HIGH TECH CLUSTER CREATION AND CLURE-CONFIGURATION--A SYSTEMS AND POLICY PERSPECTIVE

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Introduction

The current technological revolution focusing on IT high tech industries as core sectors is increasingly directing our attention to hi-tech clusters as an object of study and as a subject of industrial and technological policies in both advanced and newly industrialized economies.

To our knowledge most of recent analyses of clusters have focused on what could be termed mid and low tech industries such as those flourishing in the Italian Industrial District (Pyke, Becattini and Sengenberger 1990) or other mature industries of Europe(see Roetland 1998 for a survey of Cluster Policies in Europe). Moreover, their focus frequently lies in the *operation of an already established cluster rather than on cluster emergence or in its adaptation to changing external and internal circumstances.* A major exception is A. Saxenian's analysis of the development of Silicon Valley(SV, Saxenian 1998). The focus of this work is both IT high tech and explicitly dynamic. In particular her analysis considers the successful adaptation of the SV high tech cluster—success measured both in absolute terms and relative to the failure of the Route 128 cluster of East Coast US-- during the second half of the eighties and early nineties, in response to the crisis in the Semiconductor and Computer industries of the eighties.

The objective of this paper is two fold: first, to link the *dynamic* analysis of high tech clusters-particularly that of Saxenian- to the systems of innovation conceptual framework; and second, to explicitly introduce policy consideration into the analysis. This exercise will strengthen the positive and normative aspects of system of innovation transition analysis. It will also give us a better perspective of *cluster policies* and of their evolution through time. The analysis will also provide us with a framework for considering two different types of hi-tech clusters(from a policy perspective)-those emerging without explicit policies (e.g. SV) and those emerging in an environment of active technological and industrial policies favoring high tech industries (e.g. the emerging IT hi tech cluster of Israel).[1]

This paper is organized as follows

Section 2: Main Features of a (National) Systems of Innovation Perspective
Section 3: A simple conceptual model of SI transition and the role of policy(the Teubal perspective and elements of the Andersen perspective to vertical disintegration and industrial differentiation);
Section 4: A Systems Interpretation of Saxenian's Analysis of High Tech Cluster Reconfiguration
Section 5: Cluster Creation and Cluster Reconfiguration Policies
Section 6: Summary and Implications of the Analysis.

The paper starts with a discussion of the main components of a system of innovation perspective. It will emphasize the *dynamic* aspects of system of innovation transition (Andersen & Teubal 1995; Galli & Teubal 1997 and other papers in Section of Edquist 1997; Andersen & Lundvall 1998; Andersen 1998; Teubal 1998a.b; etc) rather than 'how a system of innovation works'. It will also emphasize the *policy aspects* and the need to consider policy and the policy system as an integral part of the national

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system of innovation. *Section 2* will present the bare-bones of a system of innovation transition conceptual model focusing on ‘collective learning to restructure’ and on ‘system effects’—both of whom act on the business enterprise sector, the backbone of the system of innovation. Schumpeterian entrepreneurs take the lead in enterprise restructuring in response to changing external circumstances and their action generate spillovers favoring the restructuring of imitator\follower enterprises. They also put pressure on the policy system to generate the new institutions and organizations required for effectively implementing their own restructuring –which institutions and organizations which will also pave the way to the restructuring of other segments of the business sector (system effects). These new or modified components of the system of innovation could be technology centers supplying industry specific public goods; venture capital companies supplying finance to start ups; or new university training and (generic) research programs. Government will also actively be involved in two kinds of policies-horizontal policies promoting enterprise restructuring directly; and targeted policies oriented to the above-mentioned new components of the system of innovation[2]. The framework suggests the existence of phases in NSI transition and in the portfolio of policies required for success. Although the focus of specific programs changes through time and there are links through time among theses programs, the policy portfolio at any point of time involves a combination of horizontal and targeted programs.
Saxenian’s analysis fits very well into the above analysis since it is explicitly dynamic and it focuses on what was termed above ‘*restructuring of the business sector*’. The thrust of her analysis is to show how the business sector in Silicon Valley restructured in response to the crisis of the early and mid eighties, in particular the Japanese threat in semiconductor memory chip mass markets. Several aspects were singled out: the role of a new wave of Start Up(SU) semiconductor companies which fragmented existing mass markets and generated specialized niches; the emergence of the SC equipment industry as a separate industry (an analysis which links with the Andersen and Andersen & Lundvall analysis of industrial differentiation); the restructuring of existing large companies (Hewlett Packard and Intel), and the emergence of new companies in the computer industry(e.g. Sun). Her analysis links the very fact of these successful business sector adjustments to the prior existence in Silicon Valley of adequate institutions and organizations and even to a particular culture. These include and stimulated even more the central roles played by personal and professional links; user -producer and user-supplier links, a culture of openness and exchange, and the so called “HP-way” of business organization (which emphasized the importance of loosely coupled and of horizontally interacting technology development teams). She does not, however, emphasize the emergence or restructuring of new components of the system of innovation as part of this overall process of restructuring (existing components of the cluster, which existed or emerged during the 70s. seem, in her analysis to have sufficed to perform the job) nor on new policies which favoured the process. Both of these are emphasized in the models of system of innovation transition mentioned above.
The main objective of *Section 4* is to cast Saxenian’s analysis in terms of the Teubal et al and, to some extent, the Andersen et al conceptual frameworks. We suggest a clear distinction between Cluster Creation or Emergence; Cluster Operation; and Cluster Reconfiguration. This parallels the Teubal et al approach where system of innovation transition proceeds from an existing to a new system of innovation. In our opinion,

[2]As suggested above these new components are required for restructuring of the business enterprise sector as a whole.

Saxenian's major contribution to the *dynamics* of systems of innovation concerns the adaptation of the existing SV hi-tech cluster to changed circumstances, what we term Cluster Reconfiguration (this took place during the late eighties and early nineties. Note that it did not occur in Route 128 during that period, despite the crisis affecting that region's computer industry-the major hi tech segment). Moreover, Saxenian's contribution to cluster reconfiguration analysis focuses on one aspect in particular—business sector restructuring. She provides numerous examples (as well as of collective learning) and even suggests a taxonomy for such processes. Note that business sector restructuring is only one aspect of overall cluster reconfiguration-the other being new or changed institutions or organizations. By emphasizing existing institutions and System of Innovation (SI) components rather than the creation or restructuring of new components of SV's system her analysis probably could not be regarded as a complete analysis of cluster reconfiguration- at least from the perspective of the system of innovation transition framework of analysis. In her analysis of SV cluster reconfiguration if 'system effects' exist they most probably derive from system components which emerged together with the SV Cluster rather than from new or restructured system components as in Teubal(1988a,b).[3]

Section 5 aims at identifying and characterizing what could be considered Cluster Creation and particularly Cluster Reconfiguration Policies. These go beyond the horizontal\ targeted distinction suggested by Teubal. They include elements of coordination and vertical desintegration policies suggested by Andersen;more explicit networking policies as suggested by many proponents of evolutionary and systemic perspectives (Lundvall); and cluster policies already mentioned by other authors(e.g. supporting weak links in the value chain, *a' la Porter)*. Our analysis will also deal with the dynamics of policy in the sense of the changing portfolios of policies and their links through time as well as links among programs and policies at a point in time. Finally, while not explicitly suggesting the provision of incentives, let us not forget that her analysis is not incompatible with the need to provide direct incentives to enterprises or other organizations as part of the overall package of cluster reconfiguration policies. This is consistent with the Israeli experience although the emphasis on institutions and networking has frequently led to de-emphasize what yet remains a most powerful component of any policy aimed at industrial transformation-incentives.

Saxenian's analysis is sparse as far as policy is concerned. Policy enters only marginally probably because there were few explicit Federal Policies or even state policies during the Cluster Creation phase of the 40s.50s and 60s although she notes the importance of Government procurement and R&D contracts during and after WWII. Moreover, the policy response at the Federal Level to the crisis of the mid-eighties was totally ineffective as far as the adaptation of SV during the 80s is concerned. However,

[3]Her analysis of Cluster Emergence is more fragmented but it must be recognized that such an analysis is inherently much more difficult. In our opinion cluster emergence, and in fact also an analysis of cluster reconfiguration, requires a more explicit discussion of the nature and roles of *Key Agents*—individuals, policy makers, enterprises etc who played a major role in triggering change-- both conceptually and empirically, in part because the antecedent events of relevance might have occurred in fragmented patterns throughout decades. Finally, her discussion of the components of an existing cluster and their operation is also of high quality although, as was mentioned, analyses of Cluster Operation have become more frequent in the last decade.

her analysis of the SV cluster suggests the types of policies which might promote new or reconfigured clusters such that emerging in Israel during the 90s (there are approximately 3000 hi-tech Start Up companies in Israel today and both horizontal and targeted policies—although no explicit “cluster policies”- were systematically being applied, the former for decades) and aimed by other countries both advanced and developing(e.g. India).

Finally, *Section 6* summarizes the above and extracts conclusions concerning the basic conceptual framework for dynamic cluster analysis, particularly as applied to cluster reconfiguration. The major issues we will address are

- Definition of cluster, cluster emergence and cluster reconfiguration
- Conditions for successful cluster reconfiguration(e.g. generation of variety)
- Cluster Boundaries and Openness(e.g. to outside information and experience);
- Key Agents

A major topic is how to define the terms cluster, cluster emergence and cluster reconfiguration. Could Route 128 be considered a cluster despite its failure to adapt effectively to the challenges of the mid eighties? Can a cluster be defined independently of its capacity to adapt successfully that is only in terms of the possibility of offering enterprises -especially SME’s- the possibility of exploiting dynamic and static economics of scale under unchanged environments? Answering this question leads to the second issue - the conditions for *successful* cluster reconfiguration. Can cluster reconfiguration take place without the modification of existing institutions \organizations (non-enterprise organizations) or do they require also new institutions? Finally, a major issue in cluster reconfiguration is maintaining system openness, at least in terms of information flows. This links with the importance of generating new variety focused on those areas which best fit emerging globalised environments. We will refer both to Saxenian’s example, provide some information from Israel’s present cluster reconfiguration; and relate to systems literature rather than the systems of innovation literature(Simon, Allen, etc).

