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EDUCATION, COMPETENCE DEVELOPMENT AND ECONOMIC GROWTH: A micro explanation to macro economic growth

by

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EDUCATION, COMPETENCE DEVELOPMENT AND ECONOMIC GROWTH - A MICRO EXPLANATION TO MACRO ECONOMIC GROWTH

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In this paper I define education broadly and indirectly as the investment activity that produces the kind of competence capital that contributes to economic growth, as measured. Hence, this essay is partly a study of proper economic measurement. I am concerned both with the particular educational activity that occurs in educational institutions, separated from the job context, and learning in a broader sense, on-the-job or in the context of the job. I ask:

1) Why is *education* in a narrow and a broad sense important for economic growth?

2) What do we know about the quantitative relationships involved, and the incentives that promote competence development?
3) What can governments do? Are there well defined parameters? What knowledge is required to achieve political ambitions?

With the growth objective in focus the knowledge capital that drives economic growth will necessarily be broadly defind. This is one important point. Above all we cannot restrict ourselves to competence embodied in individuals. Competence embodied in teams, in the organization of firms, of markets and the entire economic system will have to be accounted for. Here the micro-to - macro model of IUI will be a useful intellectual tool.

Once the incentive problem is allowed in, and the imperfections of markets for competence accepted, the analysis is taken down to the micro level. The argument will be that the dynamics of agent behavior and markets matter for macro. More specifically, the benefit of efficient markets will be the capacity of the economic system to take decisions down to locations where the appropriate competence resides.

Hence, the problem addressed in this paper includes three tasks. *First*, identify the educational factor that contributes to economic growth, *second* learn how the markets for education should be organized for incentives to develop competence to be strong, *third*, once this has been done, study how educational production can be efficiently organized? This paper is mainly concerned with the first task.[1]

One "magic" variable will run through the entire analysis; the rate of return to invested capital over the interest rate, the temporary monopoly rent that the firm captures. I will call it $\hat{\varepsilon}$, and define it exactly in section 4. This variable is an important incentive variable in the capital market. Firms strive to keep it high. The expected $\overline{\varepsilon}$ drives investment behavior in the firms of the Swedish micro macro model. The present value of future expected such rents of the firm is evaluated all the time in the stock market. In finance theory this rent is labelled the risk premium. Most important of all, as I will demonstrate in the concluding section, there is a direct relationsship between the measured change in this competence rent and the rate of total factor productivity change, or the shifting of the macro production function. With the help of this magic variable we will be able to tie the growth, the incentive and the educational problems together.

1. Growth explanation or accounting?

The importance of knowledge for the economic wealth of a nation has been discussed in literature for centuries. To connect education with growth, and to define the content of knowledge contributing to growth - which is the main purpose of this paper - we need theory. It is convenient to keep four different theoretical approaches apart.

a) Pre-quantitative times.
b) Neoclassical analyses.
c) The "new" growth theory.
d) Micro based macro analyses

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[1] In a parallel paper, prepared for the OECD: *The Markets for Educational Services* the whole range of questions are surveyed and studied.

a) Early thinking about education - pre quantitative times

Most early treatises in economics recognized the importance of knowledge, competence and skills. Such recognition was not so demanding in times when quantification was not required for "proper" analysis. In fact, already in 1768[2] - before *The Wealth of Nations* - the Swedish economist Johan Westerman was very clear about the importance of skills and knowledge for the international competitiveness of Swedish production. He traveled to England and to Holland to learn about superior production techniques, and he observed that labor productivity in the British shipyards was twice that in the Swedish shipyards. He concluded (already in 1768!!!) that the new machines were good to have, but what really mattered was the know-how to use them, and about how to organize work around them.

Awareness of the nature and importance of education and of production organization was by no means as explicit among the academic economists of these days, but it was there at least until John Stuart Mill (1848). But then it mysteriously disappeared, a disappearence in literature for about 100 years (Abramowitz 1988).

The reason should be sought in the nature of this particular capital item. It is not only difficult to measure, but also difficult to represent analytically in the kind of mathematical models that began to appear with the marginalist revolution. Knowledge is vested in human beings and acquired through the educational process (broadly defined). It applies very flexibly, and differently, depending upon use. It cannot be analytically disentangled from its carrier, and it doesn't depreciate from use as ordinary capital.[3] The easiest way was

[2] Westerman, J. 1768, *Svenska Näringarnes Undervigt emot de Utländske, förmedelst en trögare Arbetsdrift*, Stockholm.

[3] Literature, until now, does not recognize depreciation of knowledge capital (see e.g. von Weizsäcker 1986 and Romer 1986).

to disregard it. Heterogeneity is the frustration of capital theory. The most heterogeneous capital item one can think of is knowledge (Ysander 1978b).

b) Neoclassical analysis

Neoclassical analysis is a natural extension of classical Ricardian analysis of the late 19th century. In the immediate postwar period it took on a very concrete shape, as more and more statistical data were brought together. Input output analysis picked up the notion of a macro production function, which was ultimately refined by Solow and his followers.

As macroeconomic development of the postwar Western economies surpassed past benchmarks, the profession began to worry whether they had gotten their numbers properly organized. Above all, the Ricardian-Marxian notion of a production system fed with machines and manual labor hours, and possibly land, was not sufficient to explain observed, rapid productivity growth. Many researchers (Denison 1967, Jorgensen-Griliches 1967 etc.) began to look for *quality* dimensions of factor inputs, that could explain measured productivity growth. They all, however, more or less stayed within the equilibrium framework of neoclassical economics, and notably Jorgensen-Griliches (1967), who designed a sophisticated method of correcting factor inputs one by one for quality change, using the implicit price structure of an equilibrium system. In doing so they more or less removed the residual, unexplained technical or productivity factor. This, however, has to be the result by virtue of the method used. It can be demonstrated (see Eliasson 1987, 1990c, and below) that unaccounted for factor inputs, or factor inputs not paid the equilibrium price, will nevertheless contribute the market value to production, and hence, instead contribute a residual value to the owner of capital. Since this residual profit has been created by factor inputs not measured, or measured, but not properly paid, it will exhibit itself as an unexplained residual growth factor in macro production function analysis. If you correct factor inputs for errors of measurement in price statistics, you remove the corresponding unexplained production factor by definition. Jorgensen (1984) and Jorgensen-Fraumeni (1989, 1990), and others have used that method recently to demonstrate the importance of education in macroeconomic growth. In doing this they find that education matters economically very much, since pay differences, whether being the result of education, original underlying talent or some market imperfection, explain a large part of total factor productivity growth.

