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Jaroslav Jirásek

Studies in cooperative ventures disclosed a particular frequency of research and manufacturing alliances in the "high" segment of contemporary technologies.

It is in this setting where inter-firm efforts flourish, such as joint perfectioning of design and methods, mutual assistance in the development of competitive advantages, horizontal collaborative schemes (e.g., interfirm networking, satellite relationship), unification of technical concepts, standards or certificates, computer integrated interfirm information and logistics, and final producer's and subcontractor's endeavor in continuous business improvement.

Cooperative models in high technology manufacturing challenge the theoretical orthodoxy. Many empirical findings do not correspond with established theories. Conventional conclusions appear ambiguous.

Attempts have therefore been undertaken to explain the proliferation of cooperative interfirm behavior on a new theoretical basis.

1 Preludes to High Technology

The advent of a new core technologies has been signalled by a remarkable shift from the dependence on material inputs in the past to "low mass and energy" processes since the second half of 1970s.

1.1 "Capital saving" technologies

It was the first oil shock (1972) that triggered profound changes in industrial technology.[1] An unprecedented breed of technologies proliferated, reducing the input per unit of fuel, raw materials and produces that became scarce and expensive.

Subsequent changes in the logic of industrial production growth could not be interpreted without alterations within the comforting orthodox body of theoretical knowledge.

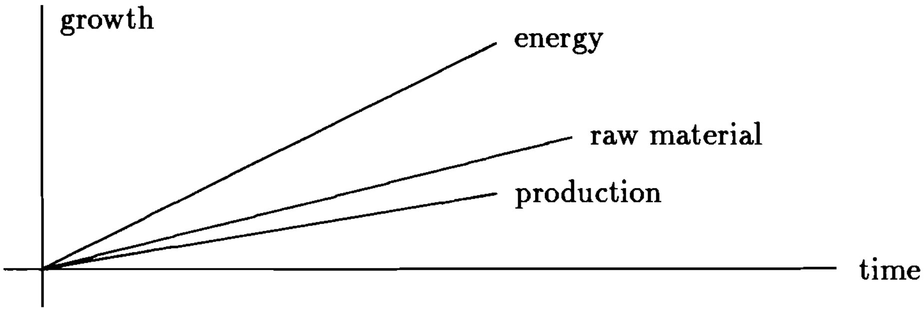
Empirical data supported the challenging conclusions facing the industrial economic theory. During the decade 1975–1985, they were particularly responsible for advanced industrialism. They prompted a search for alternative technologies and economic structures and displayed a staggering transformation of the industrial growth pattern: they

[1] Led by the OPEC crude price boom, other countries supplying primary commodities (most of them still developing) acceded to the price alliance. Between 1974 and 1979 world exports rose in volume and price: for crude oil, 128% and 211%; for aluminum, 111% and 207%; for copper, 118% and 206%, for cotton, 116% and 138%; and for coffee, 112% and 281%. Source: M. Radetzki, *A Guide to Primary Commodities in the World Economy, Appendix*, Oxford, 1990. B. Blackwell, Comparisons for Later Years, forthcoming.

achieved an increase of the industrial output at 140% while maintaining fuel, power, and raw material input at 104%.[2]

It may be questioned inasmuch this change has been brought about by genuine capital savings (e.g., adaptation to increased expenditures of industrial inputs by reducing the consumption of its material components), or by a redirected and augmented capital utilization (through technical perfection, enhanced quality, better market placement, and price increase).[3] In the end, as a number of scholars put it, industry adjusted to higher raw material and energy cost as it had several decades ago (after the extensive mechanization) absorbed higher wages.

Prior to the reversal of the input-output mechanism, it has been assumed that the growth of power and raw material input was to antecede and overtake the growth of production output.[4]



The very malleability of technology engendered a range of alternative technical, organizational and structural possibilities. A profusion of research and experimentations divulged non-conventional comparative advantages and opened an unconventional framework of national and global competitiveness. A new kind of comparative advantage arose: a dominance of permanent change, and a more structural and functional advantage than simple and temporal cost-benefit competitive edge.

As a result, not only adjustment to changed conditions of fuel, power, raw material and supply, as well as a more powerful leverage of economic growth, grew to a topical issue of theoretical thought. The revitalized industrial practice required new explanatory ideas that were not conceived in the past.

In the aftermath of this industrial transformation, the conventional explanations were subsequently downplayed as empirical findings appeared differing from the model which rendered the current models invalid. For the first time after decades, theory ceased to elucidate the course of industrial development. Conservative formulations, though convenient in use, precluded it from assimilating with the changed pattern of industrial growth.

[2]OECD Yearbooks, 1980, 1988, Paris. Data based on constant US$.

