The embedded firm

On the socioeconomics of industrial networks

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The lock-in of regional development in the Ruhr area[1]

Gernot Grabher

The glorious history of the Ruhr, the industrial heartland of West Germany, could be written as the success story of an industrial district. At a glance at least, the prosperous Ruhr industry of former decades corresponds with the prosperous industrial districts of today. Highly specialized regional industry was effectively supported by a developed infrastructure of supplier firms and regional institutions which tailored their services to the specific needs of regional industry. The agglomeration of industry facilitated personal communication and exchange of ideas and generated a process of mutual training and learning by doing. Marshall's metaphor of 'industrial atmosphere' certainly applied to the culture of the Ruhr:

> It is to be remembered that a man can generally pass easily from one machine to another; but that the manual handling of a material often requires a fine skill that is not easily acquired in middle age: for that is characteristic of a special industrial atmosphere.
>
> (Marshall 1919/1927: 287)

Especially in the steel industry of the Ruhr, the 'fine skills' to run a furnace were provided by a long-term process of mutual training. In essence, the production of steel used to be less a rational technology than a culinary art that required a fine flair for the different ingredients.

Apparently, the systemic and agglomerative character of the Ruhr justified the label 'industrial district'.

> The conditions of population density, presence of infrastructure, industrial atmosphere, which are both the source and the result, the cause and the effect, of that part of returns which cannot be explained either by internal economies of scale or by R&D, apply to the industrial district. It is this extra-element of productivity which made

Lancashire, the Ruhr and Lombardy yesterday, and the so-called Third Italy today, stand out against the rest.

(Becattini 1989: 132)

According to this analogy, however, the future of the industrial districts of today will eventually resemble the present conditions of the industrial districts of the past. Given the decline of the latter, that future is not very reassuring. The initial strengths of the industrial districts of the past – their industrial atmosphere, highly developed and specialized infrastructure, the close interfirm linkages, and strong political support by regional institutions – turned into stubborn obstacles to innovation. Regional development became 'locked in' by the very socioeconomic conditions that once made these regions 'stand out against the rest'. In other words, they fell into the trap of 'rigid specialization'.

The arguments in this chapter are not directed against the concept of industrial districts. Rather, the attempt is made to move beyond the tautological circle according to which 'industrial districts are successful economies, and they are successful because they are industrial districts'. This tautology idealizes industrial districts as a new master paradigm and a universally applicable blueprint for regional regeneration. Numerous success stories fuse description, prediction, and prescription towards a self-fulfilling prophecy, rendering assessments of the potential of industrial districts for regional regeneration superfluous (Amin and Robins 1990). The heroic intention of this chapter is to protect the concept of industrial districts against hasty political conclusions by elucidating the ambivalence of their basic features: intense interfirm linkages and close relations between leading industry and politics. The first section of this chapter deals with the decline of the Ruhr. The purpose, however, is not to offer a comprehensive theory of old industrial areas but to elaborate the significance of interfirm co-operation and regional politics in the decline of the Ruhr during the 1970s. The second section is focused on the role of interfirm co-operation in reorganizing the Ruhr during the 1980s. I describe the troublesome attempts to transform the close interfirm linkages into loosely coupled networks. Finally, I speculate on policies that could support this change of the industrial core of the Ruhr yet avoid the trap of rigid specialization.

DECLINE: REGIONAL OR SECTORAL?

