its own importance, it has not led to 'domestic' success in achieving the developed status (Frank, 1985). One has to take into account the incidence of educated underemployment in underdeveloped countries (see, Stiglitz, 1988; Rodriquez-Clare, 1996), and, therefore, permits lower 'value' to such human capital index (Mathur, 1984). On the other hand, the developed countries with higher developed status in economic development, no doubt, experience more effective role of education.

Here, as Scott (1989, 131-5) noted, Schmookler (1966) provides a key insight that has the potential to dramatically change the policy focus. According to him, Schmookler's painstaking study of inventions covering the period from 1800 to 1957 shows that the role of independent scientific discoveries is negligible as the initiating factor. The focus in fact should be on the specific type of investment programs that embodies economic (guided by higher returns) and technical problem solving, which in turn leads to inventions. As Scott (1989, p. 132) noted, "Schmookler does not deny that, in some 'science-based' industries (he mentions the electrical, electronics, nuclear, chemical, and drug and pharmaceutical industries) invention and research is heavily dependent on scientific knowledge, and that in these industries there were many instances of important inventions being directly induced by scientific discoveries. However, he argues that, even in these industries, 'economically evaluated technical problems and opportunities arising in the normal conduct of business are dominant'".

As Scott (1989, pp. 133-40) noted, there is overwhelming support for Schmookler. According to him, it is practical knowledge guided by higher expected profitability (also, see, Mansfield, 1968) that guides inventions. If scientific discoveries are also important (see, Rosenberg, 1974; Kamien and Schwartz 1982; Mansfield, 1991, 1998), the guiding principle is "Principle 4 of Gilfillan (1970)' Social Principles of Invention, which reads 'Invention need not be based on prior science. It often precedes and evokes the apposite science'" (Scott, 1989, p. 140-1, n. 5). Scott further quotes Derry and Williams (1960), 'The great majority of technological developments were the result of empirical discoveries by practical man: indeed, it has remarked already that until comparatively recently technology contributed more to science than science to technology'.

The Present Debating Issues

The present paper tries to show that even if the historical findings are important and challenges the orthodox neo-classical position, they only raise additional issues. This is because the neo classical orthodox position is self-contained unit. First, it allows for continuous growth of inventions. The historical perspective that gives importance to new investment opportunities (with higher prospective

profits) does not permit such continuous growth of inventions; Schmookler, following Kuznets (1930) and Salter (1960) maintains that the investment embodying inventions does not beget further inventions. Then, the historical school of thought does not provide an endogenous mechanism that can permit the growth of inventions, as an alternative to the exogenous source of such growth (i.e., the orthodox position), i.e., the alternative historical perspective is not an alternative in this sense.

Second, the alternative perspective has to explain the increased incidence of formal science, which, no doubt, gaining more importance in developed countries (Rosenberg, 1974; also see, Kamien and Schwartz, 1982; Mansfield, 1998). The issue is: is the growth of formal science part of the developed process that creates the initial invention?

Third, the orthodox position, by holding scientific discoveries to be exogenous, does not have to explain the possibility that there must be higher payments to individual initiatives that bring about inventions in production processes. Therefore, if in the alternative perspective, 'investment' induces scientific discoveries i.e., the latter are not manna from heaven, and are created by individual initiatives, the incentives to such initiatives also needs to be taken into account. Can such investment programs allow both for higher wages to such initiatives and at the same time permit higher returns to the firms that employ them?

In fact, there has been the recent growth of new growth theories, guided by the such theoretical conjectures (see, Romer, 1991). For example, the new neo classical endogenous growth theories (say, Romer, 1986 and Lucas, 1988) highlight the possibility that the formal education in narrow specializations (or, the increasing resource allocation towards such human capital formation) can create externalities and therefore can explain continuous growth of scientific knowledge (associated with increasing returns in the 'aggregate' production function). Nested within this framework is the possibility of market power and higher returns to compensate the scientists (see, Romer, 1991). It should be noted, this perspective, like the 'old' neo classical school of thought, retains the ideas of exogenous incidence of invention (or the existence of scientists), but throw away the reduplication principle that guides investment. Therefore, any exogenous invention, through externalities, guides further growth of inventions.

However, this theoretical formulations have their 'own' (and more severe) problems. One, it is very difficult to visualize as to how a well-behaved individual production functions (that permit of no interdependence) create such externalities. In fact, it is generally agreed, through the intervention of Knight-Graham cost controversy (and Sraffa's observation), that the external economies as envisaged by Marshall have no place in economic static (permitting perfect competition) – and the production function based estimates suggest that these conceptions are empirically unimportant (see Mankiw, Romer and Weil, 1992; Pack, 1994). Second, the growth of science (and the rate of growth of output), highlighting externalities, is not consistent with a well-behaved production function (Solow, 2000). It should be noted that if exogenous scientific discovery is just an argument in the production function without creating externalities, it has no growth effect, and, therefore, the (decreasing) returns to such discovery as such cannot explain the growth of scientific discovery.