SECTION 2: BASIC FEATURES OF A SYSTEMS OF INNOVATION PERSPECTIVE

In our view a systems of innovation perspective to cluster emergence \ cluster reconfiguration involves a number of basic features not all of which have been mentioned by other authors in their analyses(for a discussion of what constitutes a NSI analysis see Edquist 1997). The set of features in such an analysis should include or consider the

1. *Dynamics of transition to a new system of innovation*
2. *Co-evolution between the two main subsystems-the business sector and new\restructured (non-business sector) system components*
3. *R&D is only one variable in system of innovation transition, it is imperative also to consider cumulative \ collective learning, interaction and new institutions*
4. *Coordinated building of demand and supply both of new system components and of new technology ,new organizational forms or other activities involved in business enterprise restructuring*
5. *Policies associates with such a transition including the possibility of extending incentives, promoting new institutions and stimulating learning\ interaction*
6. *Role of Key Agents and of diffusion of restructuring processes*

Most of these will be exemplified in the next section. We will only briefly discuss them at this point.

As mentioned in the introduction, the focus of our analysis is not how a system of innovation works or operates but how it changes and adapts as a consequence of changed external and internal circumstances. This is fundamental—we are talking about emergence and especially re-configuration of clusters. The characteristics of an existing cluster, however, determine both its economic impact under a given set of conditions and the possibility of cluster reconfiguration when such conditions change. This conforms with Nelson's view about the nature of the dynamics feature in an evolutionary perspective-we should be interested not only about what happens after To but also how and why state at To has been arrived at.

This central feature determines almost everything else. Like the fact that most evolution is co-evolution, here we also find co-evolution—rather than simply complementarity-- between two central subsystems-the business sector and the set of other organizations and institutions interacting with it(Nelson 1996). Some of the latter need not be R&D-related e.g. Venture Capital companies today are part and parcel of Israel's 'reconfigured' hi-tech cluster(they were not so during the high tech cluster emergence phase during the 70s & 80s). We will see how timely *system effects* will act jointly with learning to enable business enterprise (and system) adaptation—a virtuous cycle. And if we explicitly consider a policy subsystem, then we will also require co-evolution between it and its policies on the one hand and the business sector or other subsystems on the other(Teubal 1997).

Another important feature is the explicit consideration of demand for new system components and for the activities involved in the restructuring of the business sector(e.g. how to induce it to be more innovative; to cooperate etc). In our opinion, an exclusive emphasis on supply has dangerous 'linear model of innovation' overtones. The key to demand is learning which at least at early phases of transition will most likely be cumulative & collective(e.g. along the transition trajectory, the experience of leader, Schumpeterian entrepreneurs with organizational change is likely to be relevant to follower enterprises), and interactive(e.g. within supplier-manufacturer and manufacturer-user networks).

Finally, a central element of any analysis of system of innovation transition should be policy, and preferably the explicit consideration of a policy subsystem. One attempt were policy is exogenous can be found in Teubal 1998a,b— with horizontal policies directly supporting enterprise restructuring; and targeted policies promoting the emergence of new components of the subsystem supporting such efforts (i.e. *indirect* support of business enterprise restructuring). Cluster policies, however, should include more explicit institutional components than those considered above e.g. network creation policies; and changes in the systems of governance of non-business institutions and organizations. In our perspective, neither incentives nor new institutions can, at first glance, be dispensed with; nor the fact that the role of incentives is not to promote a particular activity but learning about such an activity.

SECTION 3: EXISTING MODELS OF SYSTEM OF INNOVATION TRANSITION AND THE ROLE OF POLICY

We will be summarizing elements of Teubal 1998a,b and then proceed to elements of the Andersen perspective. Most of the references of these works will not be repeated in what follows.

3.1 Objectives and Methodology

The objective is to analyze the *transition or evolution or transformation* of the system of innovation of industrializing and increasingly knowledge-intensive economies which might enable their successful adaptation to the processes of liberalization, globalisation and the technological revolution of the last decade of the millennium. Successful adaptation of such economies generally requires not only the restructuring of business enterprises, including an enhanced rate of innovation, but also changes in the configuration itself of their national systems of innovation. An additional objective is to analyze the role of industrial and technological policy in enabling and stimulating such changes. There are many reasons why such policy might play a crucial role given the simultaneous need of enhancing both enterprise restructuring \ innovation *and* changing system configuration. Despite the well-known limitations of traditional market failure analysis, it is important to note that market forces by themselves may fail to undertake the required changes even within the domain where the market mechanism has a 'comparative advantage' over other mechanisms (This has been termed a "redefined' concept of market failure). In addition, there may be 'system failures'. The research does not deal with the justifications for policy but with the likely nature of the policy portfolio required to enable and stimulate desirable transitions of national systems of innovation

More specifically, the research presents a *dynamic analysis* of Technological (and Industrial) policies directed to business sector restructuring in increasingly knowledge-based economies. More specifically (i) it simultaneously considers policies which are aimed to promote restructuring directly (e.g. horizontal programs supporting enterprise R&D) and policies aimed at influencing restructuring through changes in the national system of innovation e.g. the establishment of new technological infrastructure and new organisations housing them[4]; and (ii)the sequencing of policies, and the policy portfolio required for the successful transition of the system.

Concerning method it should be noted that both past and current research involves Appreciative Theory (Nelson and Winter 1982; Nelson 1996) and presupposes a movement from a pre-existing National System of Innovation to a new one. Past research has taken the latter to be exogenous. Making it endogeneous must involve explicit consideration of strategy and the policy process-factors considered up to now as exogeneous.

3.2 What is Enterprise Restructuring?

Enterprise restructuring in response to the processes of liberalization\ globalisation and new technological opportunities , could involve one or more of the following aspects-

- product specialization,
- adoption of new technologies (e.g. information technologies together with enhanced training of employees)
- enhanced world market orientation
- introduction of new functions(e.g. search, R&D) and associated routines
- organizational innovations such as Just in Time, Total Quality Management , Business Process Re-engineering, Down(right)sizing, Innovation Management Techniques; new incentives schemes, etc
- collaborative structures, enterprise networking and links between enterprises and among these and other organizations \ institutions

[4]These are new or changed components of the non-business enterprise subsystem.

- shift to precision manufacturing and\or introduction of the 'design' function
- development of distinct dynamic capabilities, etc.

I implicitly assume firm heterogeneity at least in the sense that different groups of firms will restructure at different times and in connection with a different subset of restructuring components. Their decision will not only depend on the information they exogenously have but also on processes of *learning to restructure* the knowledge of which will flow from advanced or innovator firms(who restructure early) to imitator and laggard firms.

Most of the aspects of restructuring are *implicit* in the model--these are termed *general* ; their implementation can be visualized as depending on the knowledge and experience of enterprises including experience from others. Many of the organizational innovations and the introduction of new management routines seem to belong to this category. Full restructuring of any enterprise, however, is assumed in this paper to depend also on a *specific* aspect which involves the effective incorporation of a new (technological)input or new technological services into the organization. This aspect is extensively discussed and made explicit in the research. .The new inputs are assumed to be provided, at least during phases 1 and 2 of the restructuring process, by a newly created Technology Center (TC) rather than from imports since a necessary condition for its effective access and absorption by most business enterprises is geographical proximity of the source of supply. This is justified in terms of the need for user-supplier interactions, provision of close technical support and customized adaptation of the good or service which is both novel to the economy and relatively complex as far as effective adoption is concerned.[5]

The new technological input is assumed to be required for the restructuring of *all* enterprises-although in different configurations. In this sense it is of strategic importance for the economy and therefore some measure of policy targeting of the supply and diffusion of this input is inevitable. The input can be visualized as specialized chips or processors, or specialized measurement or design services which would enable, together with more general organizational changes, propel firms to introduce 'precision manufacturing' or to be involved in 'product design' .[6]

3.3 Firm Types and Phases in Restructuring

Despite the variety of restructuring profiles there are sufficient common elements and levels of knowledge and experience such that it makes sense to talk about *a cumulative process* of learning to restructure. This is even more so since, whatever the differences among enterprises concerning the general aspects, they always will confront a common problem of tackling with the specific aspect of restructuring.

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[5] These requirements need not occur to the same degree in all cases but it is reasonable to assume that they are valid or quite common during the restructuring processes of industrialising, catching-up economies. Note that the literature on industrial districts has also assumed the importance of close user-producer relations(for the Italian case see Pyke et. al 1990, various articles).

[66] I mentioned that the TC represents a new hierarchical level of the evolving National System of Innovation. More generally this new hierarchical level would comprise both collective organizations\ institutions **and** markets linked with the provision of new restructuring-relevant technologies whether or not they are related to the shift to precision manufacturing. These technologies could include new design technologies, flexible manufacturing and new organizational\managerial techniques and processes. Not all of the requirements for restructuring involve actors or institutions belonging to the second hierarchical level of the innovation system. The assumption made here however is that some critical ones do. For a discussion of what constitutes a new hierarchical level, see Andersen and Teubal op. cit.