As a consequence they also find that the decline in relative compensation for education since the middle of the 70s, and the strong increase in relative compensation for education thereafter (Blackburn-Bloom-Freeman 1990), also explain a large part of (or much of) the disappearance in the 70s, and "the return" in the 80s of total factor productivity growth. The method guarantees such results, and even though they are plausible, they have to be more carefully studied before any firm conclusions on educational policy can be drawn.

It is important to keep in mind that if Jorgensen's method was applied to Swedish data, with more compressed wage differences than in the US, and longer lasting, large divergencies between marginal productivity and compensation, because of Swedish distributional policies, the result technically will be that slow production growth, if it correlates well with the so corrected factor inputs, can be explained in terms of these corrections, i.e., by the equalitarian wage policies pursued in Sweden. Also this is a very plausible explanation, but much more analysis than such correlations is required for policy advice. To this I return in the micro section below.

The macro production function approach establishes one-to-one links between labor qualities and the corresponding output. It, however, misses important characteristics associated with imperfect markets and changes in the organization of production within firms, and in markets. Such organization embodies technology of various kinds within firms and in the organization of the institutions of markets, notably contract technology, (see Eliasson 1992b). Changes in such technology normally violate standard aggregation assumptions of macro production function analysis. If the contribution of organizational change to economic growth is disregarded, too much weight will be given to individual factor quality change and education. Hence such change has to be made explicit. Thus, it becomes natural to discuss what changes in *industrial structure* mean for the demand for particular labor qualities. It also becomes natural to discuss what more education at different levels will mean for output growth. As I will argue later this is, however, the wrong way to ask the question. A recent "puzzle" has been the increased demand for highly educated labor in the US (Blackburn-Bloom-Freeman 1990, Kosters 1990 and Bishop-Carter 1990) being accompanied by a matching increase in the return to education. On this, Berndt-Morrison-Rosenblum (1992) find that these increases are related to growth in highly technical (office and information technology) capital. There is, however, no reported positive relationsship between growth in such competence or in highly educated labor on the one hand, and labor productivity on the other. The problem is to capture the nature of technology change and the interaction of supply and demand of human capital. As we will see such answers require that we step down to the micro level. First, however, a few additional variations on the macro theme.

c) The "new" growth theory

The so called "new" growth theory originated in Lucas (1988) and Romer (1986). It has generated a cascade of variations on the theme. The reason for its popularity probably is its close mathematical connections with the above standard neoclassical production theory. The mathematics is the same, and some members of the old neoclassical school, like Dale Jorgensen, would argue that the "new" is no more than a modification of the "old" macroeconomic growth theory.

The idea is simple. Romer (1986) introduces an "infrastructure" knowledge competence as an externality in his model economy. This knowledge factor confers scale economies to all other factors of production. Since Romer's model is essentially the old static general equilibrium model his problem is to obtain an internal solution, despite the existence of increasing returns. His trick is to assume strongly diminishing returns to knowledge accumulation ("education"). The only difference between Romer's model and the classical (or neoclassical) model, hence, is that he has shifted the exogenous productivity or trend assumption of macro production function analysis backward in the investment production chain, *from* the exogenous total factor productivity assumption *to* the productivity assumption associated with the educational process that shifts the production function. The new growth theory also makes it more natural to introduce all kinds of externalities in the analysis of productivity advance, notably know-how created in other sectors. Thus, for instance, Government sponsored education, health care and insurance carry spill over effects to private firms.

Suppose, following Romer (1986, p. 1015) and Eliasson (1989), that the production function

$$Q = F(k_i, K, x_i) \tag{1}$$

is concave as a function of measured factor inputs k_i and x_i for any fixed value of K. K is the *level of general knowledge* which improves the productivity of all other factors. K is a capital good with an increasing marginal product. As long as there are diminishing returns in the activities that create K, the static general equilibrium model will have a finite solution.

I will now translate Romer's model for the general equilibrium setting of an entire economy to a firm model.

Let me assume that measured factor inputs are:

k_1 = Machinery and equipment capital

k_2 = Product-oriented R&D capital

k_3 = Marketing capital

x_i = Labor input, standard hours, allocated to the various capital items,

$i = 1, 2, 3$

K is the general, unmeasured knowledge base *of the firm* that is accumulated as part of the ongoing production process. In so far as some "tacit knowledge" has been compensated in the form of wages to other factors X_i, the K incorporates the general organizing knowledge needed to organize all other factors into a team, a firm (Eliasson 1990b). K has thereby been defined as the recipient of residual profits when all other factors have been paid. This is a capital input traditionally associated with the risk taking of owners, but it can as well be associated with all knowledge (competence) inputs of the owners (Eliasson 1988b). In so far as top-level managers hold stock in the company, they get paid two ways for their competence input; in the form of salaries and in the form of dividends and capital gains on company stock, if their competence contributions generate excess profits.

The main point here is that the competence capital K generates increasing returns to all other factors of production of the company, but that it is a scarce resource whose production occurs at diminishing returns. The K factor input is assumed not to depreciate from use, as do other factor inputs.