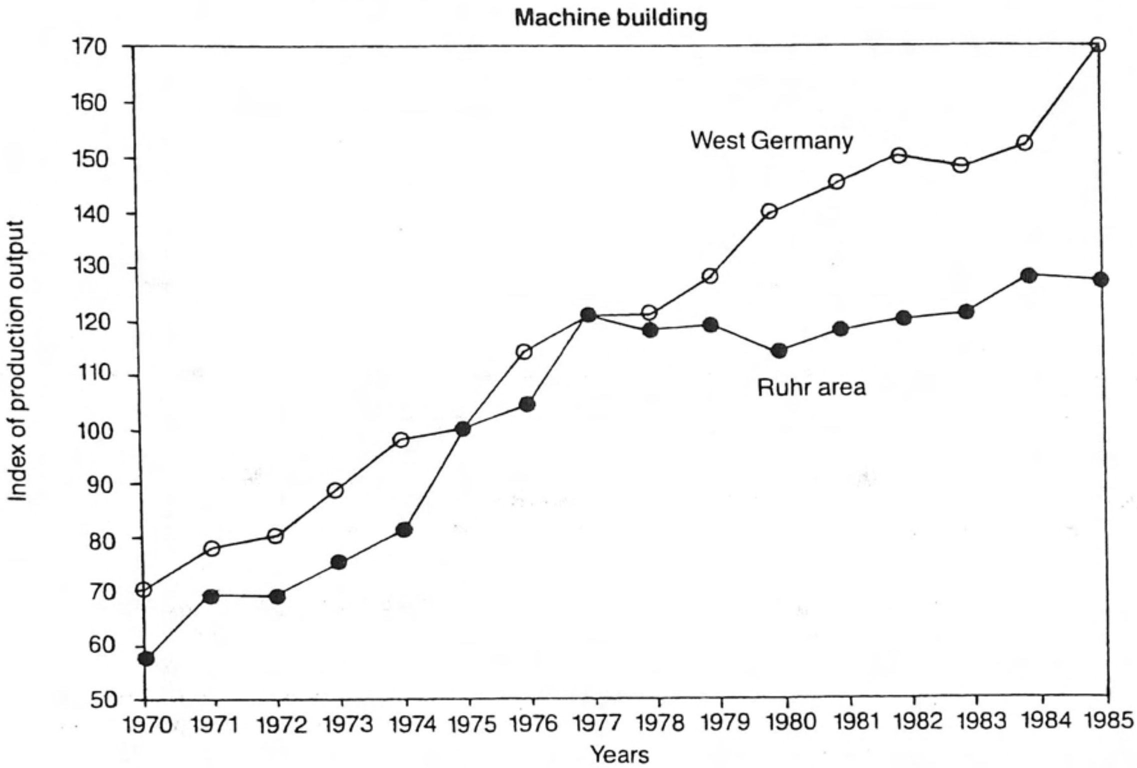
The Ruhr, a polycentric urban agglomeration of more than 5 million inhabitants, was the motor driving the 'industrial takeoff' of Germany.