In this context, the present paper maintains that a particular focus can be on Young (1928), who, like Schmookler, gives the primacy to new investment opportunities (guided by higher prospective returns) that creates inventions, but provides a complete answers to the issues raised above, for the purpose of formulating a meaningful alternative to the orthodox position, i.e. highlighting an endogenous growth process, permitting endogenous growth of innovations. The section below therefore starts with the Youngian contributions and then takes up the issue of how it provides an alternative to the orthodox positions.

Young (1928)'s Contribution

First, Young (1928)'s position on invention is akin to Schmookler's, giving primacy to the role of adaptive engineer (in the production process). To quote, "(W)e abstract outside improvement, unexpected developments, etc., those improvements which would have taken place apart from the growth of the industry though it is a moot point how far these exists. Take the so-called 'revolutionary changes' of the industrial 'revolution'. Modern economic history emphasizes the way the increasing markets led to development. It is an interesting question how far pure science is a function of industry, and how far it goes under its own momentum. It might be a good thing to drop the word 'invention' from our vocabulary; the adapting engineer is the important man" (Young, 1990, p. 44).

To start with, the adapting 'engineer' in Young (1928) is not defined by improvements that come from learning by doing in the existing 'traditional' firms. According to Young (1928), nothing much of importance can be ascribed to the individual initiatives in terms of existing firms producing traditional items with well-defined traditional tasks. Here investment would be guided by savings, which in turn passively responds to demand and supply conditions, and can be viewed as economic static adjustments, important for resource allocation function. Young (1928) also maintained that the increasing returns to scale phenomenon where firm's production adjusts to increased demand conditions, given technology, endowments, preferences, cannot be the focus. Similarly, Young mentions that the initiatives in terms of the cost reducing practices through the rationalization of firms, say, downsizing, etc., are not important.

The adapting engineer, in Young (1928), adapts to the entrepreneurial spirit that guides some 'firms' to persistently search for 'larger markets' (see, also, Blitch, 1983). As Young (1928) maintained, "It is dangerous to assign any single factor the leading role in that continuing economic revolution which has taken the modern world away from the world of a few hundred years ago. But is there any other factor which has a better claim to that role than the persistent search for markets? No other hypothesis so well unites economic history and economic theory." (Young, 1928, p. 536).

The persistent search for markets implies production in large volume, which facilitates (highlighting the contribution of the 'engineer') production to be sub-divided in to many parts, which in turn permits specialization of labor. The persistence search for market not only implies the introduction of new tasks (new specialization) in production but also creation of new specialized employment opportunities in trade/marketing, etc. These functions (see, Stigler, 1951)- targeting larger volume of production - would involve (i) arrangement of informal finance, (ii) informal creation of exact specification of machinery for industrial differentiation, (iii) purchase and storing of materials, (iv) transforming materials into semi-finished goods and semi finished goods into final products, (v) undertaking modern transport, marketing, creation of communication channels, extension of credit to buyers, etc.

Here, Young (1928) also discusses the conditions that facilitate an advanced endogenous growth process. For him, for example, the advantages of the 'informal' human capital formation, insofar as it permits higher market access (and higher returns), implies that many firms would vie for such initiatives – the external economies created by the initial invention. To quote, "Every important advance in the organization of production, regardless of whether it is based upon anything which, in a narrow sense or technical sense, would be called a new 'invention', or involves a fresh application of the fruits of scientific progress to industry, alters the conditions of industrial activity and initiates responses elsewhere in the industrial structure which in turn have a further unsettling effect. Thus change becomes progressive and propagates itself in a cumulative way" (Young, 1928, 533). This comes close to Scitovsky (1954, p. 297)'s third example of direct (and non-market) interdependence

between producers where adoption of new methods (roundabout methods of production) is made available to others without charge (and is not impeded by patents)¹.

Therefore, for Young (1928), the initiation of division of labor in any line of production, targeting large volume of production, is also associated with increased production in other lines (increases in market size), permitting division of labor to be introduced there, and consequently increases in aggregate production. Here, Kaldor (1972) noted that this increase in aggregate production cannot happen if the firm, initiating division of labour, gets higher market share (and profits) at the expense of others; the reduction of market share for others reduces the scope of their adoption of division of labour targeting larger volume of output. Aggregate production (and size of the aggregate market) would increase, according to him, if division of labour is an investment that in the Keynesian fashion increase effective demand that permits division of labour to be adopted by many – that is, firms adopting division of labour (and higher volume of output) would provide the larger required market for each other. Then, division of labour increases the effective demand.