It now only remains to show that K in fact has the "scale" or "leverage" properties we have postulated. To do that - following Romer (1986) - assume F() to be homogeneous of degree one as a function of (k_i, x_i) when K is constant. This is an insignificant further restriction. Given that, for any $ø > 1$.

$$Q = F(øk_i, øK, øx_i) > F(øk_i, K, øx_i) = ø\, F().$$

F now exhibits increasing returns to scale in K. In the growth process of the firm, K is the know-how created, say from organizational learning that can be exploited by increasing the size of the firm.

The proof I have given has been in terms of the traditional, static production function. We can then use the term economies of scale, although economies of scope may be more appropriate. However, even this term is not the right one, since we are talking about an *organizational learning process* that creates tacit competence embodied in the organization and its people.

If both traditional economies of scale and unspecified embodied knowledge accumulation are present, the two cannot be econometrically separated. And if the tacit knowledge capital - whatever it is - is perfectly correlated with "scale", a prior scale formulation will reinterpret improvements in organizational competence as originating because of scale and vice versa. The acquisitions of Zanussi (Italy) and White Consolidated Industries (U.S.) by Swedish Electrolux provide a good illustration. Obviously the acquisitions enlarged the scale of Electrolux in physical terms. There should be mechanical scale benefits to exploit. However, the success of Electrolux over the years has to do with more than that in the sense that top management in other firms doing exactly the same thing would not necessarily have created the same successful results, because they lacked the particular experience the Electrolux management team had obtained over the years. Even though one can give several examples of pure, physical economies of scale with economic implications (e.g. the natural laws controlling electricity transmission, see Smith 1966), the notion of scale becomes the wrong concept if the exploitation of economies of scale requires technology, i.e., knowledge. The question, then, is how to represent the dominant competence input in the production process mathematically. The above production function representation, borrowed from Romer (1986), is a step in the right direction, but it does not take us out of the static neoclassical world, since it does not explain the accumulation of the competence. This has to be done simultaneously with the explanation of production, if competence, or knowledge capital, is "tacit" and "learned" through participation in production. Then dynamics is created in the form of a "path-dependent" economic process to which we now turn.

2 Micro based growth Analysis

There are two problems to deal with. Neoclassical, or the "new" growth theory are no theories of growth. They describe measured economic growth, but the growth engine is essentially exogenous. In particular, they don't capture the importance for macro of agent behavior in dynamic, "imperfect", markets, and of organizational change within firms and between firms. And these factors matter significantly.

Second, knowledge and competence are human embodied "factors" that occur as micro phenomena. To understand them, one has to begin with the behavior of micro agents. Once we have accepted economic growth as the policy objective, and defined the circumstances of the production system that contribute positively to growth, we can derive certain tangible (definable) characteristics of the competence capital that we want to increase. This is necessary to say something on the organization of educational production. To identify the knowledge factor behind microeconomic growth at the macro level it is necessary to begin with each of the three different agents involved;

- the *firm,* the employer
- the *individual,* the employee (incentives)
- the *policy maker* (macro and distribution)

Each of these agents operate in an economic environment called:
- the *market*

It is obvious from this presentation that the ways micro behavior is combined (aggregated) to macro behavior matter for economic growth. The way individual behavior results in macro economic output then depends upon how individuals team up in firms, how competition in markets affects firms and how rules imposed by the policy maker affect competition. Hence, there are two aggregation problems to recognize; *within* the hierarchies of the firm and *through* markets.

Since competence and knowledge are inherently heterogeneous (this proposition will be elaborated in the next section) and since knowledge can confer strong economies of scale (here I buy the idea of the "new" growth theory) it matters very much for growth whether knowledge is efficiently allocated. The combined proposition of this paper (to be stated already here, see also Eliasson 1992) is that macro economic growth critically depends on *the capacity of the economic system to take decisions down to the levels where the appropriate competence resides*. This means that relevant growth theory *has* to be micro (firm, individual) based and that the competence or knowledge endowment of a nation includes the particular organizational knowledge that makes this allocation possible.

The firm, employer

To identify the nature of the competence capital at work in a business firm the firm has to be characterized in terms of its market environments. As will become clear from what I say, the mainstream economic model will take us along the wrong track, since it does not allow for the relevant characteristics of the firm.

The business firm organizes people with competence to satisfy financial (profit) targets. This involves recruiting people, coordinating people and upgrading their competence. This process is controlled by a top level *organizational competence* [vested with the top competent team, (Eliasson 1990b)] that also has to learn to make superior organizational decisions.

The firm of the mainstream model makes no mistakes. All *information* is available (in principle, at a cost) for the market or the auctioneer to arrange an equilibrium, full information solution. Conditions have to be *assumed* to be such for the aggregation assumptions of the above macro approaches to human capital based growth theory to be upheld. Modern IO theory, allowing for asymmetric and costly information arrives at the same result, provided the market is free from various kinds of selection problems, notably the lemons problem (Akerlof 1970, Greenwald 1986). I will demonstrate below that these problems are typical of markets, notably the labor market and, hence, necessitate the micro based macro analysis that I attempt here. The lemons problem is also the key troublemaker of the incentive system (see next section).

The individual

The firm looks for competence in the labor market, not for labor hours. The individual supplies the same qualities.

The individual is, however, at a disadvantage. It is risk avert by mental design (and assumption) and it commands no resources, except its talent and knowledge (= competence), that is, however, difficult, perhaps impossible to assess prior to inspection. A certain market or contract technology is needed to establish the trade in human competence that eventually moves economic growth.

There is a market for educational services, for intermediation services, in the labor market (search) and for insurance for the income risks over the individual's life cycle in the labor market. The absence of, or the failure of the market system to create viable such markets, or the political destruction of already functioning such markets through regulation, are sufficient causes for reducing the efficiency of the allocation of competence in the economy, and hence macroeconomic growth.