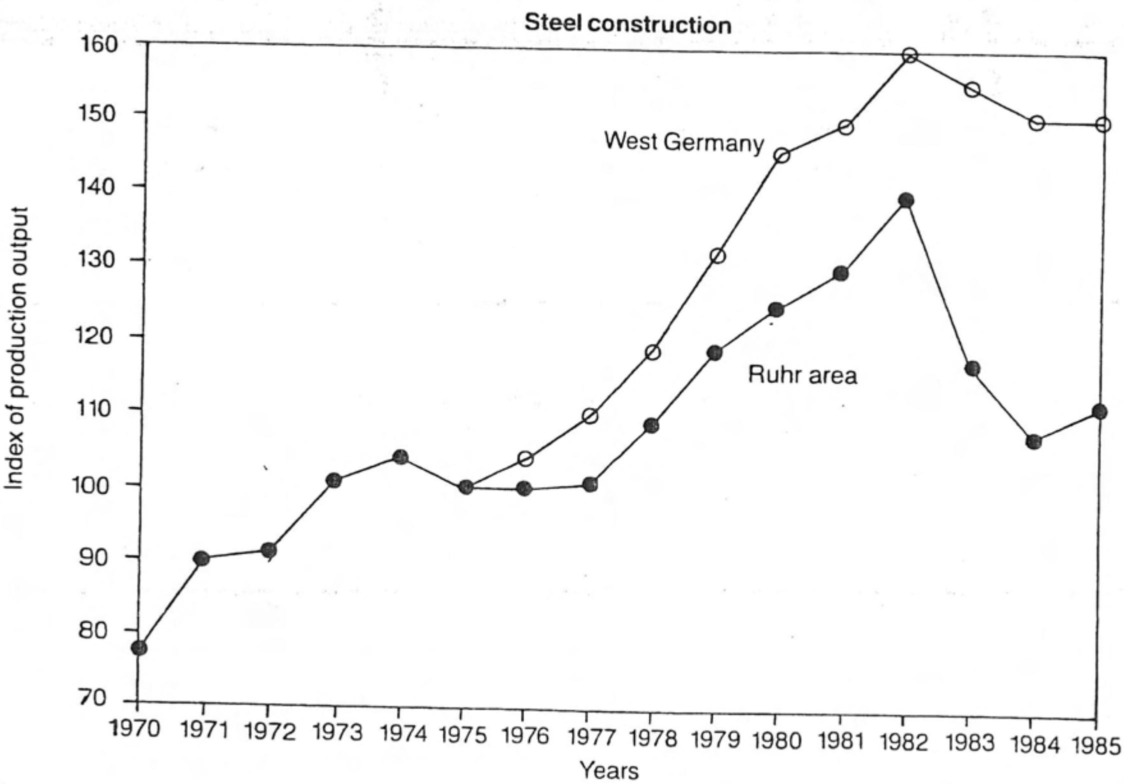
The coal, iron, and steel complex of the Ruhr was considered a major growth pole of national economic development. At the end of the 1950s, approximately 13 per cent of the country's gross domestic product was still attributed to the Ruhr, which accounts for 8 per cent of the population of West Germany (Müller 1989). At the end of the 1970s, however, spectacular plant closures, radical drops in production, and mass dismissals indicated a severe crisis in the Ruhr. To be sure, the decline of the Ruhr had already begun in the 1960s. First, the period of reconstruction, with its enormous demand for basic materials and capital goods, came to an end. Second, the income elasticity of demand for iron and steel – main products of the Ruhr – dropped from 1.8 in 1950 to 0.9 in 1964 (Schlieper 1986: 178). In other words, in the mid-1960s the amount of iron and steel required to produce an additional unit of gross domestic product was only half what had been needed one and a half decades earlier. Third, the old industrial areas were faced with increasing competition, especially from the newly industrializing countries, which had comparative advantages in producing homogeneous mass goods. As a result, the iron and steel industry reduced employment between 1977 and 1986 by 23.2%. In the first half of the 1980s, the Ruhr lost more than 100,000 jobs in industry. The unemployment rate in the Ruhr amounted in September 1988 to 15.1 per cent as compared to 8.1 per cent in West Germany as a whole. In addition, the average duration of unemployment in the Ruhr (40 weeks) was significantly above the national average of 31 weeks (Landesarbeitsamt Nordrhein-Westfalen).

The decline of the Ruhr, however, cannot be traced back simply to the dominance of a few industries that faced dramatic decreases in demand. A purely demand-side approach is inadequate for at least two reasons. First, on a theoretical level, a demand-side approach does not explain why regional redeployment of the productive resources that were set free by the decreases in demand did not occur. Second, as empirical analysis has pointed out, it is not just a few traditional industries that have been affected by crisis. Even high-technology industries and the service sector are growing at below-average rates (Junkernheinrich 1989: 31). While the production of high-technology products (according to the OECD categorization) in West Germany grew between 1977 and 1983 by 39 per cent, the Ruhr's growth in production was just 25 per cent. The machine-building and steel construction industry of the Ruhr fell far behind the development of these industries at the national level (see Figure 12.1).

An essential reason for the poor performance of these industries, which do not belong to the traditional core of the Ruhr, are the specific

Figure 12.1 Development of the machine-building and steel construction industries, 1970–85 (index of production output)
Source: GEWOS, GfAH, and WSI (1988: 92)





interfirm linkages shaping the development of the region. The regional core firms were established in locations that allowed a profitable exploitation of natural resources but that frequently lacked a well-developed handicraft infrastructure (Herrigel 1989). Although the missing infrastructure forced industrial enterprises initially to provide supplies to a large extent on their own, regional industry became involved in an increasing division of labour during subsequent periods of development. On the one hand, individual steel producers specialized in different product areas, such as Thyssen in high-grade steel and Mannesmann in pipes, whereas raw materials and crude steel were provided cooperatively. On the other hand, an industrial infrastructure of suppliers emerged that amounted to approximately 190,000 jobs in 1976, including, above all, the machine-building industry, electronics industry, and commercial services (Schröter 1986: 381). The close intraregional interdependence, which is what constituted the coal, iron, and steel complex, had disastrous long-term consequences for the region's adaptability.

