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LITERATUR – LITERATURE

A Schumpeterian Model of Growth in the World Economy: Some Notes on a New Paradigm in International Economics

By

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The traditional theory of international economics explaining trade by comparative advantage and differences in endowment in the Heckscher-Ohlin approach experienced a major innovation in the seventies when imperfect competition was explicitly introduced into the models of international specialization. Imperfect competition is due to two factors: economies of scale in production and product variety in the preference function of consumers implying heterogeneity of products. Whereas economies of scale allow a reduction of costs at larger production quantities and thus are a driving force for larger firms to develop, product variety and consumer preferences for specific products limit the market niche or the monopolistic or oligopolistic market section of a firm [Helpman and Krugman, 1985]. In such a setting, strategic behavior of firms especially with respect to an early start and market entry plays an important role. If, however, markets are open and contestable, market power of existing firms is checked by new entrants or by substitution with other goods.

Economies of scale or increasing returns can be a factor of economic growth [Romer, 1986]. Opening up an economy to trade allows a widening of the market in the tradition of Adam Smith,[1] the exploitation of economies of scale and a reduction of production costs.

Remark: This note is an outgrowth of a review of Grossman and Helpman [1991 b], promised to this journal. I appreciate comments from Bert Hofman, Karl-Heinz Paqué and Michael Stolpe.

[1] "The increase of demand ... encourages production, and thereby increases the competition of the producers, who, in order to undersell one another, have recourse to new divisions of labour and new improvements of art, which might never otherwise have been thought of." [Smith, 1937, p. 706].

Thus, international trade contributes to economic growth which in a closed economy can be explained in the Solow tradition [1956]. In an open economy, the Solovian growth factors show up in the changes in endowment, such as increases in the labor supply and capital accumulation.[2]

Technological knowledge (if it is immobile) is one of the factors of endowment, and the change in technology can be an important aspect of alterations in the comparative advantage of countries. In the traditional theory of international specialization, technical progress positively affects comparative advantage by making capital or labor (or both) more productive. Endowment then is defined in efficiency units. In these traditional models, technical progress is an exogenous factor. Quite a few attempts were made to explain technological change more explicitly. For instance, Kaldor's [1957] embodiment effect stresses the vintage aspect of capital with the latest vintage incorporating the highest productivity. A similar concept relates to human capital where workers embody different technological levels depending on their age, sectoral experience and education. Experience, such as training on the job, plays a role for labor productivity; experience gained in accumulated production or accumulated investment is also relevant for the productivity of capital (learning by doing) [Arrow, 1962]. Vernon's [1966] product cycle for the first time introduces an endogenous dynamic pattern from the production side where comparative advantage eventually migrates from the innovating country to the imitating country.

I. The Grossman-Helpman Model

Given this state of the literature on international economics, Grossman and Helpman [1991 a] develop a Schumpeterian model of endogenous technological change and economic growth of the world economy.