[3]Both contributions in diverse proportions may be traced back to the industrial development after the 1970s. While savings prevailed in earlier period, later, on the contrary, offensive marketing associated with product/service improvements gained momentum. Let us once again compare selected primary growth between 1977 and 1987 in physical and price volume: for crude oil, 70% and 101%; for copper, 118% and 106%; for cotton, 13% and 141%; and for coffee, 152% and 80%. And from 1980 to 1987: for crude oil, 76% and 46%, for aluminum, 143% and 150%; for copper, 113% and 62%; for cotton, 108% and 100%; and for coffee, 119% and 80%. In all these comparisons, a volatile character of world prices is to be taken into consideration. Per year figures may oscillate along a sliding average.

[4]In centrally planned economies developed along the Marxist thought, the priority of heavy industry was an imperative "iron law" of economic development. Key emphasis was placed to overtake steel production and power infrastructure, both in terms of time and volume, which affected decisively the program of industrialization and loaded it with excessive capital investments with a slow pay-back cycle.

1.2 From capital saving to "capital displacement"

Technologies developed in order to surmount the material input stress in industrial production passed on to a new class of technologies. The gradual reduction of "mass and energy" component reached a rather qualified number of industries a break-even point after which the capital saving turned around to capital displacement.[5]

Several empirical studies support the findings of the conversion of capital from the sole driving force of economic growth to an intermediating and catalyst factor of economic growth. Studies of microelectronics and associated technical breakthroughs proved that industrial growth was accomplished with decreased capital investment.[6] Another source of cognitive knowledge which could be brought to attention was the study of the "Silicon Valley" phenomenon[7] which dispelled the conceivement that remarkable growth capital instillment or territorial "genius loci" were solely expedient. However, many studied crucial relations and zones of capital conversion.[8]

As the more advanced industrial processes were absorbing sophistication, capital saving mode was turning into a capital displacing mode of production. It started with less capital units of input for more product units of output, and proceeded down to a retreat of capital from production process.

Labor displacement had been the subject of multiple studies since the Industrial Revolution. In the succeeding 100 years[9], labor productivity increased approximately five

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[5]There was no notice of such a contingency in previous theories except a brief prediction by K. Marx in the first part of the 3rd volume of his Capital (Chapter Savings Due to Inventions). At a mature stage, industry could proceed from the capital dependent mode of production to another one, less dependent down to an (almost) independent driven instead by technologically (productively) applied knowledge. This speculation was revitalized by a variety of contemporary scholars. Some of them went so far as suggesting alternation for capital, in most cases as "knowledge" or in a similar (but broader) grasp as "human capital".

Some scholars who recommended studies of "technological accumulation" and tried to prove it superior to theories of capital accumulation, referred to K. Marx as the first protagonist of this theoretical setting. Source: J., Cantwell, 1989, *Technological Innovation and Multinational Corporations*, B. Blackwell, Oxford, p. 7–8.

[6]The remarkable impact of microelectronics stemmed from the contradictory development of its basic active parts. For instance, in the case of the chip in 10 years, technical capacity (number of transistor units per chip) was augmented more than 100,000 times, while the cost of a transistor unit declined 1,000 times. Now, another order of magnitude has been achieved both in technical capacities as in cost reduction.

[7]This is understood as a set of diverse studies of technology clusters, inter-firm linkages, spatial organization, etc. One of the newest and well-informed papers asserts: "Technological innovation is increasingly a product of social innovation ..." which amounts to "new logics of production organization" not based on capital strength only but "upon divergent organizational forms of collective knowledge appropriation". Source: R. Gordon, 1989, *Production Systems, Industrial Networks and Regions*, Silicon Valley Research Group (together with Groupe de Recherche Européen sur le Milieux Innovateurs, Paris), Associazzone Italiana di Scienzie Regionali, Rome, p. 26.

[8]Unique so far is an empirically grounded (for the period 1960–1975 in the US industry) and theoretically generalized study on capital conversion from Czechoslovakia (J. Jirasek, 1979, *Uvolňování kapitálu* (Capital Displacement), Institute for Philosophy of the Czechoslovak Academy of Sciences, Prague). In a congenial way, however, without giving the finishing touch, approach studies of the Institute for Global Economy and International Relations of the Academy of Sciences of the USSR, on the current change of the capital-proneness of industrial production. For instance, A.P. Mileykovski *et al.*, 1975, *Ekonomicheskiy rost v usloviyakh monopolisticheskogo kapitalizma* (Economic Growth in Monopoly Capitalism), Nauka, Moscow. Strangely, as far as we know, there is still no corresponding Western study.