As the aggregate market size increases, the firms are induced for further specializations (supported by scientific spirit) to take advantage of the increases in market size. In addition, as the number of firms adopting division of labor increases, certain general functions common to firms, such as standardized tasks (insofar as Young emphasizes standardized processes rather than specialized machinery), trade, other services, etc. (and rival functions within the firm), can be undertaken by specialized firms (Stigler, 1951) – industrial differentiation. According to Young (1928), industrial differentiation, since it adds to the market size in each instance, has a tendency to grow in a cumulative manner.

Towards an ‘Endogenous Growth of Invention’ Thesis

To start with, the new endogenous growth literature (see, Romer, 1987; 1991), acknowledges the contribution of Young (1928) to the effect that a developed growth process is characterised by the abilities of the economy to generate new tasks, new processes, etc. However, they take the existence of the developed formal science or human capital (that generates such new processes) as given, without explaining it. Similarly, though Chandra and Sandilands (2005; 2006; also see, Currie, 1981; 1998) (rightly) point out that Young never emphasized the importance of the scale factor (with market power), which is otherwise is emphasized by the new endogenous growth theory, they also try to theorize a Youngian position in which once a developed and more competitive industrial differentiation-led growth process comes into being, it has a tendency to propagate itself in a cumulative way; they do not discuss the endogenous process that ensures the developed status that should come with the developed status in formal science.

In this context, the present paper’s focus, as discussed above, is on the initiation of division of labour and the external economies created by it that permit the endogenous growth possibility; this would highlight how the Youngian-Kaldorian perspective on the possibility of an endogenous growth processes highlight its contribution for developing an alternative perspective on the endogenous growth of inventions, i.e. achieving a developed endogenous growth process. Here, the present paper also tries to show that one has to add to Young to show that the Youngian endogenous growth process induces (i) the growth of formal science, to further the specific growth process, and (ii) the development process that supports both higher wages to the scientists and higher returns to the firm. As discussed earlier in section I above, these additional consideration are important for developing a perspective on the growth of inventions, as an alternative to the orthodox positions.

¹ It is clear that large scale production possibilities (with given preferences and endowments) cannot create such externalities that highlight the importance resource creating initiatives.

To start with, Young (like Schmookler) is considering that inventions originate from the need (guided by higher prospective profits) to change the production conditions, but isolates the initiation of division of labour as such important change. Here, he is not supposing that inventions beget further inventions in the same industry (for which there is no empirical support). Young (1928)'s focus is on the endogenous growth of inventions possibility where initial invention begets (through external economies) increased roundabout methods of production, reflecting specialisation between firms, which should be seen as new inventions. As he noted, "The successors of the early printers, it has often been observed, are not only the printers of today, with their own specialised establishments, but also the producers of wood pulp, of various kinds of paper, of inks and their different ingredients, of type-metal and of type, the group of industries concerned with the technical parts of the producing of illustrations, and the manufacturers of specialised tools and machines for use in printing and in these various auxiliary industries. The list could be extended, both by enumerating other industries which are directly ancillary to the present printing trades and by going back to industries which, while supplying the industries which supply the printing trades, also supply other industries, concerned with preliminary stages in the making of final products other than printed books and newspapers." "New products are appearing, firms are assuming new tasks, and new industries are coming into being. In short, change in this external field is qualitative as well as quantitative." Therefore, this perspective agrees with the lack empirical findings (a la Schmookler) for inventions begetting further inventions in the same industry (say, printing); it however shows that invention (and division of labour) in an industry induces further specializations (new industries), which should be seen as new induced 'inventions'.

Second, the present paper tries to show that these informal human capital formation, i.e. additional employment opportunities in production and beyond production related activities, have the ingredients of 'formal human capital' in latent forms. For instance, the specializations, initially, taking place in an informal way, encounter problems. However, since specializations permits higher market access (and returns to the firm), the difficulties would induce the firm (or others) to undertake a careful/accurate investigation of the principle underlying the specialization – to master them. Therefore, such inventions – division of labour – induce academic research in new tasks – the scientific interest to understanding the processes.