The business sector is composed mostly of incumbent firms --there is only marginal creation of new firms but no widespread creation of new firms including the Start-Up phenomena so characteristic of SV and Israel's high tech cluster. Assumptions are made concerning enterprise differences concerning the extent by which they are aware, have articulated their need, and are capable of absorbing the new input--conditions for shifting to a precision manufacturing or to a product innovation based competition configuration demanded by world markets[7]. (Incumbent) Firms thus comprise three groups: <u>Advanced\Schumpeterian firms(the "innovators")</u>; potential <u>imitators</u> and <u>laggards</u>- depending on both degree of awareness and capability to undertake the required restructuring.

Three phases of restructuring are considered. Advanced firms who are fully aware and posses restructuring capabilities will restructure in *Phase 1* while imitators and laggards will -under a complete NSI trajectory--restructure in *Phases 2 & 3* respectively. Despite strong capabilities the advanced firms segment cannot complete their restructuring in Phase 1 without the help of new technological infrastructure(housed in a newly created TC).Therefore they will put pressure on Government, and help to plan the creation of such a center[8]. The new component of the non-business subsystem will become available to advanced firms during (or towards the end of) Phase 1 and become fully available to imitator enterprises in Phase 2. In Phase 3 a market for the new technological inputs(sophisticated services or specialized chips) will substitute for the TC and it(together with a downsized TC) will help achieve broad diffusion of restructuring among the large remaining segment of business enterprises(*laggards)*.

Creation and operation of a TC implies embedding the business sector into a wider NSI involving the second hierarchical system level(comprising new components of the non-business enterprise subsystem-TC and eventually new markets), whose 'system effects'--if strong enough-- could pull the whole business sector through the process of restructuring. All three phases are assumed to be necessary for a successful transition of the NSI.

<u>3.4 Policies and the NSI Transition Process</u>

For the full transition trajectory considered in the research it is imperative—due to market, system and other failures- to consider the full set of policies that, in general, may have to be implemented[9]. This does not mean that some or even all policies may be ignored under specific sets of circumstances. These are summarized in Table 1.

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[7]. For our purposes here we assume-despite some other *implicit* distinctions - that there are no other differences among firms in the Business Sector which have to be made explicit e.g. according to economic sector, industrial branch or technology\markets.

[8] The Technology Centers are thus the result of coordinated actions of advanced firms to build private institutions\organizations to internalize external economies while exploiting economies of scope. Still specific policies (Technology Infrastructure Policies-TIP) would still be required to enable or facilitate the process (like in the Swiss and Japanese cases as argued by Weder and Grubel, 1994). Moreover, subsidies may also be required if advanced entrepreneurs are few in number or if their disposition or capacity for cooperation is weak(This because policy should attempt that infrastructures serving the wide needs of the business sector be created). Thus promoting new institutions \organizations is complementary to public subsidization i.e. they are not only nor always substitutes.

[9]In our opinion the main task for policy is identifying the new system of innovation aimed at and associated priorities in science, technology and innovation. The policies discussed in the research reported here presume the existence of such a strategy. Only then can one talk about (modified) market failure, system failures, etc and also identify a desirable program portfolio.

The set of policies considered here includes the following policy or program categories:

- Horizontal Restructuring Policies (HRP)
- Technological Infrastructure Policies(TIP)[10]
- Proactive Diffusion Policies (by the TC)
- Market Building (by the TC)
- SME-support schemes.

From the point of view of beneficiary firms, HRP are focused according to transition phase: in phase 1- towards the restructuring needs of advanced entrepreneurs; in phase 2-to those of imitators; and in phase 3-to the needs of laggards which means that the HRP is transformed into an SME-support scheme (I assume that a dominant if not overwhelming share of laggard enterprises are SME's). Policies at each phase exploit the spillovers from the restructuring experience had up to then (in part a result of previous policies). Thus HRP oriented to imitator enterprises might not have been desirable in phase 1 due to low awareness and capabilities of this segment of enterprises. It will become desirable, however, in Phase 2 once restructuring experience and demonstration has been accumulated from advanced firms' restructuring in Phase 1.

Despite enterprise focusing, HRP are *horizontal policies\ programs* in the sense (i) that they are aimed at firms, according to general criteria, irrespective of industrial branch or technology area or type (see Teubal 1997); (ii) their objective is to provide support for general aspects of restructuring such as the introduction of new management \ organizational routines (e.g. TQM) or novel Socially Desirable Technological Activities of relevance to enterprise restructuring such as R&D and associated routines); and (iii), their objective is to generate a collective learning process which exploits the commonalties of the experience with restructuring across industrial sectors \ types of technologies(Teubal 1996a,1997);(iv) Horizontal policies may evolve through time and become more selective in incentives and even transform themselves into sets of sector specific, technology specific <u>targeted</u> policies(this has been termed the Technology Policy Cycle, see Teubal op. cit.).

On the other hand TIP, Proactive Diffusion by the TC, and Market Building policies are *targeted policies* in the sense that they promote diffusion of the strategic new input or technology ("novel technological services or novel, custom made chips") which policy makers, advanced firms and the TC (after its inception) have identified as being of critical importance for the restructuring needs of the Business Sector as a whole. This means that policy makers no less than responding to felt needs of some firms also are anticipating the needs of others who presently cannot articulate their restructuring needs[11] or who require technical back-up in order to access required new technological inputs.[12]

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[10]In previous work this category of policy was termed Anticipated Institutional Change(AIC).

[11] A clear distinction should be made between 'general need' and articulated need\demand for a particular new product; and this can be applied to the issue of restructuring . The possibility of the former without the latter has been pointed out in Teubal 1979 ('low market\ need determinateness') In our context this could mean a very general of fuzzy awareness of the necessity of restructuring on the part of enterprises without a clear idea that this implies the need to utilise and incorporate the strategic new technological input.

[12] It may be worthwhile to clarify a number of points. First, HRP while directly aimed at satisfying the 'felt need' for restructuring on the part of *some* business enterprises(the advanced or innovator segment)

Two additional aspects should be mentioned: first, policies stimulating networking of imitators and laggards should already be implemented in phase 1 (and also to laggards in phase 2). This policy should be regarded as being of a preparatory nature i.e. it sets the stage for full restructuring later on. It is information intensive & a low-budget policy. Its main contribution would be to generate awareness of changes in the environment and assurance of the possibility of change (e.g. by demonstration) as well as a mechanism for the systematic collection of new, restructuring-relevant information. In the restricted sense given here to the term 'stimulating networking', the policy promotes and generally provides for a secretariat for a group of firms who are searching for such information e.g.about new markets, new technology or new organizational forms. If successful they may induce laggards (imitators) to move forward into the imitator (advanced) category Success of these policies has been recorded in contexts such as Chile (PROFO Programs) and Norway (private communication by K.Smith).[13]

Figure 1 summarizes the Restructuring of the Business Sector (RBS) process under a full NSI transition. The horizontal axis indicates time and the vertical one indicates the hierarchical level of the reconfigured NSI. At the first hierarchical level we observe a succession of restructuring processes starting at Phase 1 with that of advanced firms (represented by Ra); and followed by Ri and Rl (restructuring of imitators and then of laggards). At the second level establishment of TC during phase 1**;** its operation during Phase 2 and emergence of the new market M during Phase 3. The straight arrows indicate the direction of the impact on NIS transition of actions of key agents(see below)—both experience and knowledge *spillovers* (dashed arrows) and *supply\demand effects* (full-line arrows). Spillovers are shown at both NSI levels: at level one it is the restructuring experience of advanced enterprises which directly benefits imitators and indirectly, through the experience of imitators, laggards; at level two, the demand

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also involves anticipation of needs (Teubal op.cit). Second, the distinction between horizontal and targeted policies also corresponds to the distinction between the broad restructuring dimension and the specific one. Third, recent work on horizontal programs shows that these do not necessarily imply neutrality in incentives. Moreover, the learning processes involved during implementation (including enhanced Government capabilities to identify and locate market failure) may transform an horizontal\neutral policy to a set of semihorizontal and even targeted policies. Finally note that the SME- support scheme combines horizontality with a strong demand-creating bias-a dimension which differentiates it, to some extent, from other horizontal support programs (See Annex).

[13] The Promotion of networks in Chile involves subsidising the manager of a network of similar firms with the objective of improving access to Government incentives; enhancing bargaining power of the SME's viz a viz large firms; improving the pattern of division of labour among firms in the network; diffusing organisational innovations, and collecting information(Thanks to G. Crespi for information about these networks). These policies are not, in most cases, identical or similar neither with pure user-producer networks nor with full- fledged networks of innovators (or flexile specialisation networks) discussed in the context of Industrial Districts (see Bianchi & Beellini 1991) as alternatives to the Fordist, mass production model of organisation. Such networks\network promotion policies which have been discussed in the European context are akin to aspects of the overall restructuring process proposed in this paper and not only to the preparatory stage of such a process as has been the intention here. The similarities with the model of this paper are found first and foremost as regards the imitator and laggard segments of the business sector where restructuring requires the implementation of 'system effects'. For example, policies to promote the creation of new 'networks of innovators' include the stimulation of collective institutions ("Service Centers" such as CITER established in Emilia Romagna in 1980 for new and weak companies in the textile and clothing sectors) to stimulate the creation, diffusion and utilisation of new technological and market information (e.g. trends in fashion designs and and training to operate and use design workstations) and for overall coordination. In this paper these would correspond to (hierarchical) level 2 organisations such as our Technology Centers whose function is to assist RBS of imitators (and also of groups of laggards).