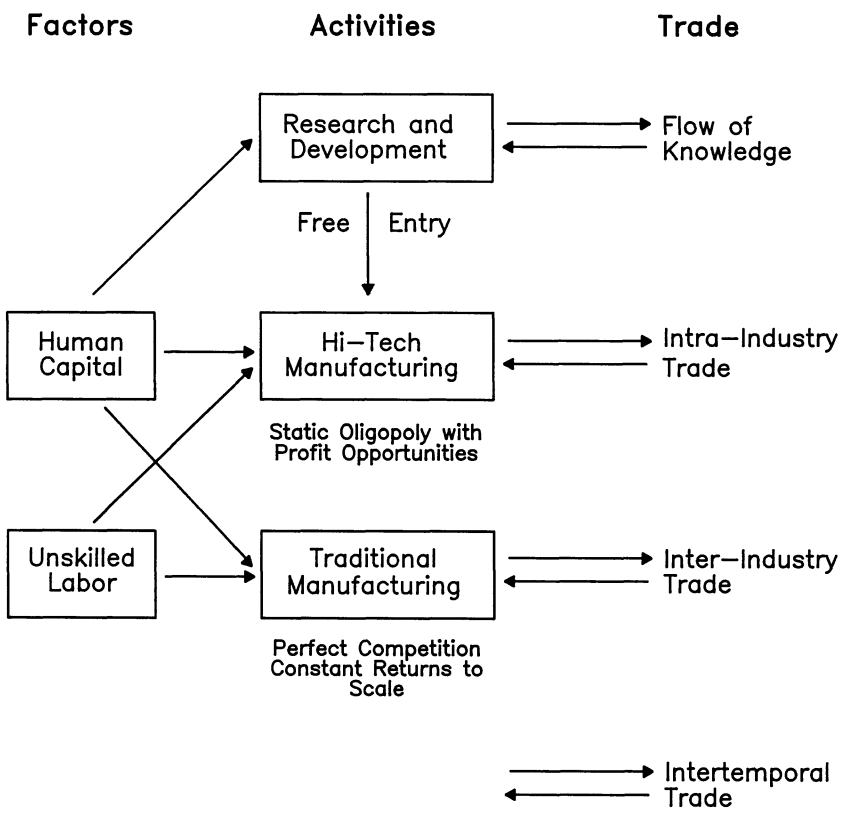
Whereas changes in endowment with the traditional factors of production influence comparative advantage and may increase the gains from trade for a country, there is the property of diminishing returns for the traditional factors in the production function. Contrasting inventions with the cultivation of land, Schumpeter [1942] made the point that the cultivation of land will eventually run into

[2] In addition, the extension of the economic space in the American tradition of the new frontier [Hansen, 1956] is an important aspect of economic growth.

diminishing returns, but that "we cannot reason in this fashion about the future possibilities of technological advance". In a Schumpeterian tradition and in line with Romer [1986], Grossman and Helpman [1991 a] claim that technological progress may not exhibit the property of diminishing returns. Industrial innovation then is the engine of economic growth in the world economy. Innovation itself is the result of agents driven by profits, again a Schumpeterian characteristic. The fascinating property of this approach is that it links trade and economic growth. The structure of the model is explained in Figure 1.

Besides capital, there are two factors of production in the model, namely traditional or unskilled labor and human capital. To what extent a worker has accumulated skills or is unskilled depends among other factors on training on the job or education. There are three activities in which unskilled labor and human skills are used as inputs,

Figure 1 – *Structure of the Grossman-Helpman Model*



however with different intensities: research and development, high-tech manufacturing and traditional manufacturing. Research and development is an input to high-tech manufacturing. In traditional manufacturing, the production process exhibits constant returns to scale and perfect competition prevails. In the high-tech sector, there is a continuum of industries, and each industry is an oligopoly. The market position of each high-tech firm depends on the research and development input. Once the R&D input is determined, the oligopolistic structure in the product market is given. In that sense, the oligopolies are static. Profits in high-tech manufacturing are the targets of the R&D industries. Thus, profit opportunities in the high-tech sector drive the R&D process. In the R&D industry, free entry prevails. R&D is an ordinary economic activity with a "production" technology relating inputs to outputs (see below). Since profits are expected in high-tech manufacturing, one is prepared to incur upfront costs for research and development in order to obtain an attractive market position in the high-tech oligopoly.

There are four forms of exchange with other countries: Inter-industry trade of traditional manufacturing can be explained along the familiar lines of the Heckscher-Ohlin context of comparative advantage and differences in factor endowment and for the case of perfect competition. Intertemporal trade is the analogue for inter-industry trade with respect to time. A country with high savings (or a low time preference rate) will export today and import tomorrow. A country with a high marginal rate of transformation over time can import today and export tomorrow. This links trade to capital flows. Oligopolistic competition in high-tech products explains intra-industry trade. As a fourth mechanism there is the international flow of technical knowledge.

