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A New Measurable Definition of Knowledge in New Growth Theory

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Abstract**—**New Growth Theory helps us make sense of the ongoing shift from a resource-based economy to a knowledge-based economy. It underscores the point that the economic processes which create and diffuse new knowledge are critical to shaping the growth of nations, communities and individual firms. In all too many contributions to New (Endogenous) Growth Theory – though not in all – central reference is made to 'a stock of knowledge', a 'stock of ideas', etc., this variable featuring centre-stage in the analysis. Yet it is immediately apparent that this is far from being a crystal clear concept. The difficulty and uncertainty of being able to capture the value associated with knowledge is a real problem. The intent of this paper is introducing new thinking and theorizing about the knowledge and its measurability in new growth theory. Moreover the study aims to synthesize various strain of the literature with a practical bearing on knowledge concept. By contribution of institution framework which is found within NGT, we can indirectly measure the knowledge concept. Institutions matter because they shape the environment for production and employment of new knowledge.

Keywords**—**Institution Framework, Knowledge, New Growth Theory (NGT)

I. INTRODUCTION

THE central notion behind New Growth Theory is increasing returns associated with new knowledge or technology. New Growth Theory is a view of the economy that incorporates two important points. First, it views technological progress as a product of economic activity. New Growth Theory is often called "endogenous" growth theory, because it internalizes technology into a model of how markets function. Second, New Growth Theory holds that unlike physical objects, knowledge and technology are characterized by increasing returns, and these increasing returns drive the process of growth.

New Growth Theory helps us make sense of the ongoing shift from a resource-based economy to a knowledge-based economy. It underscores the point that the economic processes which create and diffuse new knowledge are critical to shaping the growth of nations, communities and individual firms.

No amount of savings and investment, no policy of macroeconomic fine-tuning, no set of tax and spending incentives can generate sustained economic growth unless it is accompanied by the countless large and small discoveries that are required to create more value from a fixed set of natural resources [1].

In all too many contributions to New (Endogenous) Growth Theory – though not in all – central reference is made to 'a stock of knowledge', a 'stock of ideas', etc., this variable featuring centre-stage in the analysis. Yet it is immediately apparent that this is far from being a crystal clear concept.

Yet again, the relevant literature frequently presents equations in which (dA/dt) is set equal to some power of A (A presents stock of knowledge) multiplied by other variables. These equations too are meaningless unless A is cardinally measurable. And yet they are never supported by any indication of how such a cardinal measure may be found or constructed. This is certainly not 'measurement without theory'; it is theory without the minimal conceptual clarity required to make that theory worthy of attention. No amount of 'sophisticated' mathematical analysis can turn conceptual confusions into meaningful conclusions [2].

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II. DIFFICULTY IN KNOWLEDGE'S PRICING

The centerpiece of New Growth Theory is the role knowledge plays in making growth possible. Knowledge includes everything we know about the world, from the basic laws of physics, to the blueprint for a microprocessor, to how to sew a shirt or paint a portrait. Our definition should be very broad including not just the high tech, but also the seemingly routine.

The standard approach which economists use has been to divide the world into two parts: private goods—excludable and rival, and produced by markets—and public goods—non-excludable, non-rival, and produced by government, or other non-market means, like charities. While an important exception to the rule that markets produce optimum results, public goods tended to be viewed as a very limited exception: we can rely on markets to produce the overwhelming majority of goods and services, and turn to the public sector only in a few special cases.

But not all ideas are pure public goods. While they are non-rival—many people can use them at once without depriving others of their use—economically valuable ideas are at least partially excludable. And most importantly, their excludability is more a function of socially determined property rights than

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it is a function of the intrinsic character of the idea.

The non-rival quality of ideas is the attribute that drives economic growth. We can all share and reuse ideas at zero, or nearly zero cost. As we accumulate more and more ideas, knowledge about how the world works, and how to extract greater use out of the finite set of resources with which the world is endowed, we enable the economy to develop further.

But in the case of knowledge, markets may not send the right price signals. The social benefits and the private costs of new knowledge creation diverge. Because additional use of knowledge has zero marginal cost, once the knowledge is created, any positive price for knowledge is too high. Because knowledge isn't fully excludable, entrepreneurs get paid less than the social value of their knowledge, and they don't have sufficient incentives to distribute it widely or invest in creating more [3].