-creating implications of (and the experience with) the diffusion activity of the TC is that which contributes to the building of the market for the strategic new inputs, and through this, to the restructuring of laggards. The impacts of advanced firms through supply \demand effects are all indirect: they work through the establishment and operation of the TC. Thus Ra also contributes-through demand and the subsequent establishment of a TC-to the normal availability of the input to imitator firms in Phase 2, thereby making a further contribution to Ri in this phase.[14]

The mobilization and stimulation of the dynamic role of *key agents* (see below) by policy is also represented in the diagram (curved arrows with policy acronyms). Thus AIC reinforces the autonomous effect of demand for the new input and leads to an earlier and more effective TC which in turn, through S, contributes to Ri. Proactive Diffusion Policies (PD) undertaken by the same TC will contribute to generate the demand D for the new input (Phases 2,3). Note that the TC is both an endogenously-created key-agent(in part the result of policy) and an organization directly involved in policy implementation.

Overall, the Figure represents both innovation system transition and the enhanced embeddeness of business firms associated with such transition.

3.5 Implications

Dynamic Role of Key Agents

A *dynamic role* in pulling the NSI forward --over and beyond the direct effect of whatever they are doing-is played by certain players or actors during the transition process. Such a role involves spillovers and enhanced innovation \ restructuring possibilities open to other agents in the future . *Advanced, Schumpeterian entrepreneurs (the "innovators")* play such a role in two respects:

- they generate a fund of intangibles which is useful for other firms that restructure in the future*(spillovers)*;
- their cooperative efforts also contribute to generate new technological infrastructure *(supply and demand effects*—see below).

The concept and role of Key Agent is relevant for NSI transition rather than for system of innovation operation. Thus, F. Terman of Stanford and Hewlett & Packard could be considered as Key Agents in the creation of SV's high tech cluster(see next Section).

Coordinated Building of Supply and Demand

Successful restructuring involves the *coordinated building of demand and of supply* for novel inputs to be supplied by the new components of the non-business subsystem (TCs in the research reported now; Venture Capital companies in Israel's hi tech cluster reconfiguration of the 90s, etc). The problem is not only that of coordinating supply and demand; it is *of building both in a phased and coordinated way*.

Key Agent' role in NSI transition through their impact on the creation of the TC (supply), and through spillovers to other firms which stimulate their own restructuring,

[14] Note that the establishment of a differentiated organised market (Lundvall 1985) contributes to Rl through the stimulation of both S and D and not only through a pure supply effect. The reason for this is that the specialised suppliers comprising the new sector both provide technical back-up to users and continuously learn how to couple the new technology to the needs of various classes of laggard firms.They, in fact, are creating 'demand'.

could be viewed in terms of their contribution to the building of supply and demand for such new inputs(for further details see the underlying research).

Key Sector Alternative to a TC

Emergence of new, collective organizations (the TC) is only one possible way to generate system effects based on the supply of new technological inputs for business sector restructuring. Another possibility is emergence of a key sector which would play a role similar to the US machine tool sector in the 19th. C. as analyzed by Rosenberg (Rosenberg 1962). In our context, such a sector would comprise firms involved in specialized chip design and batch production services; in novel technological services associated with precision\quality production; in software, in capital good innovations etc. The new sector may emerge, as in Rosenberg's analysis, from vertical desintegration & innovation (e.g. which exploits an invention from an advanced firm) which in turn is stimulated by the generic nature of the new technologies (like in the model, the new inputs are eventually used by all the business sector).

It will eventually provide "depth" to the business enterprise sector and as such should be considered as an important change in the "architecture" of the NSI(see Andersen & Lundvall 1997. There is no doubt that this has been the central axis of what we will term 'cluster reconfiguration' in Saxenian's story of SV's adaptation to the crisis of the 80s e.g. the creation of a separate and identifiable semiconductor equipment industry.

Reflections on Policy[15]

- *The criticality of initial policies and more generally the timing and coordinated policy deployment may be crucial for successful NSI transition.*

Governments should not start at the outset with an SME support scheme but rather exploit and strengthen the restructuring 'spirit' of Schumpeterian entrepreneurs. The latter will create conditions for successful SME support further down the transition trajectory.

- *The policy portfolio should allow for a mix between horizontal and targeted programs and a mix between incentives and the creation of new institutions & organizations .*

  The first mix means two things-first, that one should allow for the possibility that, at each moment of time during NSI transformation, one or more program should be directed to the Business Enterprise subsystem and one or more programs should be directed to the non-business subsystem; and second, that it is very likely that Horizontal (Targeted)programs are the appropiate policy for the former(latter) subsystem.

- *Horizontal Policies are central and comprise a string of interconnected programs with a changing enterprise focus which support general aspects of restructuring.*

  We should recall here that horizontal programs are necessary under conditions of uncertainty about the location of (redefined) market failure and ignorance of policy makers; and that they may evolve towards greater selectivity and even be

[15] In what follows we have gone somewhat beyond the policy conclusions reported in the original research summarized in this section.

transformed into sets of sector\technology specific programs once conditions change(including the exhaustion of certain learning trajectories). We should also recall that horizontal programs involve selectivity at the strategic level of decision making(Lall & Teubal 1998)

- *Targeted programs support institutions and technological infrastructure(new elements of the non-business subsystem) in response both to felt needs of advanced firms—bottom up aspect-and in response to the anticipation of future demand of less sophisticated segments of enterprises–top down aspect*[16]

  This seems to be a central feature of any policy based on a dynamic, systems perspective due to bounded rationality and bounded vision of actors, gaps between socially appropiate and private actions, etc provided policy makers posess 'adequate' information and capabilities.

- *A full transition leads to a 'reconfigured' NSI which embeds the business enterprise sector within a more complex and open innovation system*

*T*he model makes no distinction between successful transition and successful business sector embeddedness or alternatively, it implies that a successful system of innovation transition automatically implies embeddedness. The embeddedness concept, therefore, relates to the capacity for system operation under new circumstances rather than to system transformation in response to new circumstances.[17]

3.6 Elements of Andersen's Analysis

SECTION 4: A SYSTEMS INTERPRETATION OF A.SEXENIAN'S(AS) ANALYSIS –DEFINITIONS, CONCEPTS AND THE STRUCTURE OF THE SV CLUSTER(70s)

4.1 AS Cluster Concept

(Hi-tech)Industrial Clusters are defined as *"A regional network-based industrial system that promotes collective learning and flexible adjustment to changed conditions among specialist producers of complex, related technologies"*(Saxenian 1998, p.).

Collective learning is about trends in markets, technologies and organizational forms e.g. new possibilities of 'fragmenting' mass markets into specialized niches or the importance of decentralized corporate structures. Thanks to it and to other factors (embeddedness in) a cluster enables the business sector to respond rapidly to fast changes in markets and technology that characterize international competition. AS analyzes business sector adjustment in Silicon Valley during the second half of the 80s

[16] The research we are summarizing has not used the bottom up, top down distinction but it seems pertinent at this point to make use of it.

[17] Our interpretation of Saxenian's analysis would show that the possibility of NSI restructuring (what we will term cluster reconfiguration) derived from enterprise embeddeness in the SV cluster as it emerged during the 50s and 60s. Thus in her analysis embeddeness is the cause of successful restructuring rather than the consequence as emphasized in our previous work. See Section 4 below.

and early 90s in response to the emergence of semiconductor memory mass markets & flexible manufacturing; and enhanced Japanese competition in the early\mid 80s.

The backbone of the flexible adjustment in AS is the *enterprise restructuring* process mentioned in the previous section in connection with the NSI transformation conceptual framework. An important difference is the central role played in the adjustment process of SV by new start ups (SU) which can better cope with the new conditions(incumbent firms were the main agents of change in the above mentioned framework). Thus, AS emphasizes also that "*..the cluster creates a favorable environment for the creation of start-ups*". Moreover, it enabled a "*..self-reinforcing dynamic of industrial advance*" in Silicon Valley. This should be construed as an additional impact of an existing cluster.

In AS analysis, the success of SV's adjustment was due to its *network based* industrial system where firms(and key individuals) have strong informal and formal links with other firms(informal links with other key individuals) and where there are considerable links between the business sector and the non-business subsystem. In contrast a *firm-based industrial system* prevailed in Route 128 where the above links, particularly among enterprises and key individuals, were relatively weak or missing[18]. In her analysis, this difference explains the differential adjustment of both regions in response to the crisis of the mid 80s- SV's success versus Route 128's failure. Given her definition of a cluster, this would seem to imply that a cluster *should be* a network based system i.e. there was(was not) a pre-existing cluster in SV(Route 128) before the onset of the crisis[19]

AS also criticizes the definition of cluster coming from the Regional Development literature(see). This alternative definition is based on the notion of *agglomeration economies (externalities)*: "*A cumulatively, self-reinforcing agglomeration of technological skill, venture capital, specialized services and suppliers, infrastructure and spillovers of knowledge-associated with proximity to Universities and information flows*". Conversely, stagnation and decline results from diseconomies of agglomeration and negative externalities. Mere agglomeration, following AS, reveals little about *abilities of the firm to respond rapidly to changing markets and technology*. Nor do they explain how the presence of skills, suppliers and information produced a *self-reinforcing dynamic of increasing industrial advance* in SV during the late 80s and early 90s while producing stagnation and decline in Route 128.

Ways to Define Clusters

A definition could focus on *dynamic cluster impacts*-- the capacity to adjust and the self-reinforcing dynamic that they generate— on *cluster components*, or on *cluster components + institutions & (other) underpinnings*. Cluster components include the various categories of firms in the business sector subsystem and organizations of the non-business subsystem. Institutions include rules, the organizations setting them and expected patterns or norms of behavior. Underpinnings might include aspects of culture e.g. social acceptance of entrepreneurship.

AS definition involves first and foremost an enumeration of (some) dynamic impacts. Her analysis then proceeds to analyze how the various cluster components

[18] See our summary below of AS analysis of cluster components.