There are two approaches to model the high-tech sector: In the variety model of the Dixit-Stiglitz type, innovation expands the set of available goods thus allowing more variety by adding additional products and increasing the choice to the consumers who like variety. Producers may like variety as well. The product set is enlarged horizontally by adding products of a different variety. In this case, the output of the R&D process is the design of a new, differentiated product, i.e., a blueprint for new products (variety approach). In the quality improvement model, products vertically move up a quality ladder with each level on the ladder representing a higher quality. In this case, the output of the R&D industry is the entrepreneur's instantaneous probability of achieving a research breakthrough, i.e., the

next generation of products. These different formulations of the high-tech sector are used to model endogenous technical change.

In a dynamic general equilibrium model with firms maximizing profits and households maximizing utility the equilibria are determined. Agents have rational expectations. In Bertrand price competition of a static oligopoly with constant returns to scale market entry is determined endogenously. There is always the potential threat that a newcomer will enter the market if a price higher than the limit price is established.

There are some interesting results in the Grossman-Helpman model. Thus, the variety model in static oligopoly for the high tech sector yields mark-up pricing for a CES utility function with constant elasticities of demand. In the quality improvement model with perfect substitutes, there is a limit-pricing equilibrium. The variety model yields the well-known condition

$$\pi/v + \dot{v}/v = r\,,$$

i.e., the dividend rate (profits π over capital value v) and capital gains ($\dot{v}/v$) as a yield on physical capital must be equal to the interest rate.

II. Non-Rivalry of Knowledge Capital

Following a concept similar to Romer [1986], innovation has a by-product in raising the stock of knowledge capital. Knowledge capital is a public good, i.e., it is non-rivalrous [Romer, 1990] and only imperfectly excludable so that innovations of a specific firm have a positive externality. Depending on the type of externality, innovation becomes a driving force for growth, and R&D expenditures of the individual firms contribute to general knowledge and to the benefit of society as a whole.

In the Grossman-Helpman model, knowledge capital is an input in the production function of R&D. In the models with product innovation, i.e., enlarging the product set, research not only produces a patentable blueprint or design for its perpetrator but also increases the stock of knowledge of the economy, and this stock of knowledge is non-appropriable. Knowledge capital is a public input. In the models with quality upgrading, it is assumed that research activities can enter the race for the next generation technology even from scratch. This is equivalent to assuming ubiquity of blueprint knowledge of the current generation.

An alternative approach is to collapse the R&D sector with the high-tech sector and to model the production function as a linear homogeneous production function with respect to the traditional inputs and include knowledge capital K as a general input besides physical capital k [Romer, 1986; Helpman, 1988]. Note that the nonrivalry of K implies that the production function does not exhibit constant returns with respect to all factors. Setting the current value of a unit of capital equal to 1, asset market equilibrium requires that the present value of marginal return (left-hand side of equation 1) is equal to the current value of capital, i.e.,

$$\int_t^\infty e^{-[R(\tau) - R(t)]} f_k[k(\tau), K(\tau)]\, d\tau = 1. \tag{1}$$

The asset pricing equation yields [3]

$$r(t) = f_k[k(t), K(t)], \tag{2}$$

requiring that the real interest rate is equal to the marginal productivity of capital.

The marginal productivity of capital now not only depends on the capital stock, but on knowledge capital stock K. Thus, investment (or innovation) of a firm is considered to contribute to knowledge capital. For blueprints, this link between innovation and knowledge capital depends on the patent system as a specific property right; for human capital, it also depends on the extent to which qualified labor is industry-specific or not.

III. Implications for International Specialization

For the international division of labor, the Grossman-Helpman model suggests that a country richly endowed with human capital will specialize in research and development. Having a comparative advantage in the production of an input for high-tech products, the country will ultimately export high-tech products which is consistent with the Heckscher-Ohlin approach (only explicitly considering R&D as an intermediate input). Countries endowed with unskilled labor will specialize in the production of traditional goods. Thus, the initial endowment determines the specialization among high-tech and traditional products.

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[3] Assuming $R(t) = r(t)$.

If a country is ahead in a high-tech product and if there is no important international spillover in knowledge capital, the country has an advantage in the next period. Thus, there is the advantage of an early start. This also holds for firms. It pays for the firm to be established early in the market and by being there to make it harder for a newcomer to enter.