THE RIGID SPECIALIZATION TRAP: THE THREEFOLD LOCK-IN OF REGIONAL DEVELOPMENT

'Functional lock-in'

The long-term stability and predictability of demand for iron and steel favoured close and stable linkages between the regional core firms and the supplier sector. Investments in the stability of interfirm relations and mutual adaptations promised to reduce transaction costs. The close intraregional relations embedded in long-standing personal connections resulted in serious shortcomings in so-called boundary-spanning functions, which are of utmost importance in scanning the economic environment and in making external information relevant for the firm. Moreover, they are concerned with identifying and mobilizing external resources (Aldrich 1979: 248–55).

First, knowledge of the long-term investment plans of the core firms made it possible for the suppliers largely to dispense with their own long-term R&D aimed at developing new products for a new clientele. The still strong orientation of development and innovation activities to regional core firms has been confirmed in a recent analysis of machine-building firms supplying the coal industry of the Ruhr. Of the machine-building firms supplying the coal industry, 57 per cent developed new products in close cooperation with their main customers; 33 per

cent cooperated solely with their single most important customer. This cooperation proved to be of crucial importance for the success of product innovations: just 9 per cent of the machine-building firms supplying the coal industry would have been able to innovate without their cooperating partners. Furthermore, 35 per cent of these machine-building firms drew innovation ideas from their main customers. By comparison, innovation ideas of machine-building firms that do not supply the coal industry stem primarily from observations made of the competitive environment (43 per cent) and from these firms' own R&D departments (20 per cent). Acting on innovative ideas, these firms draw resources from a wider network of cooperating partners, including suppliers, universities, and professional associations (Lehner, Nordhause-Janz, and Schubert 1990: 44–7).

Second, well-developed personal connections with the middle management of core firms quite often took the place of the suppliers' own marketing. Personal ties to a few client firms were given preference over the development of a firm's own channels of distribution. Consequently, the distribution departments of supplier firms within the coal, iron, and steel complex are generally of little significance. The qualifications of distribution personnel in machine-building firms supplying the coal industry, for example, are considerably below the industrial average (Lehner, Nordhause-Janz, and Schubert 1990: 18).

These empirical findings cannot simply be traced back to the 'dependent supplier syndrome'. Shortcomings in boundary-spanning functions do not apply solely to small sweatshops run by structurally overloaded artisans; they apply equally to technologically advanced, medium-sized and even large firms with developed organizational and management systems. Consequently, functional shortcomings characterizing the core of the Ruhr industry cannot be explained exclusively in terms of the structural dependence of small suppliers. Those shortcomings must also be considered as outcomes of long-term adaptations and explicit strategies to facilitate interfirm cooperation and reduce transaction costs. At least in the case of the larger firms, the high risks of low investments in boundary-spanning functions and high investments in transaction-specific personal relations seemed to be justified by the continuity of interfirm relations. The common interest in continuity, in turn, favoured transaction-specific investments, thereby setting up a vicious circle locking firms into specific exchange relations. This vicious circle, caused by and resulting in functional shortcomings, was reinforced by a 'cognitive lock-in'.

'Cognitive lock-in'

Personal ties of long standing resulted in mutual orientations involving a common language regarding technical matters, contracting rules, and knowledge on which the parties could draw in communicating with one another. Common orientation was reinforced by social processes such as 'groupthink' (Morgan 1986: 91). That is, within the coal, iron, and steel complex a specific world view was developed on the basis of social reinforcement. This world view determined which phenomena were perceived and which phenomena were ignored. Then, when events and signals were perceived, the world view determined how they had to be interpreted. Above all, this world view referred to the long-term development of demand for the main product of the Ruhr: steel. Particularly on account of the long-term continuity in demand trends (see Figure 12.2), the slumps in the early 1970s were at first interpreted as breaks in a growth path that was stable in the long run. In other words, the idea of a 'cycle' was rediscovered (Pichierri 1986: 10). In this light, the sharp downturns in demand were interpreted as a phase in a business cycle, not as the beginning of long-term decline. This unchallenged groupthink interpretation prevented a reorganization of the regional economy in an early period of decline, when the region was still well equipped with resources for innovation (Schlieper 1986).