It should be noted that if division of labour creates sub-tasks, including the task of scientific enquiry, and if it also creates external economies, i.e., generalized adoption of division of labour, there would be the incentive for the coming up of specialized firms for each sub-tasks, including specialized 'firms' for formal science – all leading to the development of industrial differentiation. This perspective on continuous development of industrial differentiation, resulting from the Youngian external economies, is particularly important for the mature development of formal science. For example, commenting on the effectiveness of R & D efforts, Scherer (1967) notes that it is a continuous effort in which each sequential step provides knowledge useful in the next step (Scherer, 1967); higher the accumulated useful knowledge, the lower would be the costs of the creation of new scientific ideas. Here, the Youngian perspective shows that the endogenous economic development, based on division of labour-led industrial differentiation, shows a symbiotic relationship between useful knowledge (and problems_ gathered from specializations) and its investigation by science, that shows that countries that kick start such development process has advantages with respect to formal science. That is, higher the accumulation of useful knowledge, the lower would be the costs of creating scientific discoveries. In addition, the development process, with many specializations in many fields, and the ensuing scientific investigations (and discoveries) in many fields, can be seen as 'an interrelated whole' that also benefits further effective growth of science (see, Scott, 1989, pp. 140-1).

It should be noted that, though Young is not explicit about it, industrial differentiation-led incentive for education on narrow specialization – the ‘formal human capital’ - improves the specializations-based industrial differentiation, further. Its focus can be on the creation of a set of new tasks that facilitates further division of labor. This possibility of further industrial differentiation forms the basis for further growth of science, indicating a cumulative causation process that favors both the development of science and attainment of further developed status.

This perspective shows that the new endogenous growth theories that emphasize the externalities created by ‘formal’ human capital as the *preconditions* for growth (to take place) can be misplaced. In the Youngian thesis, the focus is on specific type of investment that creates external economies and such investment, insofar as it creates ‘informal’ human capital generation arising from division of labour” supports the ‘formal’ human capital formation. Therefore, in a modern economy, the formal human capital formation comes in many ways (aided by formal learning) - say, specializations in transport, communication, packaging, marketing, finance, R & D efforts, etc., but these aspects of formal human capital is a function of the growth of firms, which, in turn, depends on the ‘growth’ of firms targeting industrial differentiation (informal human capital).

Third, the present paper tries to show that the specializations within manufacturing support other specializations. For example, the specializations in production – specialization in intermediate goods – permit material cost reduction. If division of labour also induces sticky prices (see, Huang, et al, 2004), this cost reduction implies that the increase in money value added would be higher than the expansion of real value added (arrived by the double deflation method), permitting higher trading profits (and higher returns to the firms) even when the real output expansions entail higher wages both for the specialized workforce in production and for the firms to undertake additional trade/service/finance related functions to reach out to more customers (higher market access).

Here, if such induced growth of science requires that there are increases in employment opportunities with higher wages (that supports specialists/scientists) and higher returns to firms (incentive to adopt scientific contributions in the production processes), it highlights the importance of an advanced manufacturing sector. The greater the industrial differentiations reflecting specializations between firms with firms specializing in many trading, service related activities that coordinate different tasks in manufacturing, lower would be the costs of outsourcing by manufacturing firms, i.e., lower would be the intermediate costs, that, in the face of price stickiness that division of labour induces, can support higher money value added per unit of money output. This in turn provides both increase in return to the firm and higher wage bill to higher employment targeting specialized trading activities (to have higher market access). It should be noted that increase in money value added is an indication of market power but the present case should be distinguished from the possibility of static monopoly power, i.e. increase in price with an unchanged intermediate goods costs). Static monopoly power makes demand inelastic whereas higher money value added through material cost reduction permits the firm to undertake higher trading/market expenses – bear additional employment with higher wages - that makes demand elastic at a given price (or even lower price).

CONCLUDING NOTE ON THE POLICY FOCUS

The present Youngian perspective has to be assessed in relation to the controversies surrounding the source of inventions. First, Young’s position, like that of the position of Schmookler, shows that inventions originate in production process, albeit guided by the need of improving upon the production process to obtain higher market share (and profits). Second, unlike the Schmooklerian thesis, and as an alternative to the orthodox thesis, the Youngian (and Kaldorian) perspective holds

that investment in inventions (i.e., division of labour) begets further investment opportunities in further inventions. Here, though division of labour in an industry can induce further division of labour (i.e., induce further improvements in specializations) in the same industry, the main focus of the Youngian thesis is that 'invention begetting further inventions' manifest themselves in the coming up of new specializations, new tasks, new industries that defines the interrelated whole concept of inventions. Third, it also maintains that inventions (and further inventions) manifest themselves in specialization (and further specializations in narrow fields); if so there is the incentive for formal education in narrow specialization to understand the principles underlying specializations – and therefore, the growth process also highlight the importance of formal education (in narrow specializations); but, the main impetus is provided by the changes in production processes.