One way to look at the world is to view the North as the center of innovation with a competitive race between Japan, North America and Europe and interpret the South as imitating products that eventually are substituted by a better quality product produced in the North. With the diffusion of knowledge capital, endowment with unskilled labor becomes more relevant as a cost factor and comparative advantage with respect to specific products migrates to the South.

IV. Growth and Spatial Structure

If the international spillover is negligible and if innovation and the accumulation of physical capital only contribute to national knowledge capital, a country may become a growth pole in the sense of Perroux [1961]; other countries may lag behind. Such a specialization between countries may become persistent and spatial hysteresis may result. Thus, equation (2) may explain economic geography [Krugman, 1991]. The immobile knowledge capital represents a factor of crystallization attracting the mobile factor [Siebert, 1969]. This approach can be extended to vicious circles and circular causation [Myrdal, 1971]. The approach can also incorporate a system of rings around an agglomeration in the von-Thünen tradition; the system of rings changes in a Schumpeterian process of population growth, technical change and capital accumulation [Giersch, 1983].

Historically, however, we have also examples that countries do not get locked into a favorable or an unfavorable position. One aspect is that endowments are not necessarily static but change over time such as the capital stock through savings and investment, human skills through education, environmental scarcity through improved abatement technology and technical knowledge through innovation. Thus, a latecomer has a chance to catch up, for instance by specializing on a more modern product relative to its rival. Germany in the 19th century relative to Britain, Japan after 1945 and some of the Pacific Rim countries in the last twenty years are cases in point.

The optimality condition in equation (2) can be interpreted in different ways. Let k be the capital stock of a country and K the

knowledge capital of the world. Then national economies of scale have a positive externality for the world, i.e., the knowledge capital of the world is interpreted as having a positive effect on national output [Ethier, 1988]. This hinges on the diffusion of technical knowledge. This approach may not only be interpreted from the point of view of a production function (for instance through learning by doing) but the approach may also include the size of the market. Then the size of the world market, symbolized by K, influences production costs. For instance, an intra-firm division of labor may be organized worldwide and a specific national industry may have an advantage by being established internationally. Or a national firm may benefit from knowledge capital being available on a worldwide scale. This effect of K on the national productivity of capital captures some of Adam Smith's aspects of the dynamic gains from trade.

Equation (2) may also be interpreted for a specific national firm with a firm-specific capital stock k and a capital stock K of the national industry. Then, the production function of the firm exhibits constant returns to scale, but the capital stock of the industry generates positive externalities (for other firms). This interpretation may also be applied in a regional context. This implies increasing returns at the industry level. An agglomeration of firms in a region may establish a market of qualified labor thus enhancing the production possibilities of individual firms. Workers receiving training by one firm may be hired by other firms, so that there is a pool of qualified labor. For the individual worker a region becomes attractive if he can cover some of his employment risks by the option of working for another firm in the same region without migrating. Examples are the Swiss watch industry in the Swiss Jura and precision engineering in Baden-Württemberg. Once specific qualifications are available in a region, the human capital can give birth to new industries.

In this context, the distinction between mobile and immobile Schumpeter industries is interesting [Klodt, 1991]. The Schumpeter industry is generally characterized as a high-skill industry. In the mobile Schumpeter industry, R&D can be separated from production. Examples are the electronic and computer industry where research is the human-skill-intensive activity which can be undertaken without a feedback from production. In the immobile Schumpeter industry, R&D interacts with production, especially because learning by doing in production occurs having a feedback on R&D. Production of airplanes is a case in point.

V. The Empirical Evidence

To what extent the paradigm of endogenous technical change is supported by the empirical facts, is an important issue. Here are some of the stylized facts:

(i) In contrast to declining per capita growth rates in an economy with capital accumulation (due to declining productivities with a larger capital stock, i.e., moving down the marginal productivity schedule), Grossman and Helpman [1991b, p. 1] claim that "growth in per capita income has been sustained at positive and apparently non-declining rates in many countries for prolonged periods of time". Looking at growth since 1700, Romer [1986, p. 1012] concludes that "growth rates appear to be increasing not only as a function of calendar time but also as a function of the level of development". For the United States, the growth rate of real per capita GDP has increased from 0.58 in 1800–1840 to 2.47 in 1960–1978 [Romer, 1986, Table 2]. This points to some endogenous vitality in the long-run growth process.[4]

(ii) Open economies have a better growth performance than closed economies. Outward-oriented countries have done better in terms of growth than countries with a focus on import substitution. The Latin American experience based on the Prebisch paradigm [1959] of import substitution and protecting infant export industries is ample proof of the proposition when compared to the experience of the South-East Asian countries. Openness ensures competition, and competition reduces costs and induces to find new technical knowledge.