Personal cohesiveness and well-established relations within the coal, iron, and steel complex turned out to be another trap. Intensive internal relations limited the perception of innovation opportunities and left no

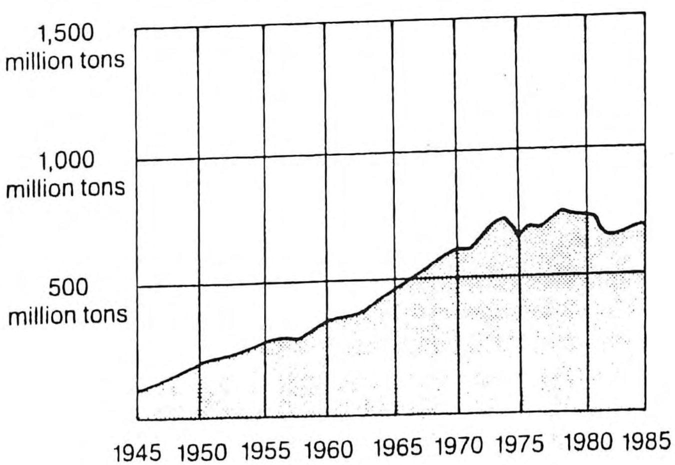


Figure 12.2 Development of world crude steel production, 1945–85
Source: Grabher (1988: 35)

room for 'bridging relationships' – those that transcend a firm's own narrowly circumscribed group and bring together information from different sources (Wegener 1987: 28). This handicap is the weakness of strong ties, to paraphrase Granovetter (1973). Personal cohesiveness and groupthink favoured 'parametric rationality', as opposed to 'strategic rationality' (Elster 1979), and resulted in 'overcompensatory response'. Increasing the quantity of the same prescription was given preference over trying a new one. In the Ruhr, overcompensatory response was reflected in huge investments in existing technology and a marked predilection for process innovations. The physical investments of the West German steel industry, for example, amounted in 1976 to DM2.7b as compared to DM2.1b in 1970, when demand for steel was still growing (Schröter 1986: 370). The machine-building firms of the coal, iron, and steel complex adopted CNC, CAD, computer-aided quality control (CAQ), and flexible manufacturing systems (FMS) significantly earlier than the machine-building firms outside the coal, iron, and steel complex, and are at present leading with respect to the computer integration of manufacturing (CIM). However, shortcomings in boundary-spanning functions prevent these firms from leaving the technological trajectory of the coal, iron, and steel complex and from shifting to more promising markets (Lehner, Nordhause-Janz, and Schubert 1990: 34). Functional lock-in and cognitive lock-in resulted inevitably in the 'sailing-ship effect' (Rothwell and Zegveld 1985: 41). The sailing-ship effect refers to the fact that most important improvements to the sailing ship occurred after the introduction of the steamship. As Rothwell and Zegveld emphasize,

> it illustrates how established companies can become locked into existing technological trajectories. Rather than attempting to capitalize on the possibilities offered by the emergence of a superior new substitute technology, they vigorously defend their position through the accelerated improvement of the old technology.
>
> (Rothwell and Zegveld 1985: 41)

'Political lock-in'

The economic development of the Ruhr along its historical trajectory was effectively supported by cooperative relations between industry, the government of the federal state (*Land*) of North Rhine-Westphalia, regional and local planning authorities, unions, and professional associations. The politico-administrative system kept the region effectively on course, even when this course became a dead-end. This political support had been mainly related to physical infrastructure. During the 1970s, however, several programmes were launched to support the coal, iron, and steel complex directly. The programme for North Rhine-Westphalia (*Nordrhein-Westfalen-Programm*, 1975), as well as highly endowed technology programmes (*Technologieprogramm Bergbau*, *Technologieprogramm Energie*, and *Technologieprogrammem Stahl*) were focused primarily on subsidies for the coal, iron, and steel complex. Altogether, these programmes supplied to R&D projects on core technologies of the coal, iron, and steel complex approximately DM2.6b (Simonis 1989: 356).