[9]Most scholars and experts did not come over the capital saving concept. For instance the last estimates of the US Congressional Budget Office (CBO) for the economic development in the 1970s and 1980s extrapolated into the 1990's forecast state: "Technological progress can improve the quality of capital goods and thereby increase labor productivity, even when the quantity of capital is unchanged"

times, an industrial wonder that was never repeated since. But the retreating variable capital was substituted by increased fixed capital.

After 200 years, fixed capital began to be complemented and substituted by ("capitalized") scientific and engineering knowledge, industrial culture, inter-business synergy, etc. That tendency could not be taken in absolute terms, but as a contemporary tendency which may stretch over many decades (and probably hundreds of years) of ongoing industrial development.

Capital proves an exciting propensity to self-sustained growth. Anything in his range grows, attains augmented quantitative as well as qualitative scope, and enters an amplifying and expanding reproduction process. However, several other phenomena dispose of similar reproductive "elan vital"; for instance, science and in wider understanding knowledge is increasingly self-productive. In a still wider concept, it is spiritual culture which also incessantly grows and ramificates. Among the last breakthroughs information (as substrate of informatics) could be introduced under this common term.

These changes have been recurring on an expanding basis. They were more localized or regionalized in the past, however at present, their dimensions are increasingly global. They are nurtured from multieconomic and multicultural sources and can be presented in complex combinations. Another border has been passed in the conquest of the "round globe".

Far from being obvious, this drift to capital displacement entails some principal economic deliberations. If proven by further studies, this designates capital's gradual retreat from its position and role in the production process. Capital will no longer be sufficient, in combination with labor, to assure growth. Other production factors come to the fore as indispensable ingredients, such as science, knowledge and skills, design culture, clients enlightenment, etc., in a very direct way.

Systems science in the economic sphere should pay more attention to the contingent interdependence and creative combinations of such authoritative contemporary factors, such as human, scientific (knowledge), environment, and international factors. Fostered by technological advancement, economics is compelled to close relations with sociology, cultural studies, ecology, politology, and other segments of knowledge.

Signals, that capital, moving free in the market, no more adequately serves some societal needs, come from some other spheres of societal activities. For instance, attempts to establish a "self-service society", proclaimed by a number of scholars, prove how several societal needs lay off the capital and market interests.[10]

Economic growth can be no more explained through simple association of capital with labor. In the 1960s, the theory of growth was already induced to appropriate a "residual factor" responsible for a growth pace beyond the direct contribution of capital and labor. Later, this factor was deciphered as a set of specific factors, such as enterpreneurship, management, applied science, social organization, etc.

2 Critical Issues of Theoretical Thought

Conventional theories ceased to explain the logic of industrial process mainly because they were stuck exclusively or predominantly to "linear and algorithmic reduction".

(Economic Impact, USIA, Washington, DC, 1990/2, p. 56).

[10]Examples: old, disabled and chronically ill people attendance; children from divorced marriages care, education and entertainment (substituting the missing parent); local environment care; inter-family cooperation; combined transport in personal cars, etc. (A. Matzner, 1983, *Gesellschaftliche Selbstbedienung*, Frankfurt, a.M., Econ.).

The thrust of their approach to reality highlighted simplified quantitative concepts of relations and linkages within a materialist and formalist descriptions of structures, input-output flows, product cycle consecutive stages, intra-firm organizations, etc.

The post-war theories of industrial modernization mostly interpreted industrial progress in terms of technological determinism involving changes in the technical division of labor and structure of industrial institutions.

It was broadly subsumed that technological change would dominate in a socioeconomic environment with cross-cultural, cross-national, and social convergence to egalitarity. Therefore microeconomic studies could have been scattered into individual cases of firms or branches (sectors) of industry and treated as goals for local optimization.

In the pre-war and post-war studies emphasis was focused on large oligopolies, in particular, on multinational corporations (MNC). They proved to be a highly performative formation in the era of "big science". J. Galbraith, the "father of corporate economics" welcomed MNCs as the most appropriate form of technology promotion. Market can be to a large extent substituted by studies undertaken by the MNC "techno-structure" and internalized in the large firms.[11]

In the post-war period, small and medium-size business proliferated. After J.K. Schumacher published his "small is beautiful", microeconomics turned more to the issues of non-corporate business. In that segment of business, most new innovations were found, highest contribution to job formation, considerable flexibility and customizing ability.

In a variety of studies small was opposed to big. In the 1960s and 1970s, dichotomies of business promotion were contrasted as small size versus big size, "fordistic" versus flexible mode of production, "mechanofacture" versus "systemofacture", economy of scale versus economy of scope, product standardization versus product diversification, "vertical organization" versus "horizontal organization", localization (or regionalization) versus globalization, etc. Strange enough, theoretical conclusions suggested opposite options as equal.

Microeconomic theory, faced with unprecedented phenomena of high technology, tried to explain continuously the changed industrial pattern recurring to the conventional quantitative approach, algorithmic simplification, and linear dichotomy of recommendations.