[19] In our terminology there were two different (regional) systems of innovation despite their differences in the business and non-business subsystems; in the links within and between subsystems and in culture and institutions.

interact to achieve these ends; and she strongly emphasizes institutions and underpinnings.

The alternative Regional Development literature definition emphasizes cluster components without explaining how they lead to a cumulative, self-reinforcing processes(the impact emphasized). Their outlook is sparse as far as institutions and underpinnings are concerned.

Institutions and other Underpinnings

In AS analysis the key to collective learning, the ability of firms to adapt and adjust, and a favourable environment for start ups(her definition of Cluster) lies in[20]

- *supportive social structures*—particularly, entrepreneurship and social & professional networks,
- *institutions*--educational institutions and their links with business, business associations, fora for the exchange of information, standards' committees and the structure & organization of business enterprises,
- *collaborative practices*--large scope of informal exchange of information and experience; and formal collaborative arrangements such as cross licenses, second sourcing, technological agreements and joint ventures.

[20]Her teminology. Thus institutions would include organizational forms of business enterprises.

4.2 Comments From a NSI Perspective: Cluster Emergence, Operation and Reconfiguration

The NSI conceptual framework summarized in Section 3 suggests a number of points \issues to be taken into account as well as a reordering of some of the concepts used by AS particularly as far as the SV experience is concerned.

Cluster Emergence and Cluster Reconfiguration

The NSI transition perspective would emphasize a *pre-existing system* which was operating under an old set of circumstances e.g. a closed economy with few links both within the business sector and between it and the non-business subsystem--and a *new reconfigured system* resulting from a 'full transition trajectory'. Since a cluster is also a system of innovation (albeit a localized rather than a national one), this suggests a distinction between *cluster emergence*—which led to a pre-existing cluster-- and *cluster reconfiguration.*

Moreover like other systems of innovation clusters must involve both a central business sector subsystem and a non-business subsystem. This also holds for a reconfigured cluster, one emerging from a full process of adjustment and adaptation in response to changed conditions. Compared to the original cluster, a reconfigured cluster implies a restructured business sector(the focus of her analysis and the backbone but not the sole elements in the NSI analysis) and a changed non-business subsystem - new or restructured non-enterprise organizations to which we may add new institutions and links among the two subsystems.

Dynamic Impact of Clusters

It is important to distinguish between *three dynamic effects of a cluster when confronted with new circumstances*[21]

- how it facilitates enterprise restructuring(a partial or narrow impact)
- how it sets the stage for its own reconfiguration(a broader impact including both enterprise restructuring, co-evolved changes in the non-business subsystem; and new types of institutions and links); and
- how it creates a dynamic of self-sustained growth.

If the latter is a major measurable economic impact of the existing cluster it is mediated by *cluster reconfiguration..*

AS emphasizes the impact of an existing cluster in enabling the restructuring of the business sector-the first dynamic impact mentioned above. She also talks about the dynamic of self-sustained growth(third impact). The insufficiently analyzed issue is under what conditions an existing cluster could set the base for effective cluster reconfiguration which includes both the business and components of(and links involving) the non-business subsystem. This seems to have been less emphasized in her book.

System Effects

While Collective Learning is a precondition for *successful* adaptation of a NSI these operate in conjunction with timely *system effects*. Moreover, NSI transition analysis suggests that at least a portion of the *system effects* that are likely to operate

[21]Dynamic effects should be contrasted from simple cluster operation under unchanged conditions—a static effect.

during business restructuring may result from new components of the non-business sector—which co-evolve with the restructuring of business enterprises(particularly with advanced, Schumpeterian entrepreneurs who e.g. promote the establishment of TC, Venture Capital companies or new areas of University Research and training).

In her analysis, AS system effects seem to derive from the pre-existing system rather than from new or restructured elements of the non-business subsystem. That system effects also operate through new non-business components of the cluster and\or changed institutions is strongly implied by and illustrated in her analysis(e.g. her analysis of the re-creation of social and professional networks).

AS focus

AS's analysis focuses a) on the (pre-existing) SV cluster as it emerged in the 50s and 60s - the business sector subsystem, components of the non-business subsystem, and institutions, culture etc—and b) on business sector restructuring (late 80s, early 90s) in response to changed circumstances. Cluster Emergence involved a long process beginning before the WWII and proceeding during the 50s and 60s during which the Semiconductor Industry made its appearance side by side with the more traditional Electronics Instruments area. The 70s was a period both of consolidation of the cluster and of a *self-reinforcing dynamic of industrial growth* (impact of the cluster). One of the keys is how the cluster that got established during that period shaped business sector restructuring of the 80s.. As mentioned, her analysis is probably not a full description of cluster reconfiguration since the changes in the non-business subsystem are relatively under-emphasized.

Comments on Institutions and (other) Underpinnings

We could re-classify these based on distinctions between institutions, non-business subsystem components or organizations, and other underpinnings pertaining to social structure and culture. Thus AS *social and professional networks*—and the patterns of broad and extensive exchange of information that they imply—could be classified as institutions *(*informal, accepted patterns of behavior) and partly, together with *entrepreneurship,* as part of social structure and culture. Our view of institutions would also include informal *collaborative practice*s, and the informal *links* between non-business organizations(what AS calls institutions) and enterprises. However the borderline here between institutions and social structure and culture is not clear. *Formal links* such as Alliances, Joint Ventures and University-Industry agreements, and "rules" such as patent and bankruptcy laws would also be part of institutions. Finally, our view of institutions might also include "*rule-setting organizations*" such as Standards' Committees(institutions also in our terminology)[22].

Thus the AS category *institutions* seem to include at least two different things: formal institutions or non-business organizations such as educational institutions which we would consider as components of the non-business subsystem*;* and patterns of firm organization(these would define categories within the business enterprise subsystem

Structure of the Business Sector

[22]Rule setting organizations could also be a component of the non-business subsystem. Similarly, the organizations and mechanisms of policy could either be classified as institutions or as part of the non-business subsystem(or of a third policy subsystem as suggested in Galli & Teubal 1997). This emphasizes the lack of a clear distinction between institutions and components of the non-business subsystem.

Cluster Operation versus Cluster Emergence & Reconfiguration

The nature of the business and non-business subsystems together with the institutions and other underpinnings characterizing the cluster that got consolidated during the 70s might be sufficient to analyze how clusters operate. They are not, however, sufficient for analizing emergence and reconfiguration of the cluster. Such an analysis requires other variables as well such as Key Agents which--through spillover and infrastructural roles—triggered successful NSI transition trajectories in the conceptual framework of Section 3.

For cluster *emergence* we must also analyze how the various components of the system were first assembled and how the various institutions and the particular social structure and culture evolved. For example the role of Frederck Terman of Stanford University in stimulating the creation of Hewlett Packard and other high-tech companies which comprised the initial core of SV hi-tech companies; the subsequent role of Hewlett Packard —by then an established firm—and of Hewlett and Packard the individuals in helping establishment of new SU in the 50s and 60s ; etc. Central issues here would include--

- how a self reinforcing processes of collective learning emerged(e.g the informality and ideology of early entrepreneurs; and the common background and experience of many entrepreneurs and engineers who previously worked at Fairchild Semiconductor during the 50s, 60s),
- how and by whom did the supporting structures and institutions e.g. Business Associations, arose etc.

Similarly for cluster *reconfiguration.* But here there may be two opposing patterns. First, when extant non-business organizations, a favorable structure of business enterprises and existing institutions\underpinnings almost automatically assure a smooth process of enterprise adjustment without need for specific new triggering mechanisms; second, when the new challenges require significantly different components in the non-business and business sector as well as significantly changed institutions and other underpinnings. This is the implied structure of the NSI framework of Section 2, where triggering by key agents would then have to play a central role.

4.3. The Nature and Structure of SVs Cluster during the 70s (and Aspects of its Emergence)

Ideology and the Formation of a Technical Community(*Culture and Social Structure)*

Early entrepreneurs saw themselves as pioneers of a new industry in a new region; and as pioneers of a new technology(Semiconductor Electronics, SC). It was a shared challenge. It affected their view of themselves and of their community.

Habits of Informal Cooperation(*Institutions, Culture)*

Several factors played important roles here-

- Homogeneity of SV Founders
- Common Experience from Working at Fairchild("origin" of SC industry)
- Informality in the early phase(HP, prior to emergence of SC industry)
- Geographical proximity
- Pervasive, informal conversations
- Social relationships, gossips and personal ties
- On-the-job information exchange.

Founders were white, graduate engineers in their 20s. from Stanford or MIT. They had industrial experience, no roots in the region and a generalized distrust of East Coast institutions including those pertaining to the Business Sector(e.g. organization of firms).

Hewlett and Packard were very involved in the formation of other companies. They encouraged entrepreneurs, shared with them what they learned; and got Electronics companies to work together.

An important factor in the Semiconductor Industry which began in the 50s was the common bond of early SC engineers derived from the fact of having had common experience and training in Fairchild. Their Fairchild past gave them a sense of community even after moving to competing companies. Moreover, Fairchild represented an important training ground.

Informal conversations are pervasive and represent an important source of information about customers, technologies and markets. Common background, among other things, helped develop the credibility and trustworthiness of the information provider.

Competitors consulted on technical matters, and they shared problems and experiences. A culture developed where people talked to each other. ”Even if I don’t know him, I will call him”.

Social and Professional Networks(*Institutions, Culture)*

Important for the dissemination of technical and market information; they also represented efficient job-search networks. They transcend company loyalty; also there is a lot of mobility and turnover accepted. “Lots of people believe they work for Silicon Valley”.