The highly cooperative relations between industry and the politico-administrative system petrified to a pre-*perestroika* culture of consensus. For decades, this culture, shaped by rather conservative social democrats, conservative unions, and patriarchal industrialists, remained unchallenged. The close formal and informal relations among these groups, which were colloquially labelled *Filz* (venality), led to a strong alliance supporting the coal, iron, and steel complex. The cohesiveness of this alliance was reinforced by emphatic appeals to the specific 'production mission' of the Ruhr within the national economy (Heinze, Hilbert, and Voelzkow 1989: 79). The specific regional 'production mission' also provided the ideological background for blocking the settlement of new industries. While the leading industrialists aimed at protecting their monopsony position on the regional labour market, the unions and the social democrats tried to maintain the cultural coherence and homogeneity that produced 'resonance' among workers – a basis for solidarity (Friedman 1977: 53). For both the unions and the social democrats, support of the coal, iron, and steel complex during the 1970s turned more and more into a desperate defence of their political base, for which they had pushed through high wages and high labour standards. Certainly, this is not to blame them for pursuing their policy but to indicate how the symbiotic relations between the politico-administrative system and industry obstructed a timely reorganization of the Ruhr and paralysed political innovation (Kunzmann 1986: 413).

THE DIALECTICS OF ADAPTATION AND ADAPTABILITY: A THEORETICAL CONCLUSION

The production pattern of close interfirm linkages embedded in strong personal relations and supported by a tightly knit politico-administrative system reflected the perfect adaptation of the Ruhr to a specific economic environment. The crisis of the Ruhr, however, illustrates how perfect

adaptation to a specific economic environment may undermine a region's adaptability. If adaptation and adaptability are not necessarily positively correlated, the success stories of today's industrial districts could also indicate the challenges they may face in the future. In any case, the relevance of the dialectics of adaptation and adaptability for the successful industrial districts of today cannot simply be neglected by saying that the Ruhr never has been nor ever will be an industrial district in the Marshallian sense (which is claimed in this chapter only for polemic purposes). In the case of the Italian industrial districts, however, some rather superficial observations could be interpreted as potential threats to the regional adaptability. First, innovation in the industrial districts seems to be concerned mainly with improvements of the production process rather than with major product developments (Bianchi, forthcoming). Second, at least in the less urbanized industrial districts such as Marche and Abruzzi, the firms often produce for a few, large subcontractors or wholesalers and, consequently, lack boundary-spanning functions (Amin and Robins 1990: 199). Finally, cultural coherence and corporatist relations at the local level (Trigilia 1989) may also give rise to inertia that restricts regional adaptability.

Adaptation endangers adaptability through processes of 'involution'. Adaptation leads to an increasing specialization of resources and a pronounced preference for innovations that reproduce existing structures. And while the system optimizes the 'fit' into its environment, it loses its adaptability. Ultimately, the internal coherence of the system results in a 'pathological homeostasis'. The system loses its ability to reorganize its internal structure in order to cope with unpredictable changes in the environment (Maruyama 1963). Adaptability crucially depends on the availability of unspecific and uncommitted capacities that can be put to a variety of unforseeable uses: redundancy. Redundancy enables social systems not just to adapt to specific environmental changes but to question the appropriateness of adaptation. It is this kind of self-questioning ability that underpins the activities of systems capable of learning to learn and self-organize (Bateson 1972). The essential difference between the adaptive type and self-organizing type of learning is sometimes identified in terms of a distinction between 'single-loop' and 'double-loop' learning (Argyris and Schon 1978). Single-loop learning allows systems

1 to scan and monitor significant aspects of the environment;
2 to compare this information against operating norms; and
3 to initiate corrective actions when discrepancies are detected.

Single-loop learning is essentially the intelligence of a thermostat.

However, the learning abilities thus defined are limited in that the system can maintain only the course of action determined by the operating norms and standards guiding it. This is fine as long as the action defined by those standards is appropriate for dealing with the changes encountered. But when this is not the case, the process of negative feedback eventually promotes an inappropriate pattern of behaviour. This is the story of the overcompensatory response to the decline of the Ruhr. In a sense, this story demonstrates 'that highly sophisticated single-loop learning systems may actually serve to keep the organization on the wrong course, since people are not prepared to challenge underlying assumptions' (Morgan 1986: 90). It is the ability to question the appropriateness of behaviour that distinguishes double-loop from single-loop learning systems. The self-questioning and self-organizing ability of the coal, iron, and steel complex of the Ruhr was restricted by a production pattern of rigid and intensive interfirm linkages. The more this production pattern adapted to its specific environment, the more redundancy was eliminated on the regional level. Analogously, the coherence of the political alliance supporting the coal, iron, and steel complex prevented constructive conflict and debate over the pursued strategy.

REORGANIZATION: CONVERSION OR SUBSTITUTION?