The market

The nature of the firm or the individual as they appear in economic theory depends on the theory of the markets in which they are supposed to operate.

The classical model offers little help here, since it is totally silent on the dynamics of competition and of firms as well as on the significance of knowledge, except as it appeared in macro production function analysis above.

This is not a particularly promising foundation for an inquiry into the nature of the knowledge base that contributes to economic growth. For this we need an alternative to the classical model, a model of dynamic markets which never clear, but are characterized by an evolutionary ongoing economic process, moved by ex ante unpredictable entrepreneurical initiatives, some generating success stories but also a steady flow of mistaken decisions. I have called this the *experimentally organized economy*[4] (1987, 1988a, 1991c), since this economy thrives on a certain amount of local uncertainty caused by individual agent behavior, and looses performance from the imposition of too much order.

Hence, the experimentally organized economy does not only allocate given resources on given uses. It is also – and more importantly – part of the creation (entry) and the allocation of new resources, and of forcing obsolete resources to move, or to exit. In the labor market such innovative activity takes on particular forms since it concerns human beings that are both creative and capable of upgrading and changing their ability characteristics. Education and experience accumulation in a broad sense is part of this selection and allocation process. Economics and pedagogics have been caught, over a couple of decades, in a long winding controversy over the relative importance (for economic growth and individual proficiency) of this selection, on the one hand and educational investment on the other. The classical economic model which reallocates given resources to given and known uses

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[4] For a presentation of the distinguishing characteristics of the EOE see Eliasson (1987, 1988a, b, 1990b, 1991c). It is obtained by a seemingly innocent modification of the assumptions of the classical, static equilibrium model, forcing bounded rationality on the agents of the economy, namely a sufficient expansion of the state space (called the opportunity set) of the economy and a provision for free innovative entry. All conclusions in favor of a centrally planned order have been achieved by assuming a sufficiently small or transparent (at no cost) state space in models with no entry.

is, by its very assumptions limited to the analysis of the educational investment decision (human capital theory), disregarding more or less the selection effects. Its representatives tend to push this particular view hard as an empirical phenomenon, by assumption. It is obvious that the theory of the experimentally organized economy allows a much broader view of the educational process, allowing explicitly for both the educational investment process and selection phenomena. In fact, studies on the Swedish micro-to-macro model – an approximation of the experimentally organized economy (Eliasson 1990c, 1991b, c) – suggest that the selection component of total factor productivity growth may be the by far most important one (Eliasson 1991a, Carlsson 1991).

The ability of the individuals of the economy to cope with the unexpected change of the selection dominated experimentally organized economy constitutes part of the human capital of the economy. As will become apparent as I go on this ability depends on the capacity of the economic system to provide adequate *insurance* (see further Eliasson 1992) in an economy where risk avert individuals are subjected to rather rough treatment as a consequence of business mistakes being in turn a normal cost of economic growth.

3. Organizational learning and Competition drive economic growth

Once we have left the accounting framework of macro theory and taken the growth explanation down to the level where agents operate in dynamic markets organizational learning, knowledge and technological competition become the mechanisms behind a viable growth explanation.

The limits to learning

New competence can be acquired through internal education, or in the market through recruitment and through the acquisition of competent firms or parts of firms (Eliasson 1991d). At some rate such acquisition of new competence is perfectly reliable, but the economic value of the competence is reduced to the extent that competitors acquire the same or better competence faster. If, on the other hand, the firm tries to acquire competence very rapidly it normally incurs a higher cost in the form of a higher rate of business failure. When seen at the aggregate level of a sector or the entire industry, business mistakes constitute a standard cost of economic development. The more rapid (everything else the same) competence accumulation of a firm, a group of firms or a whole industry, the larger the incidence of failure, but also the larger the probability of a major business success. Since the economic value of acquired know-how depends on what other competitor firms do, *strongly diminishing returns to learning* or the acquisition of knowledge should be exhibited because of the rapidly increasing rate of business failure (Eliasson 1990c). This means that no individual firm will be able to raise K in (1) through allocating all its resources on learning and thus, forever outcompete its competitors through the consequent gains in economies of scale. The same results should hold for a country.

The strongly increasing rate of failure, the faster the ex ante rate of learning has to do with the inability of a decentralized economy to cope with massive innovative behavior that disrupts the stability and coordinating capacity of its price system.[5]

[5] It should be noted for the record that this does not mean that a hierarchical order (central planning) will do it better. Under the relevant conditions of the experimentally organized economy, the necessary condition for transparency (perfect information) are not upheld.

The content of economically valuable knowledge

Apparently, the content of economically valuable knowledge is a quite complex blend, that has to be defined at different levels of aggregation: It is multidimensional beyond emprehension from one point of assesment and only parts of it are applied on each occasion. Individuals also embody human capital of different quality. Firms organize individuals into competent teams, contributing through their organizational technology something in addition to the component indivudal qualities. The economy as a whole merges - through its organization (the economic system) - individuals and firms to generate economic values (output). The number of possible combinations, if we start from the level of the individual and move up, is enormous and beyond everybodys understanding. This is the "basic fact" of the experimentally organized economy. Each "merge" has been achieved through experimentation in markets and hierarchies, not through careful analysis and explicit decision. The key to macro economic performance, hence, is to organize the economy such that the mass of heterogenous human and firm based competence residing in an industrial economy is optimally exploited. This, first of all, means organizing the economy such that decisions are taken down to levels where the appropriate competence resides, i.e. in general at the level of firms and individuals, and away from central hierarchies.

But this is only part of the organizational, "tacit" knowledge capital of a national economy. The enormous complexity of this organization means that there exists no simple optimal point. There are several "high levels" and even though the economy may be temporarily close to one optimum, nobody in the system will be aware of it. The economy, hence, is constantly in a flux, being moved by agents striving to reach better positions, pushing other agents out of their established positions (Eliasson 1991c).