Technological determinism, as verified in the past, suggested to treat the ongoing changes as functions of technical shifts in production, as gradual development stages of the same production process and looking for the formulation of the handy comparative advantage.

Many new terms were introduced which assisted in understanding the change, however most not sufficiently explained. The volatility of terms dwindled between empirical findings, ideal models or claimed normatives.

Sometimes, but not rarely, theories were focused on one kind of factors, leaving unconcerned others (or "ceteris paribus"). The conclusions were offered that other participating factors and socioeconomic environment be reconsidered (relying upon the decision maker's individual knowledge, experience, intention or fantasy).

The dualism in explaining high technology's business effects was vigorously questioned in many newer works. For instance, a variety of studies suggested that in the haydays of fordism, small and medium-size business not only preserved its role, but reached higher levels. Now that small and medium-size business is praised, many facts support the finding that the role of MNCs and other big oligopolies do not diminish and have been amplified in several industries.

[11] Three years ago, when lecturing in Prague, J. Galbraith admitted that he had not rightly judged the risk of bureaucratization which later became true.

The first to propose this duality was J.R. Schumpeter in the 1930s and 1940s. Both big monopolies, and small and medium-size firms may assure their prosperity in the area of technology advancement. Older theories isolated crucial components from their complex fabric socioeconomic relations, and tried to work out simple formulas for action. They progressively became alienated from the realities of modern industrial life.

Their cognitive structure precluded their association with fundamental transformation of industrial development, such as innovative strive and continuous improvement as well as low predictability of economic, social and environmental, and regional or global mutations.

Newer theories try to overcome the overlapping dichotomy and unify the opposite roles of small and big into a more general concept. They study the interdependence of both and disclose their generic interlinks. Small and big do not exclude each other, and they fill up logical functions. The border between them does not seem as stiff as it was in the past.

Several facts provide evidence how small firms grow or join big ones, and also how big firms disintegrate and found small firms. Hewlett and Packard started as the first "garage enterprise" that became successful. So did Apple and many others. Meanwhile, other small firms surrounded those big producers supplying them specialities.[12] Ten years ago, there was not any single biotechnological firm employing more than 100 engineers and workers. Today, big chemical concerns have established new divisions for biotechnology and harvested its benefit on a large scale.[13]

Production firms, marketing networks, R&D facilities, manufacturing plants, and sales and services form productive systems. The present division of labor within those systems is not dichotomic (either – or), but interdependent, complementary, and associative.

3 High Technology

"High technologies" appeared in early 1980s. Science-based technological breakthroughs reached a remarkable volume and became topic of studies. The title "high" was used already before that for conspicuous, advanced, and expanding novelties.

4 Technical, Organizational and Economic Identification of High Technology

The term "high technology" is frequently used, however, not well defined so far. Most studies identify the gist of high technologies by their above average share of R&D (R&E) cost or of scientist and engineers participating in the production.[14] Some also by the above average pace of development.

Generic links join high technologies to science. They cluster around prominent scientific findings.[15] However, they diffuse by cross-fertilizing processes (burn-in, spin-off,

[12]A taxonomy of frequent forms of cooperation are introduced in the Working Paper Cooperative Business Strategies, IIASA, 1990.

[13]In the 1980s "enterpreneuralism", that is enterprising enclaves inside the corporations or companies were constituted.

[14]As a matter of fact, high technologies are picked up from industrial nomenclatures according to the prevailing character of respective branches. Examples are semi-conductors, computer technology, telecommunication, aircraft and spacecraft, biotechnologies, extreme materials, etc.

[15]The OECD identifies all high technologies into the following sectors: semi-conductors, communication, informatics, biotechnology, new materials.

hybridization, etc.). Indirect application of science accounts for the vast majority of high technology industrial achievements.

Most high technologies appeal to creative thinking, but there are also some dependent on smart shop floor adaptations. Therefore a number of high technologies have found adequate manufacturing conditions in NIC or even in developing countries.

The sophistication of high technologies appeals to the "brain", to research and development or experimentation, engineering culture and commitment, information flow, etc. High technologies unleashed an unprecedented rate of non-market (however, market-bound) forms of interfirms alliances and coordination.

There are several reasons for the amplification of cooperative business. All industrial revolutions reformulate the way to progress. In the last decades the concept of "one best way" was subject to serious criticisms and almost disappeared from the scene.[16]

Another closely related reason consists in overlapping technological competition. Technologies formerly separated became interconnected and developed jointly in diverse mutualities (parallelism, complementarity, intersection, hybridization).