Moreover, there is (or has been) commitment to one –another and to the advance of technology more than to a particular firm. A company is just a vehicle which allows you to work; if you can’t do it in one company you will do it in another. Thus these networks are *“a meta-organization through which engineers, in shifting combinations, organized technical advance”*[23]

The main implication is accelerated diffusion of technological capabilities and know how throughout the region(SV is characterized by the speed of diffusion of such knowledge); enhanced viability of SU; a distinct ‘shared technical culture and language’[24].

[23]This is to some extent related to organizational characteristics of firms-blurred boundaries between firms and also within individual firms(a firm is an interdependent confederation of project teams).

[24] There are also numerous formal gathering on every area and topic in the valley.

Emergence of Venture Capital(*component of the business sector but one that facilitates the operation and restructuring of manufacturers)*

Venture Capital emerged from the region's base of technological enterprises(usually *a successful enterpreneur* who created and build a company and then sold out..). The entrepreneur brought skills, operating experience and marketing contacts.

New University- Industry Links and/or new Educational Institutions(*non-business system componentsand links between it and the business sector)*

There were a number of cluster-creation and cluster operation links involving institutions of higher education. The original links (those involving the creation of the SV cluster) involved Stanford University. Stanford also provided *continuing education* to top talent working in small companies. It also created an Industrial Affiliates Program which promoted research collaborations between individual faculty and companies.The University of California at Berkeley undertook a rapid expansion of engineering programs particularly Electrical Engineering. It also fostered research in Computer Science and on Semiconductors.

State Universities such as San Jose College and Los Altos College created special programs for SC industry operators(such programs were unthinkable in the context of Stanford or Berkeley). They also considerably expanded their training of electronic engineers.

Establishment of Research Labs of Large Corporations(*component of business sector)*

In the fifties Lockheed, IBM, Xerox and other companies were attracted by the local infrastructure. In turn they contributed to the emerging cluster e.g. through spinoffs of personnel to create new companies(check).

Establishment and Operation of Business Associations(*component of the non-business subsystem or of the structure facilitating operation of business enterprises)*

They played an important role in Silicon Valley´s decentralized system.

By the late 70´s problems arose from explosive growth: housing, roads, environment- and the community wanted to control industrial expansion. Also shortages of technical skill arose. Local businesses formed an umbrella organization Santa Clara County Manufacturing Group (SCCMG) whose 26 founding members included -older Electronic Companies(HP, IBM), new firms(Intel), non electronic companies and banks. The objective was to work side by side with representatives of county government in solving social and political problems. The group set voluntary targets and indicative plans. Some firms committed money and expertise to devise solutions to land, transportation, environment problems. Cooperation between Industry and Government then became a “model” for local policymaking.

Other organizations included WEMA- Western Electronic Manufacturing Association- and SEMI- Semiconductor Equipment & Materials Association. The also contributed to integrate a decentralized structure.

WEMA

Since 1964 WEMA identified with small firms and formed an identity among West Coast manufacturers which was different from old-line Electronic business. The focus-

- providing services to assist management of small Start Ups, rather than lobbying for established corporations;
- holding seminars(free) and educational activities including management training sessions on a wide variety of subjects: finance, technical, marketing, production, export assistance.
- its activities were valuable for SU having technical backgrounds. Most SU managers are inexperienced in some important management area.

WEMA became the American Electronics Association (AEA) in 1978. It further strengthened social and professional networks by hosting meetings by managers and CEOs. Friendships made through AEA help the companies develop the products and work together. Managers reported finding customers and business partners at AEA meetings; and these meetings were also sources of market and technical information.

SEMI

SEMI was founded in 1970 by 3 SC vendors who were dissatisfied with the attention received at the regional Electronics Trade Fair(WESCON). They

- sponsored trade shows(many SC firms depended on trade shows for survival since they could not afford the cost of marketing to distant customers)
- coordinated standards setting activities
- organized educational and market research for small companies(who were highly fragmented, but highly sophisticated in the context of changing technology).

The annual trade shows enabled firms to exchange technical ideas, expand the range of product contacts, socialize with industry colleagues. *Trade Shows effectively compress social and professional networks in time/space.*

Considerable effort to build consensus on industry technical standards. In 1973 there were over 2000 specifications for silicon wafers were in use and wafers also were produced in a variety of shapes. Problems of waste, inventory and planning for vendors and customers. Despite opposition from SC manufacturers a SEMI Standards Committee defined and publicized specifications for emerging 3 inch wafer lines. By 1975 80% of all new wafers had met SEMI standards.

Setting the standards involved voluntary efforts by 3000 industry professionals in the standards setting committees. It involved also coordination of more than 100 International committees and task forces that met more than 200 times a year. The effort culminated in a book. From there on customers could choose among alternative sources of supply rather than depend on a single supplier.

The *process of standard setting was important-it build close understandings and working relationships between suppliers and end-users.* Standards are a precondition for production networks e.g. supplier-manufacturing networks; and standards' setting helps create these networks. This also means that standards were a precondition for enterprise specialization.

SEMI also was involved in semi-education and information activities(e.g interchange between members and customers, capital providers, and engineering faculty; provision of market forecasts for various segments of the industry). These services *allowed small SC companies_to stay abreast of fast changing markets and technology; and to continually refresh their networks.*

The Basic Silicon Valley model of Firm(*defines a central component of the business sector)*[25]

In parallel with the decentralized industrial community of SU which was developing, and in part as a mirror of such a system, large established corporations developed particular organizational configurations. These blurred the boundaries between corporate functions *within* firms, and in their place, created *interdependent confederations of project teams linked by intense informal communication.*

The system was pioneered by Hewlett and Packard and by Noyce (Intel). It explicitly avoided the hierarchical structures of East Coast companies like DEC. The model included *trust in individual motivation, professional autonomy and generous employee benefits* (these summarize the so- called HP way). It also emphasizes commonness of purpose and team work. Management provides direction, well defined goals, shared data and resources. Yet employees are expected to contribute their own ways for contributing to the company's success. The features of the model included-- no layoffs (some firms), generous stock options, less formal and centralized work environment, etc. As firms grow larger they preserve many of the entrepreneurial qualities of SU). Absence of organizational charts, procedures and other formal mechanisms of control. Informality of work place, dress and

[25] The 70s is a period of rapid growth of the cluster created during the 50s and 60s. It was accompanied by at least (partial) cluster reconfiguration characterized by, among other things, enhanced centralization of large companies and a trend towards mass production in semiconductors. The basic model of the text excludes these later trends.

work style; elimination of status barriers. Also, continuos interaction between senior personnel and their employees at all levels of the organization; deliberate attempt at stimulating ideas(innovation bubbles in unexpected places), rewarding performance rather than status, diffusion of knowledge about firm & industry among all levels of workforce.

The critical unit is not the firms but “loosely coupled engineering firm” comprising *a shifting and horizontally linked confederation of teams.*

All of this set the foundation of a *Decentralized Industrial System* which blurred boundaries between social life and work; between firms; between firms and local institutions; and between managers and workers. While competing fiercely, SV producers were “embedded in” and “inseparable from” social and technical networks.

<u>SECTION V-CLUSTER RECONFIGURATION</u>

<u>5.1 Antecedents</u>

Crisis of the 80s

During the eighties we see the worst downturn in the histories of Silicon Valley and Route 128. In Silicon Valley , SC producers lost market share to SC memory producers in Japan; while in Route 128 minicomputer producers lost share as customers shifted to a)workstations, b) PCs.While Silicon Valley recovered, this was not the case in Route 128.

Trends Before the Crisis

In both regions SC producers during the boom of the seventies and early eighties adopted high volume strategies and competition based on cost cutting(continued “betting on a product”)--rather than competition based on innovation. The crisis of the eighties showed the limits to the above model. Note that for SV companies the strategy adopted represented *a departure of the pre-existing decentralized industrial system.* During the 50s and 60s SC <u>customization</u> to optimize system performance dominated (era of custom LSI); and engineers at Texas Instruments and Fairchild actively developed CAD and Test Equipment to support this process.

They had abandoned the structures that the previously had pioneered and embraced “learning curves” and “scale economies” concepts-which were prevalent in contemporary management literature. Up to sometime during the 70s SC industry was very dynamic in terms of innovation in product and processes, but it later embraced the incremental refinements trajectory and production standards replaced customization.

Competition to produce low cost SC began in 1970 with Intel´s 1 DRAM which began the memory race. Computer and equipment producers that still required custom devices “ were forced to set-up their own in-house design and fabrication facilities or to acquire SC firms ..” Custom supplies thereby were available only in in-house captive suppliers like IBM, DEC and Bell Labs. The outcome was that SC firms-- especially those that grew big like Fairchild, Intel, NSC and AMD) shifted to mass manufacturing. The wave of acquisitions from outside computer & systems houses eliminated a dozen indpendent SC companies. Firms thought this was a natural process.

The outcome was abandoning the networks. Open exchange and informal collaborations were not useful any more; abandonment of local culture and relationships; distanced themselves from customers, antagonized equipment suppliers, adopted functional management hierarchies, separated R&D from manufacturing(isolation of design and engineering from production)-- in short the SC industry embraced the mass production model of the US post war period. Even worse, SC producers failed to identify key new market and technological opportunities (what they had done so well in the past). They missed new opportunities in ASIC, CMOS and CHIP SETS.

All of this happened when the Japanese were developing a more flexible mass production strategy which in 1984 captured the 256K DRAM market and by the end of the 80s dominated the world SC memory market. Japanese manufacturing process was consistently superior in yields and quality compared to US producers. The result was the worst recession in SV history (20% jobless in SV during 1985-6).