The ability of the agents to compete successfully through innovation is in principle a "learning" phenomenon, as is the ability of agents to cope with unexpected change.

The continuing flux of the competitive market process also means that the exact nature of firm or individual competence required for success, will also constantly change. There is no stable specification of the characteristics of the optimal knowledge at each allocation (organization). Since requisite knowledge is not a well defined item that can be replaced, when needed, knowledge capital, as all other capital has to be depreciated, and increased through new investment (education).

The complex nature of such knowledge makes it more or less unmeasurable, except indirectly in terms of the present value of future expected returns of firms as assessed in the stock market, or directly in terms of the cumulated value of investments in "education" of a firm or an individual. The reader should take note of a particular distinction here. Human, capital theory assumes the existence of stable earnings functions, implying the existence of perfect markets, being perfect in terms of their capacity to perfectly evaluate the human capital embodied in an individual. Such measures will always be biased by the imperfections of the labor market.

At the same time the standard method in capital theory is to accumulate investments in machines, buildings and inventories, assuming a certain depreciation rate, thus obtaining a measure of capital stock. Even though I say that competence capital, due to its complex and varying specification, is not directly measurable, what I propose to do is to apply the standard capital measurement method in economics to measure competence. The only distinction to add, however, is that it may be possible to measure certain simple capital items, like machines directly through explicit specification of performance characteristics, which is done in engineering contexts, but rarely in economics.

The firm of my market reference model, *the experimentally organized economy* (see Eliasson 1991c) makes plenty of mistakes, because of the general non-transparency of its local market environment and the unpredictability of the responses of its competitors. The firms are, however, supposed to be capable of coping with such a competitive market environment, or go bancrupt and exit, even though firms frequently try to protect themselves from market competition, thus creating market imperfections. Hence, unique, but transient knowledge and the competence to identify and correct decision errors early dominate firm success (Eliasson 1990b). *Individuals,* on the other hand, being assumed to be normally risk averse, cannot be expected to be able to cope with their experimentally organized market environment alone, and, hence, have to be treated specially.

Since the unique knowledge base of the firm is constantly exposed to competitive peril threatening the firm with sudden obsolescence, coping with change, forgetting and organizational learning are key critical competence characteristics that also dominate firms' recruiting.

The recruitment problem of the firm is, hence, schizophrenic. At each point in time the firm needs a particular package of competence characteristics. But firm management does not know, and will not be able to predict with any accuracy the nature of that package. It will have to develop the required characteristics through experimentation, and suffer from repeated failure along the way.

This means that a firm will be as concerned with getting rid of people with the wrong competence, as it is with acquiring people with the right competence (in expectation) provided internal retraining programs, that are also profitable, cannot be organized.

This behavior on the part of the firm also determines the local environment of its employees. Employees, typically characterized as being *risk averse* do not like this environment. As a consequence, labor directly, and indirectly through unions or through the political process has exercised a demand on the firm for *insurance* for the vagaries of market life.

Even though knowledge capital cannot be directly measured and its content still remains more or less a mystery, we can say that besides *education* broadly defined, individuals as well as firms require the *additional ability to cope with unexpected change*. This is partly a capacity acquired through experience in the market. For individuals this means that a *functioning labor market* is part of their educational experience. It also requires that appropriate and efficient *insurance* markets exist to make individuals overcome their innate risk aversion that is otherwise detrimental to their human capital accumulation.

Technical change creates more competition

At this junction we may make a choice. We can tell a (1) *neoclassical* story about exogenous technical change, which will be partly untrue and misleading and (2) we can do micro-macro analysis and also explain technical change. I will do both, and begin with the micro-macro analysis and then simplify it in the next section through imposing some strong aggregation assumptions, such that the outcome looks very neoclassical and devoid of the important and interesting economic knowledge content.

The micro-macro analysis will be done verbally in terms of what may be called a Salter curve analysis.

In this section the magic variable $\overline{\varepsilon}$ will be defined. Its presence in my story - besides being a useful tool to derive neoclassical macro analysis as a distilled version of dynamic micro-macro analysis - becomes a natural part of a nice chronology of economic doctrines.

Since the marginalist revolution diminishing returns have been needed to secure internal solutions in economic models. But diminishing returns have constantly failed to show up in empirical studies, which has been a source of constant concern. Knight (1944) suggested that observed increasing returns must be the result of an unmeasured knowledge input.

McKenzie (1959) came back to the same problem, observing that measured factor payments constantly failed to exhaust total production value. This difference, again, when divided through by employed capital, constitutes - as we shall see - the epsilon value. And McKenzie suggested that this difference must be the return of (the rents from) some unmeasured knowledge capital that can be associated with individuals or firms.

At the micro level such rents are both positive and negative signifying business sucess or failure. Hence, in the computable risk environment of modern finance theory the epsilon constitutes a risk premium only, since finance theory, being shaped in the classical model without selection does not recognize the presence of unmeasured competence capital (Eliasson 1988b).

In the experimentaly organized economy of our analysis, uncertainty, as distinct from risks prevails (Eliasson 1990b). Already Knight (1921) suggested that the competence to convert uncertainty into ex ante computable risks constituted the rational foundation of a firm. So the two devices come together naturally in a world where both uncertainty and risks prevail, and then allow an empirically better founded explanation than that of finance theory alone.

The story can therefore be nicely concluded if the competence rent, that I have called ê, can be demonstrated to be related to the shift factor in production function analysis.