(iii) Growth rates vary considerably across countries in a given time period. Over a long time period, different countries have taken the leading position in the growth process [Maddison, 1983]. This points to the fact that economic growth may slow down in a country. It is open to what extent resource constraints, for instance resource availability and environmental constraints in the seventies and eighties, take their effect. At least, a high growth rate today is not a guarantee for a high growth rate tomorrow. In this context, it seems to be an open question to what extent countries with a lower income level catch up with the leading country.

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[4] It is an open question to what extent the productivity malaise in the seventies and eighties is an exception.

(iv) In order to show the empirical validity of the Grossman-Helpman approach one would have to establish a clear relationship between technical change and output growth which requires to clearly isolate the inputs and the output in the production of new technology (and human capital).

VI. Policy Implications

What are the policy implications of this new line of research? An important implication is that openness matters. In addition to the traditional argument that international trade creates benefits by reducing the opportunity costs of obtaining a good, the world provides a larger market, and a larger market reduces costs through economies of scale. Moreover, the intensity of competition will be increased in a larger market. The contestability in high-tech manufacturing may take the form of competition in the R&D industry.

Should a country undertake strategic trade policy [Brander and Spencer, 1985] in order to have the benefit of an early start and to position its industry? The problem with this policy of rent creation by export subsidies is that strategic trade policy is sector specific. This also holds for industrial targeting by sector specific stimulation of the technical process where the government must pick the winner ex ante. The government, however, does not have sufficient information on the future state of the world; thus, strategic trade policy rules out the exploratory power of competition [Hayek, 1968]. In addition, it can be expected that the potential gains from rent creation, if they can be established in a robust way [Siebert, 1988], will be eaten up by inefficiencies of government intervention.

A more fruitful policy conclusion is to stimulate the conditions for inventions and innovations as well as human capital formation more generally. This can be achieved by allowing write-offs for R&D in a general way that is not industry specific, stimulating basic research and building up an efficient educational system, including vocational training.

Improving the general conditions for innovation and human capital formation is in line with the paradigm of locational or institutional competition [Siebert, 1991]. According to this concept, some factors of endowment influencing trade and growth are given; others can be influenced by policy and represent acquired comparative advantage. Thus, a country may influence its state of technology or its capital

stock in the long run. One specific aspect of locational competition is that immobile factors of endowment define locational advantage and thus determine to what extent mobile factors can be attracted to a country. An important policy instrument is the provision of public goods; then the issue arises how national public goods can be integrated into the economic theory of international trade [Clarida and Findlay, 1991]. The provision of public goods is not the whole story because public goods have to be financed, for instance by taxation. Thus, institutional competition relates to a broad spectrum of problems including environmental policy as well as the financing of public goods through user charges or the private provision of supposedly public goods.

Another policy issue that arises from the new line of research in international economics is how property rights for knowledge capital must be defined so that an optimal process of endogenous technical change is stimulated. Whereas human capital is embodied in people, knowledge on new processes and design is, in principle, ubiquitous. Property rights for knowledge capital must provide enough incentives to stimulate research and development as well as innovation; but at the same time product markets should be kept open so that newcomers can enter. The correct incentive may be found in a temporary patent granting a monopoly position; the openness of markets can be established by discontinuing the patent and making the knowledge generally available after the patent period.

An institutional arrangement of intellectual property can be considered as a specific aspect of competition policy aiming at keeping competition alive and markets open. This poses an unresolved question with firms operating in the world market and competition policy being undertaken by national governments or regional integrations such as the EC.

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