The options available where one of two a) recognize emergence of a new mass production model- and follow the Japanese in building collaborative ties internally(R&D and Production) and externally; or b) focus on design and manufacture of high value added devices and rebuild relations with customers and suppliers; rebuild flexible organizations; and fully utilize local social networks, institutions and shared understandings. SV companies returned to the strengths of the network-based system while Route 128 SU, in contrast, were isolated from sources of essential market information, technology and skills. Lacking forums for experimentation and learning they repeated the mistakes of the minicomputer makers and foundered or grew only slowly.

5.2 Restructuring and Transformation of the Business Sector-General

In SV a new generation of SU in SC and in computers emerged (e.g. Sun Microsystems, Conner Peripherals, Cypress Semiconductors); and there was reorganization and continued dynamic in existing large companies like HP and Intel. The HP Way features were reinforced or re-created during the mid 80s crisis and became even more prevalent during the early 90s. SV firms introduced a continuing stream of high value added products in semiconductors, computers, components and software-related products. They helped maintain US dominance in these areas over Japan in spite of loss of competitive advantage in consumer electronics and commodity semiconductors.

The reason was the pre-existence of a cluster in SV (see above characteristics). On the other hand there was no (successful) cluster in Route 128 which was dominated by a small number of relatively integrated corporations which internalized a wide range of activities. Secrecy and loyalty governed relationships with customers, suppliers and competitors. Authority there was centralized and information flowed vertically. The four minicomputer companies remained shackled in institutional and cultural rigidities and fell further behind technologically. SV became the dominant computer industry area of the US.

Dimensions of Business Sector Restructuring during the 80s

These include not only restructuring of existing enterprises, but other aspects such as the appearance of new layers of suppliers and customers; horizontal specialization; and a wave of new SU. The full set of elements analyzed by AS includes-

- the surge of SU

- Successful growth of some SU (e.g. SUN)
- New industries(computer industry e.g. SUN, MasPar,etc; and new layers of suppliers(e.g. SC equipment suppliers) ,customers, and service providers
- Decentralization of established corporations (HP)
- Unlocking the capabilities of large companies i.e. making them available to others e.g. Sun in 1990(effectively this contributes to blurring the distinctions between large and small firms)
- institutionalized longstanding practices of informal cooperation and exchange---formalized the process of collective learning
- blurring boundaries within firms
- enhanced scope and new patterns of collaboration in R&D
- creation of new production networks.

5.3 Chip Start-Ups and their Strategies

The new SC SU began a model of chip production based on the regions social and technical networks. Avoid price wars, define new markets. Many focused only on product development and design, while subcontracting manufacturing. They also created flexible organizations designed to respond rapidly to market changes.

Larger companies produced large volumes of general purpose devices such as DRAMS. SU small batches of complex, high value added components. These products were typically developed jointly with customers. And subsequently applied in new areas, and in computers, were they increased speed and power, computational and graphics capabilities, and led to reductions in size. Cirrus Logic for example, developed specialized chips for hard disk drives, graphics displays, etc. It introduced 56 new chips and chip subsystems in 1989 alone. Another chip producer Maxim produced an average of 67 new products each year between 1983 and 1989.

The strategy was “fragmenting mass markets”. They became capable of producing variety within a single production line(in 1987 Cypress Semiconductors produced 75 different products within a single line). And the underlying capabilities enabled the identification of market and technology trends, new applications and rapid introduction of differentiated designs. These development were helped by advances in computer aided design, engineering and testing.

Quick SC design and development; unbundling of SC activity

The SC SU increased their flexibility by unbundling SC production. Whereas established firms had designed, manufactured and assembled integrated circuits in-house, the new firms typically focused either on chip design, manufacturing or marketing.

Cypress, Integrated Device Technology and others specialized in leading- edge process technologies and design-process integration. Others such as Chips and Technologies, Xilinx and Weitek specialized in speedy design and subcontracted manufacturing to outside fabs.

Some 2/3 of the new Silicon Valley semiconductor firms were "fabless". Producers of ASICS such as LSI Logic and VLSI Technology, assisted systems firms in designing semi-custom chips that they manufactured. Others such as Orbit Semiconductor, served as flexible, quick-turnaround manufacturing foundries for a variety of chip and system houses.

Existence of external manufacturers reduced the cost and risk of SC SU--of setting up a manufacturing facility in-house- and also helped them optimize designs(use of multiple foundries to optimize designs). Use of external fabs also increased responsiveness and service obtained compared to what could be obtained from the manufacturing division within the company(opinion of an executive of Altera, a SC SU).

The new strategy also led to collaboration among local SU as when Altera agreed to invest in a state-of-the art fab run by Cypress to ensure manufacturing capacity for its chips.

Having said this, there were still new SC companies that chose to manufacture also(see below-minifabs)

Minifabs

They pioneered the use of low cost, low-volume, flexible *minifabs* that could quickly process short runs of different designs on a single line.These were modular fabs. They represented an important departure from the traditional, dedicated production lines that were optimized for very high throughput of a single design. The traditional ´megafab´ cost more than 250 million and took two to three years to build, while a minifab could be build in six months for 20-50 million $.

Organizational Changes

The new SC firms consciously attempted to avoid the cumbersome organizations of their predecessors. They sought to create structures which rewarded individual initiatives and preserved the focus and responsiveness of SU i.e. *decentralized organizations*.

Once Cypress reached 100M$ in sales, it adopted a VC model. The firm invested 65 M$ between 1987-90 to *spin-off four satellite companies* in closely related lines of business, including a chip fabrication facility and a design group to develop a second-generation microprocessor.

Other firms such as IDT and Chips and Technologies *decentralized internally*, constructing product based business units that retained significant autonomy yet shared a common corporate vision.

These organizational innovations allowed SV new chipmakers to introduce state of the art products faster than their more integrated producers. While the new-product lead times in the industry traditionally exceeded two years, by the end of the decade firms like Cirrus Logic and Chips and Technologies had shortened their development times to 9 months.

Summary-Restructuring within SC industry

We mentioned-

- Appearance of SU side by side with traditional producers,
- unbundling of SC activities e.g. possibility of manufacturing externally;
- a varied pattern of specialization within the new segment
- enhanced variety of chips
- new process technologies including minifabs
- collaboration among SC SU.

By 1985 Silicon Valley SU produced an average of 100 to 200 different types of chips on the same line with production runs ranging from 10 to 10.000 units. US commodity memory or logic producers, in contrast, produced 10-20 devices on a line with runs of millions of units.

By 1990 the SC industry consisted of two businesses with distinct technical and economic requirements. First, production of memory and other commodity devices-the province of a small number of very large companies that could afford the massive investments required to become a high volume, low cost manufacturer (this business was dominated by Japanese companies who also ere committed to continuous improvement in quality and in yield essential for high volume manufacturers).Second, the new set of firms which were set up alongside the crisis ridden established producers. They captured the unique strengths of Silicon Valley including

- access to leading edge customers,
- sophisticated design talent,
- specialized suppliers, and
- up to date information[26].

The new firms were highly profitable and fast growing(while existing firms like AMD and National Semiconductor struggled to stay in business).The balance between the two groups changed during the 80s. Commodity Chips generated 80% of SC industry revenues worldwide in 1983 but only 33% in 1990. This indicates a *structural shift in the SC industry away from a commodity-driven business.* [27]

These trends forced the established SV producers to become more flexible. Intel, which *abandoned memory production* in 1985, dramatically increased its pace of new product introduction and by the end of the decade had revitalized its microprocessor business.

[26]Weitec's CEO stated: " The key to winning is ((not cost or price)) but getting close to the customer".

[27]The above reflects both increased variety and a process of selection towards non-commodity chips.The restructuring was pioneered or led by SU, so these companies were the Key Agents.

National Semiconductor and AMD both began replacing standard, off the shelf parts with *more specialized, design-intensive, devices.*

The markets of commodity chips while large were being eroded by the small specialized companies ”You’ve got to keep subdividing the market and making the niches smaller and smaller..”(Weitek). This is a process of fragmentation of mass markets. Even the prototypical commodity market-standard memory-was segmented in late 80s by a proliferation of products which were more tightly coupled to particular applications or systems. There were half a dozen designs in 1985 and more than one hundred standard memory architectures and options by 1988**.**

5.4 Rise and Dominance of SVs Computer Industry .

A second no less important aspect of restructuring involved *the rise of computer-related industries*. SV outgrew its origins as a center of SC production during the 80s. The SV computer systems complex continued to grow and diversify during the 80s. From 2500 firms in 1965 (according to one estimate, see p. 125) it grew to 50 000 firms in 1990--most having entered the industry during the 80s. By 1990 computer manufacturing businesses alone employed close to 60000 workers in SV, four time as many as on Route 128(the dominant region up to then) where computer employment had fallen to under 15000.

Computer SU

There was a wave of computer SU in SV, and they adopted strategies similar to those of their SC counterparts. Examples- Sun Microsystems, Silicon Graphics, MIPS, MasPar, and Pyramid Technologies, who created new markets and developed differentiated services and applications rather than simply lowering manufacturing costs on standardized systems. In so doing they also fragmented computer systems markets and uprooted the industry’s dominant producers. During the 80s the computer business splintered into scores of market segments including supercomputers, super-minicomputers, fault tolerant computers, workstations, and pen-based and hand-held computers. By 1987 only 24 % or the worlds data processing revenues came from mainframes.

Computer-SC collaboration

The new *SC firms allied themselves with computer SU* in order to influence and to respond to changing systems requirements. Computer companies tended to substitute semi-custom and specialized chips for commodity devices in order to differentiate their products, improve performance and reduce development times. Sun Microsystems--replaced 70 standard chips in its Sun 3 workstations for 5 ASICS from LSI Logic[28].