A sizeable segment of high technologies employs the modular (aggregate) principle of design. This is in particular true of semiconducters, programmable automation and robotics, computer and communication technology, and aircraft or spacecraft technology. Modularity renders it possible to combine and assemble autonomous modules (aggregates) which at the same time unbinds the stiff chain of production.

Microeconomics formulated three principal options: either a hierarchial conglomeration, organizational intra-firm reshaping, or inter-firm relations. The latter collaborative models transcend the conventional repertoire of discrete intra-firm closed product cycles or sell-buy market transactions.

After the stagnation of the 1970s, collaborative strategies seemed to be the response to the risk of restrained markets. However, the collaborative option consolidated and the surge continues.[17]

In many cases, the collaborative behavior is the second best (and will tend to reverse to a more conventional option). Still more often it proliferates as the preferred attitude, encompassing not small and medium-size firms but large corporations, too.[18]

5 Socio-cultural and Ecological Identification of High Technologies

It is recommendable to round off the identification of high technologies taking into consideration other than technical parameters. The rapid increase of high technologies is supported by their remarkable social, cultural and environmental impact. High technologies' unique human and ecological potential graduate them to attract a particular concern of scholars, policymakers, and public.

[16]Just an illustration of expanded variety of technical solutions: industrial welding some 40 years ago disposed of some 4–5 basic methods. Now, in the electrical welding only, there are more than 300 varieties of the basic method which were unknown before.

[17]The growth of collaborative arrangements increased in the 1980s in Europe 20 times, between the US and Europe 10 times, Japan and Europe 8 times and the US and Japan 4 times (J. Jirasek, 1990, *Cooperative Business Strategies*, Working Paper, IIASA).

[18]In the present context particularly, neither firms nor industries exist completely as discrete entities exhibiting fixed and definite boundaries and rationally organizing their relations with other firms or sectors on the basis of contractual prices (R. Gordon, op cit., p. 13).

High technologies first of all are turned less to the hands but more to the heads of workers alluring not only trained but educated people. They are apt to surmount the one-sidedness of conventional division of labor and work operations. An inventive and performative personality appears no more like a distant socio-cultural ideal, but more like an indispensable socio-cultural component of the "high manufacturing".

Next to that, high technologies prove to be more environment friendly and less nature depleting than the conservative industrial technologies. They can operate in the zone of "low mass and energy" and "low waste" production,[19] better utilize the substrate of fuels, power and raw materials, appropriate natural stuff and procedures, etc. Many high technologies are already designed with the target to alleviate waste deployment and recycling.

The current technological development leaves much to be improved. No country disposes of the sum of technologies that could be generally adopted on a global basis. Not only because they are expensive and require an advanced cultural level (and therefore less accessible for developing countries), but also because they cannot be expanded beyond present available world resources.[20]

The outstanding human and ecological potential of high technologies is so far being disclosed only partially. Despite their attractiveness, they are still peripheral in relation to the whole industry.[21]

6 Implications for Systems Research

Contraversions between new realities and conventional theories degrade the acumen of industrial economics. Decision making finds itself deprived of reliable arguments and exposed to pragmatic situational procedures.

The substantial lesson derived from contemporary studies about high technology impact on economy and business appears to be that in reality the market, R&D, manufacturing, supply and sales or financial linkages are far more complex and diverse than their reducible assumptions would allow. Also that the former borders between macro-economics and micro-economics, or between economy and business cease to be that much distinct as the orthodoxy would admit.

In the end, the theoretical scene induced by increasing high technology is not principally different from the changed common paradigm disclosed by the advancement of science[22], and by "new thinking"[23] in practical negotiations.

High technology does not set up diverging trajectory of systems research, but it relies upon an updated systems concerned as a specifically salient support in policy and decision making: alteration of conventional monistic deterministic assertions proceeds toward a

[19]The objective of low material inputs and low waste outputs was primarily challenged from the point of view to overcome scarcity of supply or high prices. However at the outcome it turned over to higher sophistication. Most "low" (input) technologies are in themselves "high" technologies.

[20]It has been estimated that a global application of the present advanced technology would demand 2-3 globes for fuel and raw materials supply and 1 globe for waste deployment and also almost 1 globe for supplementing "gastarbeiters" (low skilled labor).

[21]No country exceeds some 5% of high technology's share.

[22]In the theoretical branch, I have in mind, for instance, the discoveries made in "post-Prigogine" physics and chemistry, in life sciences (gene manipulation) and in ecology, in methodology the advancements in potentiality, turbulence and chaos studies.

[23]The phenomenon of "new thinking" was introduced firmly in politology, mainly in international affairs. However, it should be extended to other paradigms as an active reflection of the changed "scientific image of the world".

new set of pluralistic and non-deterministic conceivements. New theories look not only for the real state of affairs (events) but more for their potential (integral ability).