The lock-in of the coal, iron, and steel complex prevented an appropriate and timely reorganization of the Ruhr. The dramatic aggravation of the crisis in the early 1980s, however, broke this lock-in. Plant closures and a shift of economic activities to the prosperous south of West Germany were the most obvious signs of an incipient reorganization triggered by repeated sharp downturns in demand for steel. For example, the oldest firm of the coal, iron, and steel complex of the Ruhr, Gutehoffnungshütte (founded in 1758) transferred its headquarters and R&D department from the Ruhr town of Oberhausen to one of the major centres of Germany's electronics industry, Munich. In all, the old steel firms have cut more than 60,000 jobs since 1980 (Heinze, Hilbert, and Voelzkow 1989: 33). Symptomatically, the historically dominant interpretations and world views were not modified gradually; they were abruptly replaced by new world views. All of a sudden, the short cyclical fluctuations in demand in the 1970s were recognized as structural changes. Firms of the Ruhr considered themselves no longer part of the coal, iron, and steel complex but as 'technology firms'. Although the billboard jargon of business reports and political rhetoric overstated the factual extent of innovation,

leading Ruhr firms made considerable progress in reorganizing their business and their interfirm relations. They began to reduce the 'steel' divisions in favour of new fields of production with a significantly higher value-added component. The strategic reorientation of former steel companies towards new markets can be observed especially in the development of revenue shares accounted for by the 'processing' divisions (see Table 12.1).

Table 12.1 Shares of central divisions in total sales of the five most important steel enterprises in western Germany (in percentages)

		1970	*1980*	*1986*
Thyssen[1]	Steel	60.3	37.8	35.9
	Nonsteel	39.7	62.2	64.1
	of which processing	4.2	22.5	23.7
Krupp[2]	Steel	31.9	36.3	27.6
	Nonsteel	68.1	63.7	72.2
	of which processing	34.0	36.5	47.0
Mannesmann[3]	Steel	43.9	30.4	25.1
	Nonsteel	56.1	69.4	74.9
	of which processing	23.8	43.9	53.8
Klöckner	Steel	60.7	60.8	49.5
	Nonsteel	39.3	39.2	50.5
	of which processing	28.3	38.8	49.5
Hoesch[4]	Steel		40.5	40.9
	Nonsteel		59.5	59.1
	of which processing		33.3	38.4

Source: Grabher (1991: 68)
Notes:
1 Until 30 September 1975, Thyssen-Gruppe; thereafter Thyssen-Welt.
2 Steel, including about 50 per cent high-grade steel.
3 Only pipes to be subsumed under steel; 1970: domestic corporation; as of 1975: global corporation.
4 Until 1981, together with Estel.

Thus, Thyssen alone, the largest of the former steel companies, increased the revenue share of its processing division from 4.2 per cent to 23.7 per cent between 1970 and 1986. During the same period, the steel division was reduced from 60.3 per cent to 35.9 per cent. Another firm of the coal, iron, and steel complex, Mannesmann, increased its processing division between 1970 and 1986 from 23.8 per cent to 53.8 per cent. Of course, the situation varied from company to company, but plant engineering, environmental technology, mechanical engineering, and electronics were the sectors at the centre of the strategic reorientation. Plant engineering, in particular, was traditionally part of the production range of large steel enterprises, though initially it was limited to serving the needs of the maintenance and repair departments within the enterprise. With the reduction of steel capacity to a level that no longer allowed the full utilization of these maintenance and repair departments, companies began marketing their plant-engineering know-how externally (Geer 1985: 86). This led to an organizational differentiation and decentralization that was oriented to product markets rather than to internal production processes.

The steel companies did not enter the field of environmental technology primarily on the basis of an explicit marketing strategy. Rather, the plant-engineering divisions were confronted by the requirements of customers who had to adhere to new environment regulations. These customers figured large as 'lead users' (Von Hippel 1988). Their experience with the operation of pilot plants directly flew in the face of research and development process of the producer. The exchange of ideas between user and producer contributed considerably to the final design of the plants. Although this 'user-producer interaction' (Lundvall 1988) triggered innovation, it reinforced a concentration of resources upon specific problems of the coal, iron, and steel complex. The cooperation with the traditional clientele resulted repeatedly in products based on 'end-of-pipe technologies' aimed at mitigating already existing environmental problems. Cases in point are filtration plants and decontamination plants designed by Ruhr firms to repair environmental damage caused by Ruhr firms. To give an impression, in North Rhine-Westphalia, the *Land* in which the Ruhr is located, more than 8,500 areas are laden with noxious substances. These areas consist mainly of former mining and steel mill sites that are concentrated in the Ruhr. More than 80 per cent of all sites of the regional real estate pool of the Ruhr (*Grundstücksfond Ruhr*) are suspected of containing noxious substances (Minister für Wirtschaft, Mittelstand und Technologie des Landes Nordrhein-Westfalen 1988: 7).