Silicon Graphics

The geographical proximity to the new semiconductor companies afforded by a location in SV was particularly important for Silicon Graphics.”...Our hardware strategy coincided with the chip companies getting booted out of the commodity business and specialization. This coincidence of supply and demand created a whole new breed of computer companies....this allows our technical ideas and architecture ((the company designed 50 different ASIC chips)) to be implemented in silicon in very short time periods, which is essential since product cycles in this industry used to be three to five years long but now they are closer to eighteen months”.

5.5 *The infrastructure of specialist firms(beyond SC and computer firms)*

By the end of the 80s SV was the home of increasingly diversified networks of specialized equipment, component, subsystem and software producers including firms that specialized in disk drives(such as Conner Peripherals, Maxtor and Quantom), networking and communications products(such as 3Com, Excelan, Cisco and Bridge Communications), computer-aided design and engineering systems(Daisy Systems, Cadence Design, and Valid Logic Systems), and color displays(SuperMac, Radius, and RasterOps)

These firms often defined the state of the art in their respective fields; they competed by rapidly introducing differentiated products; and they relied on the active involvement of nearby customers and suppliers to continue innovating.

[28]Frequently the computer companies designed their chips or collaborated with SC companies in chip design.

Disk Drive Valley

Due to the new firms in this area the US controlled 75% of the world market for fixed disk drives by 1988. The evolution of the disk drive industry resembles that of the SC industry.

An early IBM disk drive facility in San Jose became the *spawning ground* for successive waves of disk drive start-ups in the region. The largest, Seagate, followed the traditional model of vertical integration and high volume manufacturing of standard products in the 70´. By 1980 it lost market share to a wave of spin-offs that were more flexible and innovative. The new firms pioneered high performance drives by avoiding vertical integration and collaborating with customers to design and introduce new products rapidly.

Equipment Manufacturers and Contract Manufacturing

The new firms spawned a further diversification of the supplyer infrastructure. During the 1980´s a new crop of manufacturers of *SC equipment* and materials(e.g. Novellus Systems, Lam Research, and Genus); makers of *disk drive equipment* and components (e.g. Read-Rite, Komag, and Helios); and providers *of contract manufacturing* services (e.g. Solectron, Flexronics, and Logistix) emerged in Silicon Valley.

As in the past *many were spinoffs of of the established companies*. These firms remained highly focused and often replicated the strategies adopted in the computer and SC industries. " *Avoid vertical integration like the plague*.... forces the company to build in a high fixed cost, which assures loss of profitability when volume drops...also the design of components and assemblies which are a product of vertical integration will likely be inferior to those which can be obtained from a vendor that specializes in de designs" (Robert Graham, CEO of Novellus).

5.6 Vertical Desintegration in Hewlett Packard(Rethinking the Large Firm)

Both DEC and HP began the decade of the 80´s with bureaucratic decision making processes and internal conflicts typical of large firms. Both missed opportunities and made false starts in workstations and RISC markets and both had difficulty in keeping up with newer more agile competitors. Yet HP became quickly the leading producer in the fastest-growing segments of the market including RISC and UNIX based computer systems; and had a strong position in desktop computing, particularly workstations and non impact printers. By 1990 HP controlled 31% of the 8 B$ RISC computer systems market-- a market in which DEC still had no presence.

HP invested heavily in RISC microprocessor technology and the UNIX operating system in the early 80s-well before most established computer companies recognized the importance of open standards. By 1990 a report by Salomon Brothers stated “over the past 4-5 years HP have done an excellent job of identifying trends in the computer market such as Unix, RISC, and PC. No other major computer company has done a better job of positioning. There are the one company I can count on surviving”.

HP ability to identify these market trends early reflected the <u>firm’s openness to external changes</u> in technology and markets and <u>a location that gave it easy access to state of the art technology.</u>

HP in 1985 bet the future of its computer division on RISC.

In 1990 HP created an independent team to develop a RISC-based workstation. The ultimate product, the Series 700 workstation, was far ahead of the rest of the industry.

By 1990 HP and DEC were 13 B$ companies and the largest and older civilian employers in their respective regions. Both were vertically integrated producers of proprietary minicomputers and both faced comparative competitive challenges. They responded in different ways. HP adjusted by gradually opening up and building a network of local alliances and subcontracting relationships. It successfully managed the transition from proprietary minicomputers to workstations with open systems. DEC, in spite of its formal commitment to decentralization, retained a substantially more insular organizational structure and corporate mind set. Moreover, DEC remained dependent on its proprietary VAX line of minicomputers and showed only limited progress in the shift o an open architecture.

In addition DEC maintained clear boundaries between itself and other companies or institutions in the region. HP´s semiautonomous business units and growing reliance on external suppliers allowed it to bring products to market much faster than DEC(which continued to rely upon its conflict-ridden matrix organization and extensive vertical integration).

Finally, HP's "participation" in local labor markets and in the associational life of the region allowed its engineers to *learn about new computing technologies and market trends more rapidly than those at DEC*((more learning from others than in the case of DEC)).

Background-transformation of the computer industry in the eighties

Premium on speed and focus. Half of HP´s orders, it was claimed in 1988, came from products introduced in the preceding three years. Despite technological leadership, the margin of catch up was often under a year. Also the cost of innovation increased as products became more complex. *Innovation was occurring in all segments from microprocessors and logic chips to systems and application software; to disk drives, screens, input-output devices and networking devices.* It became increasingly difficult for a single firm to produce all of these components, let alone stay at the forefront of each of the underlying technologies. All of this required collaborations and a shift from proprietary standards to open systems.

Subcontracting and competition with external vendors

In the late 1980s HP began to subcontract most of the sheet metal fabrication, plastics, and machining for its computing systems. It also consolidated the management of some fifty disparate circuit technology units into two autonomous divisions-IC Fabrication and Printed Circuit Board Fabrication. These companies were organized as internal subcontractors for the company´s computer systems and instrument divisions. They were forced to compete with external vendors for HP business and were expected to remain competititve in technology, service, and cost in order to sell successfully to outside customers.

HP Alliances with firms having complementary technology

During the 80s it built partnerships with Octel Communications for voice-data integration; with 3Com for local area network-manager servers; with Weitek for SC design; and with Informix for data base software.

HP divisions gained autonomy and began collaborating with specialist producers

While during the 80s the firm was opening up it created a new model of a decentralized large firm. Its divisions gained autonomy and began collaborating with other specialist producers-may of which were local.

No such thing happened at DEC. Its dominant and isolated position at R128, its autarkic organization, and its being located in a region with few social and technical support for a more flexible business model-all of this hindered efforts to shift to new technologies or to new corporate forms. In 1992 Ken Olson was forced to resign.

5.7 Creation, Growth and Restructuring of Sun Microsystems

In 1982 as a SU, Sun lacked the resources to develop the broad range of technologies needed for a computer system. The firm published the specifications of its RISC microprocessor, SPARC, in order to enlist outside engineering and manufacturing resources, while forging partnerships with several suppliers of components who in turn shared Sun´s efforts to improve the SPARC design and rapidly introduce new generations into the market. Although competitors as well as suppliers had access to its specs, this open model allowed Sun to grow in the years from a start-up to a 3 B$ company that dominated the workstation market.

Open systems represent a radical bread with the past. Proprietary systems locked customers into a single vendor, while open systems encouraged new entrants and experimentation by forcing vendors to differentiate their products while competing within a common industry standard. It allowed systems firms to focus on only those elements of the product in which they had specialized skills, purchasing all other components externally.

Formalizing Production Networks(Sun)

The new generation of SV computer systems firms such as Sun and Silicon Graphics responded to rising costs, shrinking cycles and rapid change by building production networks from the bottom up. By focusing on what they did best and purchasing the remainder from specialist suppliers they created a network system which overcame the above problems.

While specialization is critical for SU, Sun did not abandon the strategy even as it grew into a multidollar company. “If I were making a stable set of products I could make a solid cases for vertical integration”. With desintegration it introduced 4 major product generations in 5 years.

Most of the new computer systems firms like Sun(Tandem, Silicon Graphics, MIPS, Pyramid Technologies) concentrated on design and assembly of a final system and the advance of technologies at he core of their firm’s capabilities.

Measures of Vertical Des-Integration

One measure,albeit very imperfect measure, is sales per employee.Apple, Sun, Silicon Graphics, HP had higher sales per employee in 1990 than Prime,Wang,Data General and DEC((the first group-between 144 and 383 K per employee; the second group between 104 and 128 K per employee)).

Restructuring of Sun Microsystems(5 quasi-independent companies)

They avoided hierarchy and created flat organizations that significantly dispersed decision-making and authority. “There is no steady state in this business. We have to reinvent our company continuously ((every two years)) because our product line changes every 18 months..we are careful that there are no major structures in place that will resist change: we hire people who are change junkies and we have an extremely fluid organizational chart based on small multidisciplinary teams that focus on bringing new products to market first”(CEO of Silicon Graphics, Ed McCracken).

When Sun became a 3.5 B$ organization in 1990 the workstation maker pioneered a radical reorganization, breaking itself into five quasi-independent companies under a single corporate umbrella. Their managers were given full responsibility for profit and loss and their own independent sales force. The ´planets´ were encouraged to exploit business opportunities even when they might harm another Sun unit.

For example the SunSoft group provided the Solaris operating system for Sun workstations built by Sun Microsystems Computer Corporation (SMCC) but also sold it to SMCC competitors such HP, Intel and Next Computer Co.

The notion was that customers, not managers, would best identify where Sun was and was not competitive. This radically open structure forced the company continually to redefine where it added value and where it should rely on external partners for critical innovations.