In a simplified version the move of the theoretical thought may be presented as a gradual change of paradigms (demonstrated on some key terms).[24]

"Fixism"	Probabilism	Possibilism	Generalism
Fixed	Probable	Possible, potential	Plausible, conceivable
Well-defined	Well-defined interval	Fuzzy	Turbulent, chaotic
Causality		Teleology	Common tendencies
Defining		Searching	
Sure	Risk	Uncertainty	
Regularity		Exploration, creation	
Data	Information	Knowledge	Metaknowledge

This shift in knowledge engineering[25] provides revealing opportunities for a more realistic explanation of whole classes of very dynamic events and processes. It can, among others, illuminate new horizons of economic and business problems.

While the formal (mathematico-logical) interpretation involves complex procedures and is seldom met in practice, it draws attention to many non-conventional approaches and brings about a revitalization of practical policymaking and decision making.

The loosening of orthodox determinism is on the other side balanced by the enhancement of "subjective factor", i.e., by inventiveness, creativity and thrust of the entrepreneur, company leader, manager, or professional expert.

In theory, flexible procedures flourish, such as alternative deliberations, scenarios generating, reveral detecting, exploring and searching, and prognostics. Altogether, previous mechanical treatment and processing of facts have been replaced by more creative approach to reality. Pre-eminently quantitative mode of speculating[26] is being combined with qualitative assessments.

7 "Critical Mass" and Collaborative Models in High Technology Industries

High technology displays a diversified pattern of successful cases. (As well as many—around one-third—bankruptcies.)

[24]More on comparison of probabilism and possibilism in: M. Vitek, *Possibilist Computation in Knowledge Engineering*, in: M.M. Gupta and T. Yamakawa, eds.: *Fuzzy Computing*, N. Holland, Elsevier, 1988.

[25]Another light may be thrown on this change from the point of view of the information theory. Since the 1940s, the term "information" penetrated the theoretical deliberations, mainly in association with C. Shannon's theory of information (in particular) and N. Wiener's cybernetics (in general). The former initiated the measurement of information and introduced it into programmable technology, the latter endowed it with broad conceptual framework for controlling machinery and bioprocesses.

[26]The quantitative approach has been supported by the massive introduction of formal algorithms and computer data processing. A new fetishization of the "growth" concept (as equal to progress) followed.

Contemporary empirical studies (based on an already extensive practice) reinforce the belief that there is not a specific configuration and size of industries and firms related to high technology. Neither large corporations, nor small-scale firms, neither vertical (intra-firm), nor horizontal (inter-firm) interlinks, neither organizational nor economic (market) mechanisms exclusively favor or disadvantage the birth and growth of high technology.

The flux of innovations does not depend on a single sort of resources, neither on a strictly regulated diffusion process. Innovation stems often from R&D achievements however most frequently it evolves through several improvements and finally looks for R&D support. Innovation variates as reciprocal effect and cause of R&D.[27]

The majority of innovations (related to the number not to their historical sway) results from combinations across the industries. Subjects of innovative drive extend from fundamental science over R&D (R&E), engineering and skilled workers in the industry, to clients (consumers)[28] and public initiatives.

Still, there are some findings which entail more conclusive orientation in the field of high technology constitution. As a rule, the process of technology accumulation depends on a variety of choices and initiatives from available resources and on synergy of activities (both in the range of the firm).

Along with innovation and its implementation in manufacturing, other concerns have to be also taken into consideration, like marketplace potential, client or customer expectations (or behavior), flexible financing and capital investment, and others. Technological breakthroughs, progress and dominance are scarcely a genuinely scientific or technical task. The specificity of market absorption and diffusion is a usual organic part of the deal.

The stimulating impact of synergy (of creative forces and resources) can be best achieved either through a spatial convergence or through information circulating and supply or subcontract logistic. There again is no exclusive choice but offers several options.

One of the rules, which really matters, though not adequately attended to, is the rule of the "critical mass". Borrowed from physics, it identifies an inter-stage position of the mass, a threshold volumes preparing a change. In economics it habitually appears associated with the amount of creative forces, technical means and capital indispensable to launch a breakthrough.

High technology is especially perceptive to critical mass of creative resources, interlinks and negotiations. It is due to this feature of development that the burn-in, spin-off or original creation constitute a specific pattern of social (socio-cultural) interdependence which cannot be easily substituted by informatics (in the intellectual sphere) or logistics (in the material sphere). This could explain why so many high technology firms tend to converge spatially.

Large firms committed to high technology try to combine advantages of highly sophisticated products with a large scale (or scope) economy. They substitute personal contacts and negotiations by information collecting, processing and circulating. Many MNCs are extremely successful in operating with relevant information and elevating the technological accumulation.[29]

[27]In the framework of high technology the R&D concept frequently turns to R&E (E for experimentation) pattern.