The difficulty and uncertainty of being able to capture the value associated with an invention is a real problem.

The gap between the social returns of research investment and their private returns is evidence of the inability of firms to capture the benefits of their research [4]. Careful econometric studies have repeatedly shown that the social rate of return to research (the value of all of the economic benefits received by society) is typically two to five times higher than that private rate of return (the profits accruing to the individual or the company that pioneered the innovation)[5].

III. Shortcoming of Knowledge's Measurement

A. Conceptual Confusion of Knowledge

Romer's [6] paper makes little advance over (1986) with respect to the issues at hand. At first we find a rather abstract discussion of the relations where A represents non-rival inputs and X rival inputs.

$$F(\lambda A, \lambda X) > \lambda F(A,X) \quad (1)$$

We are reading of non-rival knowledge and of A as 'the benefits of research and development'. Are 'knowledge' and 'the benefits of R & D' synonymous expressions? Either way, are there cardinal measures of these magnitudes? The 'existing stock of knowledge' is an input in the research sector; is the 'stock of knowledge' the same thing as the 'index of the level of technology'? Can a 'stock' be an 'index'? If they are not the same thing, how are they related? In any case, the product of the research sector is designs for new producer durables or, by the next page, 'new designs or knowledge'. Romer produces new terms (for the same thing?) at an impressive rate! At this stage in Romer's analysis A becomes an integer; but he is not really claiming to have produced a cardinal measure of the level of technology/knowledge/designs, of course. The integer nature of A is a mere artifact. Subsequently, in equation:

$$A = H_A \cdot A \quad (2)$$

where HA is human capital in research and A is 'the total stock of designs and knowledge'. This equation is meaningless unless there are cardinal measures for both HA and A. Aghion and Howitt make it perfectly clear that the problem is not a purely empirical or data problem: 'It would be more accurate to say that formal theory is ahead of conceptual clarity. As the English side of the Cambridge capital controversy used to insist, the real question is one of meaning, not measurement. Only when theory produces clear conceptual categories it will be possible to measure them accurately'[2].

These shortcoming of Knowledge's measurement also exist in models such as Young/Peretto/Aghion-Howitt/Dinopoulos-Thompson and all offering for example (non-) constant-returns and variable marginal products with respect to variables one of which – the stock of knowledge – has not been shown to be, and may well not be, cardinally measurable. Such a cavalier approach does the profession little credit, for conceptual confusions cannot yield convincing conclusions[2].

B. Explicit Knowledge versus Tacit Knowledge

But if we look more closely, it's possible to measure entire part of knowledge. To understand why, it is helpful to divide knowledge into two types, codifiable knowledge—that which can be written down—and tacit knowledge—which is learned from experience and can't easily be transmitted from one individual to another. Credit for the distinction between these two types of knowledge is generally given to Michael Polanyi."[7].Codifiable knowledge is blueprints, mathematical formula, operations manuals, and tables of statistics, organization charts and facts.

Tacit knowledge is how to hit a baseball, ride a bicycle or know how to work with a specific group of people on a team. At key part of our knowledge is tacit in the sense that we can figure out whether to safely pass another car on a two-lane road without stopping to solve the system of simultaneous equations needed to prove that a collision will not occur [8].

The distinction between tacit and explicit knowledge has drawn increasing attention among those studying business and the economy. Management experts studying innovation and competitive strategies of Japanese manufacturing firms noted the role of the development of tacit knowledge as a key step in designing new products. One of the keys to successful product development has been encouraging employees to understand and develop their tacit knowledge of particular problems and their solutions (how to knead bread) and then to work to translate and codify this information so that it can be used by the entire organization (to design a bread making machine)[9].

Tacit knowledge is clearly different. Because it is embedded in the minds of individuals and the routines of organizations, it doesn't move easily from place to place and create more difficulty in its measuring methods.

The distinction between codifiable and tacit knowledge helps explain why technology doesn't completely erase the importance of proximity in transmitting ideas. Simply having access to codifiable information doesn't mean you have knowledge. A formula specifying the solution to Fermat's last theorem—a centuries-old mathematical puzzle—would be information, but it wouldn't be knowledge unless you were one of the few hundred mathematicians who possessed the tacit knowledge to understand it [8]. With respect to Dosi

puzzle, quantity of knowledge is ambiguous.