With competence being the ultimate, dominant capital input of a firm, its incentive system has to be organized such that returns to the competence to coordinate inputs to the benefit of the owners of the firm are satisfactory. At the firm level, however, such competence has to be much more broadly defined than technological competence. It resides in the people of the organization and how they have learned to work together in teams. And the top competent team of the firm is instrumental in achieving this coordination through integrating the three dimensions. Exploiting market imperfections is an important business activity and eliminating the results of such imperfections from productivity measurements may be directly misleading. Competence is, however, human or team embodied and not subject to the same contractual property rights as physical goods. It is acquired through experimental learning in the market. It is not easily tradable and difficult to learn or imitate by outsiders, if they lack the requisite receiver competence. Failures are, hence, frequent, both when learning is through imitation and when innovative and bold. It follows that "lost competence" or "obsolescent" competence can rarely be replaced by crash learning or innovation programs, especially on a broad industry-wide basis. Strongly diminishing returns to learning rapidly set in, due to frequent failures.

The dynamic competition story on the allocation of educational knowledge services can be nicely expressed in terms of so-called Salter distributions of epsila ($=\hat{\varepsilon}$), or the rents from competence (See Figure 1). I will discuss this market in terms of competing firms but it is equally valid for competition among individuals in the labor market.

Competition creates technical change

Firms in Figure 1 are lined up from the left in terms of their ability to generate rents or a return above the market interest rate ($=\hat{\varepsilon}$). The size of the rent is measured vertically and the size of the firm (its capital in per cent of total capital of all firms) is measured horisontally. There is a layer of ex ante such distributions at each moment of time, depicting the ex ante perceived rents of all existing firms, of all firms including entering firms and excluding exiting firms, and (very important) the corresponding expected distributions as anticipated by each firm. All these distributions change as decisions taken are ultimately realized ex post, reflecting over time the dynamics of competition in financial markets, being driven by the organizational competence of firms.

Let me briefly go through the dynamics of competition in the capital market as it occurs in the Swedish micro-to-macro model (Eliasson 1991c). Each firm in the model is represented in each market by a ranking on the vertical axis or the epsilon distribution, the width of the column measuring the size of the firm in percent of all other firms. (Fig. 1 shows that even though the firm indicated has increased its rate of return between 1982 and 1992 it has lost in ranking).

Each firm also has its own potential productivity frontier, under which it is operating to position itself on the productivity and rate of return rankings. This is still actual ex post performance. The dynamics of markets on the other hand is controlled by a second set of *potential ex ante* distributions, that capture the planned actions of all other firms, including new entry.

There is a third set of Salter curves that tell how *each firm sees itself positioned relative to other firms*. The real world of the experimentally organized economy, and its model approximation, the Swedish micro-to-macro model both show large *divergencies between actual and perceived positions*. Those ex ante distributions indicate the potential for a given firm to outbid all other firms in wages, or in paying a higher interest rate.

The firm learns directly if competitors can do better. Management then knows that it had better improve in order not to be pushed down along the Salter distribution, and, perhaps, out. Similarly, when the firm finds itself close to the top, it knows that close competitors are taking actions to better their positions through innovation or imitation. If potential Salter distributions are sufficiently steep in the top left-hand group, firms attempt to improve their positions on the Salter curve through innovative activity, or through entry. No firm is ever safe under these market circumstances, and constantly has to take action to better its position. This moves the entire economy through a selfperpetuated, growth creating, competitive process. The other side of this growth process that concerns us, is the steady change in the environment of the employees, as each firm tries to outcompete its competitors. Large opportunities are created for everyone capable of capturing them. In doing so they push their competitors down and right on the curve. During the 60-s and part of the 70-s it was thought that better planning would replace this experimentally organized competitive process, and measures were taken that slowed down the process, lowered competitiveness of firms and slowed down economic growth, eventually causing even more hardship on the people. Currently economic political sentiment seems to be moving in the contrary direction, as more and more sectors are deregulated, and even the most hard core of all protected production, the public sector is gradually opened up to competition. My a priori position (also expressed in an earlier book, Eliasson 1992) is that the preferred policy is to make people accept and learn to cope with the volatile environment of the experimentally organized economy. This is essentially an argument for improved insurance in the labor market. In this insurance education plays a fundamental role.

The story will therefore be nicely concluded if the competence rent, that I have called $\hat{\varepsilon}$, can be demonstrated to be related to the shift factor in production function analysis.

4. Connecting Organizational Competence back to Competition and Economic Growth

Competence coordination and monitoring is a matter of managing people with competence. It involves not only incentives to contribute but also to stay with the team. In this section I link the "unmeasurable knowledge" or innovative competence function to firm objectives (profits) and the creation of economic value over and above the value of resources put in (total factor productivity growth = DTFP)[6]. I will do this mathematically in terms of the information and monitoring system of a firm as it appears in the Swedish Micro-to-Macro

[6] The mathematical derivation has been taken directly from Eliasson (1990c).

(M-M) model. The task is to establish a relation between the competence rents (= $\overline{\varepsilon}$), firm total productivity change (DTFP) and growth in output (DQ).

In doing so I cut right through the dynamics of competition discussed in the previous section. I thus exclude the endogenous growth drive of the macro economy by assuming perfect competition and making ex ante equal to ex post. In doing so I remove the explanation to economic growth and take the model back to the neoclassical accounting format.

Let me assume for simplicity that the only measured inputs needed to produce output (Q) are labor (= L) and capital (= K). DX stands for the rate of change in X.