[28]In many processes of customizing the products/services the client (customer) activates and participates in innovations by requiring and combining products/services according to his specific needs, making selective decisions, improving the operations, etc.

[29]K. Marx, who is credited to have initiated the theoretical reflection of technology accumulation,

Three alternative models of high technology institutional shapes may be presented in brief in *Table 1.*

Once again it must be remembered that a schematic presentation makes it easier to provide a survey, however, it tends to invigorate borders between prototypes, while in practice there are many transitive and inter-mingled forms.

As a matter of fact, the transient character of institutional setting of high technology development should be viewed not only from the point of interfaces but of consecutive stages of development (either toward singular inventiveness or toward mass diffusion). More than other phenomena in economics, high technology requires a "development thinking".[30]

What conventional theories treated as disparate cases of high technology institutionalization, appear to be "crystallized" events of a development process. Their studies should be supported not only that much by special theories as by an integral theory embracing the whole industrial high technology as an evolving process.

8 The "Silicon Valley" Phenomenon

Penetration of scientific discoveries into the web of industrial relations, particularly in the U.S., initiated new industrial formations concerned with intensive technology accumulation.

Among the first examples was the "highway 128" in the Boston area.[31] Scientific (and technological) parks proliferated and they are as many in the American industry as some 150 for the time being. Borders between them frequently tend to disappear thus converting local parks into consistent zones.

Most prominent became the case of Silicon Valley in California. The short story of the Silicon Valley is rich in lessons related to high technology both in a stimulating as well as in an admonishing sense.[32]

In the Silicon Valley, some specific conditions and factors rendered local cooperation strategy as most rewarding. For some in that area, competition strategy was ruled out *a priori*. For a time, Silicon Valley was able to develop an integral ability for permanent change and accrued benefits associated with product sophistication.

The intellectual coherence of conventional theories presupposed to treat innovation as an outer and random factor which eliminated the spatial context and deprived territorial coordinates of any productive potential.

The growth of high technology in local context gave force to the opposite assumption that it was areal or regional environment where high technology conglomerates were encapsuled, which provided an unspecified but impacting "genius loci". In many newer

remarked that the technological progress is firmly rooted as much in the intellectual heritage of the predecessors as in the cooperation of contemporal innovators. When modern science and engineering took its start, scientists and engineers were extremely restricted in professional communication. Most of them never travelled and were left with postal services. Nowadays, informatics and telecommunication (tele-informatics) open a possibility to intensify professional contacts and set an almost achievable goal to "know everything".

[30]The difference is markedly represented in the German doublet of "sein" and "werden", the development thinking is "werden"-prone, reflects particular issues as an interwoven sequence of events.

[31]Indeed, there had been similar conglomerates much earlier, e.g., in Britain the steel and shipbuilding, in Germany the chemical and machine-tool industries, etc.

[32]See contributions of the Silicon Valley Research Group or B. McSummit, J. Martin, *The Silicon Valley Story*, Konstanz, Artigas, 1989.

Table 1. Three alternative models of high technology institutional shapes.

	I	II	III
Product	Standard low labor share	Changing standard (partly customized) low labor share	Diverse and customized labor intensive
Customer	Mass	Large groups	Dispersed
Production type	Mass	Mass flexible ("flexible specialization")	Flexible
Ownership	Corporate	Corporate or company	Individual or partnership
Manufacturing	Large-scale regular multi-plant	Large scale or scope semi-regular multi-plant, chain or "satellite" form	Small scale and scope (prevailing scope orientation) irregular single plant
Supply and subcontract	Constant selected from market offer	Semi-constant partly involved	Changing, negotiated highly involved
Labor	Low cost with a small core of high skilled	Low cost with a core of high skilled	Core of high skilled with low cost for simple and repetitive jobs
Interlinks	Information and communication network	Information and communication network with personal contacts	Personal negotiation
Spatial relations	Not important	Partly important	Locally (or sectorally) converging

studies "area (or region) variables" were introduced in order to explain the unusual vigor of high technology industry.

The resourcing of the high areal or regional creative potential is attributed to advanced universities, research and experimental bodies, advanced expertise, professional associations, craft traditions, also venture capital opportunities down to a specific lifestyle and local amenities.[33]

Many attempts to imitate the Silicon Valley model failed. Their failures demonstrated that "mere existence of requisite locational factors does not incubate dynamic high technology growth. Contiguity does not generate industrial synergy".[34]

There is no simple, straight and immediate correspondence between specific types of production and spatial organization. Agglomerated firms do not necessarily maintain links with each other. Several of them obtain outside resourcing. Silicon Valley "imported" a number of low cost labor from other regions (and also from abroad). In the last decade, the agglomeration depends more on foreign capital.