Empirical data also support the notion that evaluating of knowledge creation tends to be under real value. As a result of the interdependence between codifiable and tacit knowledge, even explicit innovations like those covered in patents don't flow freely from one nation to another. Frequently, in order to take full measurement of the insights provided in a patented (codified) invention, one needs also to have the complementary tacit knowledge to apply it to a particular product or process [10].

C. Abrupt steps in New Growth Theory Leads to an Approximate of Real

The conventional view of economics, crystallized by Alfred Marshall in the late 19th century was of the economy as a well-balanced system, always tending toward equilibrium. All of the forces acting on the economy generated signals or reactions that tended, over time, to push the economy toward an optimal state. A shortage of some particular good or service was associated with a rise in its price, which in turn called forth additional resources to produce it, ultimately triggering a greater supply and a reduction in its price. The view of economic change afforded by this model of the economy is one of smooth and continuous adjustment.

This view was challenged by Joseph Schumpeter, who argued that economic change was almost exactly the opposite: abrupt and discontinuous, rather than smooth and orderly. Schumpeter proposed that the search for higher than normal profits (quasi-rents, in economic jargon) led individuals and firms to innovate, to seek unique new practices and technologies. New products, almost by definition, give the businesses producing them a monopoly, if only a temporary one and enable firms to earn higher profits until their product is successfully imitated by a competitor or displaced from the market by yet another new product. New businesses, with new ideas, changing the definition of markets, not simply lowering the price of some commodity, are the driving force behind change.

New Growth Theory leads us first to think differently about the role of history in shaping economic growth. The increasing returns associated with knowledge produce "path dependence": future options are constrained by past actions. New Growth Theory is also broadly consistent with an evolutionary view of how the economy changes. This evolution, moreover, happens not smoothly but in abrupt steps, as new ideas and new businesses replace old ones in a process of creative destruction. In other words, abrupt process can lead to some disability of measurement tools[3].

In the view of the evolutionary economists, change isn't the smooth and continuous adjustment at the margin, but is rather the abrupt and often uneven displacement of the one technology by another. Economic growth is a dis-equilibrium process, and as the competitive environment changes, development and improvement of new techniques and changes in markets cause some firms to grow and others to shrink. Economies move ahead by successively generating new experiments and trials. A critical policy implication of this work is that encouraging experimentation and learning is essential to economic progress. A corollary is that a diversity of firms and institutions helps encourage and sustain experimentation [11].

Such evolutionary theory is closely related to path dependence. As Arthur points out, the nonlinear qualities of increasing returns models of the economy have distinct parallels to the evolutionary theory of punctuated equilibrium (Arthur 1989). Because development is path dependent and the future cannot be predicted with any precision, business managers will have to emphasize adaptive behavior rather than optimization [12].Consequently with absence of equilibrium point and abrupt steps in new growth theory, Role knowledge evaluation is an approximate of real.

IV. Institutional Framework and New Definition of Knowledge

The most important job for economic policy is to create an institutional environment that supports technological change Portland [13].

Are governments obstacles to economic growth or instigators of growth? Is the government that best befits the economy one that gradually withers away, or a strong one? Much economic theory gives the impression that governments are needed only when markets won't work, to address market failures, or provide public goods like national defense, and to achieve purely social aims, like taking care of the poor and elderly. Governments that do more than the minimum, the conventional wisdom goes, sap the economy of its strength. New Growth Theory gives us a new view of the role of institutions in creating the necessary conditions for growth in an economy driven by new knowledge [3].

What are institutions and why should they matter? If we think of the economy as a game, institutions are the rules of the game and the processes by which rules are determined and enforced. Formal rules, like constitutions, statutes and regulations, and governmental bodies, like courts and legislators, are institutions. So too, are informal rules that shape and limit transactions, like common business practices, cultural attitudes and values, and reputation, and the social constructs that guide and enable interpersonal and business relations.

History influences the pace and trajectory of knowledge creation. But knowledge creation is not purely the product of market forces. Non-market forces, particularly institutions can also influence what kinds of knowledge are created. A number of economists have begun to consider the role that different institutional arrangements play in economic development. Then by considering numbers of institution which are engaged in growth process and their effectiveness coefficient, knowledge measuring will be more realistic[3].

Ignorance of dynamic adjustment and institutions in new growth theory leads definition of knowledge to an ambiguous environment. Institutions shape the creation of knowledge and adaptive efficiency indicates that changes of new knowledge take place over time.