Define:

$$\varepsilon = PQ - TC \tag{2}$$

$$\bar{\varepsilon} = \varepsilon/K \tag{3}$$

$$TC = wL + (r + \rho - \frac{\Delta p^K}{p^K})K \tag{4}$$

$$R^{NE} = R^N + (R^N - r)\phi \tag{5}$$

$$R^N = M\alpha - \rho + \frac{\Delta p^K}{p^K} \tag{6}$$

$$M = 1 - \frac{w}{p}\frac{1}{\beta} \tag{7}$$

It follows immediately that:

$$\bar{\varepsilon} = R^N - r \tag{8}$$

$$pQ = TC + \bar{\varepsilon}K \tag{9}$$

R^N = nominal rate of return to total assets K

R^{NE} = nominal rate of return to net worth (E=K-D)

ρ = rate of depreciation

M = operating surplus per unit value

D = nominal debt

w = cost per unit of labor input (=L)

r = interest rate

p^K = capital goods deflator

p = value added (=Q) deflator

Φ = D/E

α = pQ/K (capital productivity, uncorrected for relative (p,p^K) price change

β = Q/L (labor productivity)

$\bar{\varepsilon}$ is the difference between the rate of return on total assets (R^N) and the interest rate (r) paid by the firm. $\bar{\varepsilon}$ can be positive or negative. But a firm will not survive for ever with a negative $\bar{\varepsilon}$. Compare (2) and (7) and you will see that $(r+\bar{\varepsilon})$ is the equilibrium price for capital services that exhausts total value (=pQ) product when $R^N=r$ and $\bar{\varepsilon}=0$.

$\bar{\varepsilon}>0$ arises - as suggested by McKenzie (1959) - as a consequence of unmeasured (or not measurable) capital, not included in K. This asset has a time dimension in the sense that returns may come with a delay. Even if $\bar{\varepsilon}$ is negative the corresponding asset, hence, might very well have a large positive present value. Part of this time dimension can be interpreted as a risk factor that demands a reward (a risk premium).

To explain growth, however, you have to explain the way $\hat{\varepsilon}$ arise (innovation) and are competed away. This is done in the micro based macro model or in the theory of the experimentally organized economy. In neoclassical macro growth analysis aggregate $\hat{\varepsilon}$ are assumed or measured, but not explained. To the extent one $\bar{\varepsilon}$ measures value created by a not measured capital input in a firm it must have something to do with economic growth. I therefore prove (see appendix) the following relationship:

$$DQ = s_1DL + s_2D\bar{K} + \frac{\Delta\varepsilon}{pQ} \tag{10}$$

s_1 and s_2 in (10) measures labor and capital income shares respectively. Apparently $\Delta\varepsilon=0$ when these shares exhaust total value added.

A whole lot of technologies are compatible with constant income shares s_1 and s_2, the most well-known being the power function (so-called Cobb-Douglas) specification.

After differentiation the entire class of functions:

$$Q = CL^{s1}K^{s2}T \qquad (11)$$

becomes (10), where T is a shift factor, usually assumed to represent exogenous disembodied technical change.

Apparently from (10) and (11) total factor productivity change becomes:

$$DTFP = DT = \Delta\varepsilon/pQ \qquad (12)$$

under the assumption of Cobb-Douglas technology. This is enough for my purpose. I have demonstrated - for one particular production technology - that the estimated (on specification (10)) shift factor (DTFP) picks up a host of economic influences related to the allocation of resources and the exercising of competence within the firm. As a consequence the return to that unmeasured capital - that I have labeled $\overline{\varepsilon}$ - also shows up in the "technical shift factor". This competence input - by definition - also includes the ability to deal with uncertainty (successfully taking on business risks). Hence, the interpretation of $\overline{\varepsilon}$ in the modern theory of finance becomes part of this more general formulation.

The technology factor, however, also picks up the contribution of the entrepreneur, or trader, from exploiting market imperfections, for instance to successfully hire talented people at lower wages or salaries than their marginal productivities. Also capital gains will appear in ε. Since capital gains are also the result of trading in imperfect markets they reflect the competence of the entrepreneur to trade and should not be deflated away in productivity measurements. This competence can be seen to be exercised through the formation of synergistic teams, in which individual contributions are magnified through the exercising of top entrepreneurial competence.

Scale effects originating in the application of top entrepreneurial knowledge by definition make markets imperfect. Whether the firm operates as a

Kirznerian (1973) equilibrator or trader or imitator, making money from moving the economy closer to equilibrium, or as a Schumpeterian entrepreneur, enhancing the productivity of the system through changing its parameters and disturbing the equilibrium, it creates (in both cases) positive value additions to output.

It is not, however, universally accepted to allow such improvements in allocational efficiency to appear as technical change in macro production function analysis, and much work has been devoted to correct price indexes for the effects of such market imperfections. (For a discussion see Dargay 1988 and Färe-Grosskopf 1990, Morrison 1990).

If, for instance, prices used are equilibrium prices - corrected or not - a new competitive situation is reflected in a new set of equilibrium prices, and all quantities adjust to this new price configuration along the production frontiers. This is the method of computable equilibrium modeling. The a priori production technology chosen usually demands a particular price index to leave the shift factor (DTFP) invariant to such adjustments.

The preceding discussion, however, raises a much more profound question. If imperfections in markets are fundamentally due, not to asymmetrically distributed information or slow learning or adjustment behavior, but rather to fundamental inconsistencies in beliefs, competence endowments or the formation of business judgements, actions taken on the basis of such inconsistent opinions will constantly reshape the structures that at each point in time represent the productivity characteristics of the firm or the economic system, that in turn shape future ex ante perceptions of what is to come and so on. The path the economy takes will spin off ex ante/ex post realizations that will be reflected in the shift factor DTFP in (12) since they represent positive or negative value contributions to output.

This paper has been devoted to showing that the use of economic knowledge embodied in the organization of the firm or the economy, notably the organization of human talent, determines the character of the value added contributions that appear as total factor productivity change in macro production function analysis. The ultimate organizational technology of a nation then becomes the art of organizing itself - through experimental learning - such that these value added contributions are steadily positive. Then economic growth occurs. Hence, an analysis of the macroeconomic effects of competence also requires (1) an analysis of the capacity of markets to stimulate (reward) competence development and allocate competence and (2) the capacity of firms and schools to organize learning efficiently.

5. Summing up

I have shown in this paper that the returns to some unmeasured capital input that I call knowledge or competence by definition makes up the excess returns or rents on measured capital in firms, while the change in these excess returns to figures importantly in total factor productivity change in macro production function analysis.