In fact, the facts would bear out that the countries experiencing higher growth of demand (and higher scope of division of labour) are in a better position to undertake higher specialized scientific research. Here, the supply side of scientific discoveries has also to take into account the fact that it is specific to a division of labour-led cumulative process where inventions creates further inventions. The policy focus therefore has to be on the specificity of 'informal' human capital formation based on division of labor, which creates external economies, and forms the basis of formal human capital. Industrial differentiation, insofar as it transforms competitive environment (technological external economies) and leads to growth, gives concrete shape to deliberate formal human capital creation - deliberate knowledge gathering initiatives - which, if facilitates further division of labor, forms the basis of continuous structural transformation of the economy from the point of view of cumulative endogenous growth.

Therefore, the present perspective shows that the formal education – academic research - no doubt facilitates economic development (as found in Mansfield (1991; 1998)), but its incidence could be specific to a few developed countries and the nature of development process should not be undermined. That is, its effectiveness depends both on the pre-existing developed status with narrow specializations and on its impact in terms of creating the opportunities for further industrial differentiation (which should be the policy focus of education policy). In this perspective, the impact of the 'formal' human capital formation and its effectiveness depend on this specific development process. Therefore, the role of the formal human capital formation, independent of such specificity of capital and labor, is problematic.

Moreover, the present elaboration of the Youngian thesis shows that Rosenberg's criticism (see, Scott, 1989) - that mere demand (higher prospective profits) does not induce inventions and the role of scientific discovery (and the role of scientists), independent of prior demand conditions cannot be brushed aside – is misplaced. Here, the Youngian perspective shows, the focus should not be on mere increases in demand conditions as such, as a factor determining inventions. The development of scientific discoveries, as a specialization, is induced by a particular growth of demand, which is guided by division of labour. That is, the Youngian-Kaldorian thesis holds that division of labour supporting further division of labour ensures the growth of demand that also supports academic science (as an side effect). Once specialization in scientific discovery is induced, it not only creates inventions for the industry that provided the initial thrust, but also creates new tasks, new specializations, and new industries. That is, even if formal science is behind the coming up of new such new industries, it is only an aspect of a development process in which division of labour creates the scope of such greater roundabout methods of production that effect further growth of demand (market size).

If the effective scientific development in a way highlights the role of the dynamic firms trying to get higher market access to increase the rate of return, the globalization process needs careful

examination. Globalization provides both advantages and disadvantages for the underdeveloped regions/countries. To discuss the disadvantages first, as Rodriguez-Clare (1996) noted, a developed country with deep division of labor, providing both higher real wages and higher returns to capital, induces a reallocation of resources (including scientists supported by academic research) from the underdeveloped to the developed ones. It would also explain as to why the underemployment to 'education' exists in countries that are late starters with shallow division of labor. As Bardhan (1995, pp. 2986-9) also noted, from a development economics perspective, technological improvements can be seen as strategic investment and the initial differences in technological front in terms of already accumulated knowledge capital can play a decisive role permitting some countries to dominate, which shows that ideas as private property does not permit easy diffusion. Rich countries, say, given first mover advantage and past accumulation of ideas, may dominate in all fields concerning with technological improvements, and poor countries, given that they loose out in the technologically advanced fields (in terms of market share and profits), may opt for less technologically advanced traditional sectors and spending less on R & D. Globalization, therefore, would adversely affect the initiation of a proper development process in underdeveloped countries and inhibit effective scientific development in these countries.

On the other hand, 'globalization' can provide certain advantages. If the late starters depend on a particular set of industrial policy to start industrialization (and focus on the scientific discoveries), they have to depend on a few select industries that both provide the opportunities for greater division of labor (on a global scale) and create important dynamic external economies. Such a concentrated focus however depends on higher market access. That is, division of labor cannot depend on the existing size of the market of the underdeveloped local economies. The initiation of a proper development process, therefore, depends on the participation in the globalization process. One broad conclusion therefore is that the globalization process should permit such growth of effective science in many countries. As Kaldor (1981) noted, the historical experience shows that the industrialization of erstwhile underdeveloped countries (say, Japan and South Korea) supported an increase total world income (and supported higher growth prospects of the developed countries). If the effective growth of effective science depends on the division of labour-led growth of income (i.e., scope of greater industrial differentiation), the globalization process that supports the initiation of division of labour in the existing underdeveloped countries would support further division of labor and the overall growth of science.

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