A. Creation of New Knowledge and Institution

The cumulative learning of societies, reflected in culture and the shared mental models of how the world works, guide people's interpretations of economic and political problems and opportunities. Beliefs about the value of new knowledge, risk taking, and the trust in social institutions influence the rate and type of economic growth in a society. The structure of incentives in society is shaped by institutions, which means that ultimately the effectiveness of markets is dependent on collective, political processes. Markets alone cannot produce the set of conditions needed for the efficient function of a market economy [14].

Many important institutional innovations deal with the creation and diffusion of knowledge. Some of these institutions, like patents and copyright law, have relatively long histories. Universal public education is a relatively recent development. So too are public land grant universities, peer-reviewed academic research and public-private research partnerships. As Paul Romer points out, there are many conceivable sets of institutional arrangements that can be developed to encourage the further development and deployment of economically valuable new ideas [1].

Importance of institutional arrangement in economic development leads to importance of institution as a key variable in measuring entire knowledge.

B. Dynamic Adjustment and Institution

The ability of institutions to adapt to the changing economic situation, and to develop new rules and practices to guide transactions shapes the ability of economies to continue to progress. North argues that it is this adaptive efficiency, the ability of economies and institutions to change over time to respond to successive new situations—and not static efficiency, the optimization of the allocation of resources at any given time—that is the critical factor shaping economic development. North explains:

> Adaptive efficiency . . . is concerned with the kinds of rules that shape the way an economy evolves through time. It is also concerned with the willingness of a society to acquire knowledge and learning, to induce innovation, to undertake risk and creative activity of all sorts, as well as to resolve problems and bottlenecks of the society through time. We are far from knowing all the aspects of what makes for adaptive efficiency, but clearly the overall institutional structure plays a key role to the degree that the society and the economy will encourage the trials, experiments and innovations that we can characterize as adaptively efficient. The incentives embedded in the institutional framework direct the process of learning by doing and the development of tacit knowledge that will lead individuals in decision-making processes to evolve systems that are different from the ones that they had to begin with [15].

One critical element in adaptive efficiency is the tolerance for new ideas. As Schumpeter observed, change often entails the creative destruction of the existing economic and political order. The willingness of societies to tolerate new ideas that challenge the current arrangements of business and government has varied over time, and still varies considerably among (and within) nations. In a historical sense, the openness of the West to new knowledge in the Renaissance and the Enlightenment produced the new ideas that led to the industrial revolution; the particular institutional arrangements of the United States (the Constitution, the interstate commerce clause) led to the development of a national economy. Similarly, among nations today, the relative openness to new ideas in some nations (Singapore, Taiwan) may have much to do with their recent economic success.

Governments have a crucial role to play in setting up the right structures for economies to evolve over time. Many of the most critical changes will deal with the incentives for knowledge creation. As technologies change and economies grow, our institutions will continue to need to devise new arrangements and solutions for economic problems, from allocating the electromagnetic spectrum to refining the law governing patents [16].

New Growth Theory emphasizes the central role that new ideas play in driving economic progress. The careful study of history and contemporary international comparisons of development highlight the role that new ideas for arranging institutions can play in shaping the direction and pace of economic development. Then institution framework help researcher to measure knowledge's quantity accurately[3].

V. Conclusion

In all too many contributions to New (Endogenous) Growth Theory – though not in all – central reference is made to 'a stock of knowledge', a 'stock of ideas', etc., this variable featuring centre-stage in the analysis. Yet it is immediately apparent that this is far from being a crystal clear concept. Really no amount of 'sophisticated' mathematical analysis can turn conceptual confusions into meaningful conclusions.

The real question is one of meaning, not measurement. Only when theory produces clear conceptual categories will it be possible to measure them accurately. We should now perhaps establish that our critical remarks are not directed to a pure figment of our imagination – and recognize that worries about the measurement of knowledge can indeed be found within the NGT literature. In historical order – which will make it clear that there has not been clear cut progress in conceptual clarity about measuring knowledge!

By contribution of institution framework which is found within NGT, we can indirectly measure the knowledge concept and no more directly possible to measure stock of knowledge. Institution matter because they shape the environment for production and employment of new knowledge.

New Growth Theory emphasizes the central role that new ideas play in driving economic progress. The careful study of history and contemporary international comparisons of development highlight the role that new ideas for arranging institutions can play in shaping the direction and pace of

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