So presented we have no explanation to economic growth, only measurement or growth accounting. Growth theory or a growth explanation demands that the dynamics of rent creation and destruction through competition in markets also be explained at the micro level. In such a model of what I call the experimentally organized economy, the creation of new knowledge (innovation) in firms and the destruction of old knowledge capital through technological competition through the use of such new knowledge become the driving forces behind macro economic growth. I also argue that the competition to create such new knowledge and rents is as much a matter of how people with competence are allocated in the market or team up in firms as it is the result of well defined educational investements in people. Since this allocation is very much a matter of how the institutions of markets for educational services and competence are organized, this organization of markets in turn becomes a major explanation to economic growth.

Appendix: *Proof of (9)*

From (1) and (2);

$$PQ = wL + (r + \rho - \frac{\Delta p^K}{p^K})K + \varepsilon$$

Take differences, assuming (p, w, r, p^K) fixed;

$$P \cdot \Delta Q \equiv w\Delta L + [\ \ ]\, p^K \Delta \bar{K} + \Delta\varepsilon$$

Thus,

$$\frac{\Delta Q}{Q} = DQ \equiv \frac{wL}{pQ} DL + \frac{[\ \ ]\, \Delta p^K \bar{K}}{pQ} \cdot D\bar{K} + \frac{\Delta\varepsilon}{pQ}$$

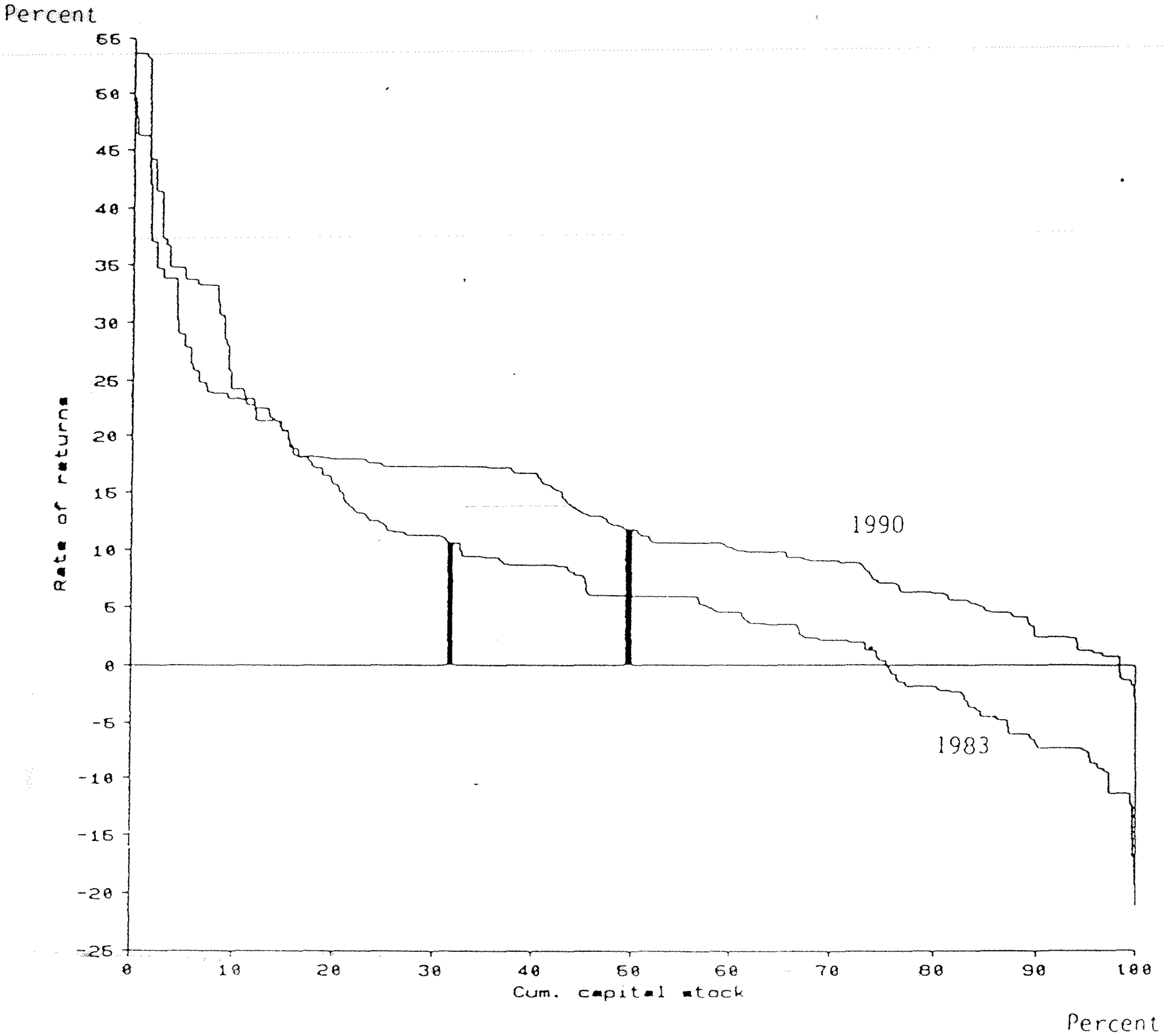
$$DQ = S_1 DL + S_2 D\bar{K} + \frac{\Delta\varepsilon}{pQ}$$

$$S_1 = \frac{wL}{pQ}$$

$$S_2 = \frac{[r + \rho - \frac{\Delta p^K}{pK}]p^K}{pQ}$$

$\frac{\Delta\varepsilon}{PQ}$ is, by definition DTFP. QED.

Figure 1 Epsilon distributions (salter curves)



Excess rates of return ($=\hat{\varepsilon}$) distributions 1983 and 1990.

Source: Eliasson (1991c, p. 164)

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