The life cycle of Silicon Valley had started with urgent need to foster information technology for military purposes. The emergence of Silicon Valley coincides with the advent of the VLSI chips. The development was heavily subsidized by governmental grants and investments. (This decisive instillment of knowledge and capital passed in many studies into oblivion.)

Semi-conductor manufacturers moved into high performance equipment and control systems. After a time, equipment domination encapsuled the semi-conductor manufacturing. Recurring crises in Silicon Valley (rather sensitive to oscillations in the market and capital supply) accelerated a vertical combination of leading firms.

At present, Silicon Valley is no more an agglomeration of small scale firms but a blend of them with larger companies and MNC's affiliations. It was through them that Silicon Valley became internationalized. The famous high technology agglomeration reaps superprofits partly from its advanced sophistication and partly from hegemonic position of participating MNCs in the world market.

However, a great deal of the Silicon Valley advantages, the cooperative arrangement of the industry, remains preserved. Partners are putting together their knowledge, coproduction, capital in order to achieve more than instrumental market selling and buying relations may provide.

Conventional cost minimizing and benefit maximizing hardly can highlight the "shared myopia" of knowledge, learning, inventiveness, or capital venturing, that ranges beyond any single firm perspective. On the opposite side, conventional approach does not outline the principal virtues of different firms and their participation in the local myopia, either. Spatial socio-cultural context is obliterated and denied its part in high technology drive.

High technologies respond mostly to market needs of product diversification, not that much to those of cost reduction (save for high manufacturing methods). They seek abundance of contact options which is their driving force for innovative behavior.

Personal commitment and expertise develop for the most part along idiosyncratic trajectories of each firm but look for generic links to the dynamic turbulence of enhanced

[33]Several theories were constituted to explain the development trajectory of high technology. Among them specific studies were devoted to spatial organization, capital investment thresholds, market technology relations, product cycles, and division of labor. They were able to illuminate particular problems, however, mostly fell short of integral explanations.

[34]R. Gordon, o.c., p. 9. This paper worked out by the Silicon Valley Research Group of the University of California jointly with the Group de Recherches Européen sur les Milieux Innovateurs (GREMI), and presented to the Xth Italian Conference of Regional Sciences, conveys many revealing ideas on the "Silicon Valley phenomenon".

knowledge, industrial practice and enterpreneurial audacity.

Informatics and communication can intermediate such links being looked for, and in many large firms, in particular MNCs, this is the way they operate. They are able to attract such permanent animating resources from vast spaces, in fact from global plethory. However, in agglomerations, similar resources bear a stimulating localized socio-physiological component.

The last, so far, stage of Silicon Valley development is using a combination of local and global resources, supported by the involvement of international capital which is an obvious trend to a new structure of technological creativity, production flexibility and market saturation.

There are also some lessons regarding the technology transfer from advanced industries into traditional industries. The majority of studies confirm that this technology transfer proceeds slowly, its intensity and scope are far from being satisfactory. At the same time, a more rudimentary enrichment of industrial technologies is pointed out as a paramount modernization potential.

Traditional industries and their technologies need more compatibility with high technology, starting with more information about that, more intimate contacts, and also more experimenting and learning. Both traditional and high technologies have to be concerned with working out common standards assuring component interchangeability and systems integration.

There are several principal options of high technology development. The American model would recommend "flexible specialization", a downstream diversification of products due to programmed automation. The Japan model makes use of advanced flexible manufacturing systems (FMS). The German model prefers what is called "flexible precision manufacturing" relying on scientifically prepared engineers and high skilled workers.

In addition, the Swedish (Scandinavian) model would involve group work organization. The Italian model is associated with the build-up of flexible production cooperative and town-centered chains. The Dutch model accentuates flexible logistics. And this choice is far from complete.

All aforementioned models to different extent refer to high technology agglomerations. And they try to imitate the "Silicon Valley approach". A variety of high technology incubation and diffusion schemes have been outlined and tried in practice.

As a duplicate of the U.S. scientific parks, similar formations are established in other parts of the world. Like technological centers in many European industrial areas, scientific and technological parks around scientific centers or newly founded scientific and technological terms[35] (technopolis).

By far not all of them prove to meet the initial expectations. Again it is being proved that mere spatial agglomeration without conceptual congruence does not match for an intensive technology accumulation.[36]

The principal lesson from the Silicon Valley story is that the Silicon Valley was not only "found" as a given local potential but that it was created by enterprising leaders, usually supported by public instillment of knowledge and capital.

[35]E.g., scientific town Novosibirsk in the USSR, Sophia-Antipolis in France or Tsucuba Technopolis in Japan.

[36]Analysis and generalization will be subject of a separate IIASA study.