Doubtless, environmental regulations such as the new water and soil protection regulations will transform these environmental problems into effective demand for the end-of-pipe technologies supplied by the Ruhr firms. Investment in end-of-pipe technologies, however, is generally considered a transition stage. In the long run, the costly *ex-post* reduction of pollution with end-of-pipe technologies will be replaced by production processes that prevent environmental pollution in the first place. This bias towards end-of-pipe technologies refers primarily

to the reorganizing of old steel companies. The environmental technology complex of the Ruhr, however, is not confined to reorganizing old firms. About half of the firms that have entered the market for environmental technology since 1981 are newly founded firms. And most important, more than 50 per cent of the firms founded since 1987 are mainly concerned with pollution-preventing technologies (IFO 1988: 5). Thus, the end-of-pipe technology bias of the reorganizing old firms is partially offset by newly founded firms.

In all, the environmental technology complex of North Rhine-Westphalia accounts for more than 600 firms, totalling about 100,000 jobs, as compared to approximately 300,000 jobs in the coal, iron, and steel complex, which still represents about 40 per cent of all industrial jobs (GEWOS, GfAH, and WSI 1988). However, more essential than the sheer size of the environmental technology complex is its internal structure. According to the diagnosis of the lock-in of the coal, iron, and steel complex, regional adaptability depends basically on the redundancy embedded in the regional production pattern. In fact, as preliminary empirical evidence suggests (IFO 1988; Heinze, Hilbert, and Voelzkow 1989; Grabher 1991), the environmental technology complex seems to be less prone to lock-in effects than the coal, iron, and steel complex is, because redundancy is provided by loosely coupled networks of relatively autonomous firms.

LOOSENING TIES: REDUNDANCY WITHIN NETWORKS

Redundancy on the firm level: relative autonomy

Cooperation in plant engineering and environmental technology is typically arranged as consortia. Large firms act as 'general contractors' that offer integrated system solutions, from the conception of plants and equipment to their maintenance and servicing. Since plant engineering and environmental technology are customized individual production, it would not be rational from the point of view of the general contractor to maintain resources for solving clients' specific problems. Rather, general contractors attempt to deal with their clients' widely varying demands, such as those in the areas of control systems and complex plant components, by cooperating with specialized firms. The strategic know-how of plant engineers, as a Krupp manager has put it, consists precisely in 'knowing the right project partner for each problem'. The general contractors are responsible for the financial expenditure connected with the planning and management of large projects, costs that would pose an insuperable barrier to market entry

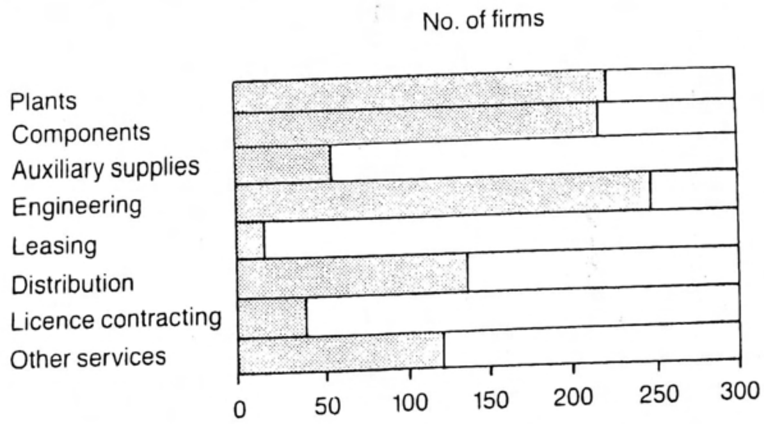


Figure 12.3 Profile of suppliers of environmental technology in North Rhine-Westphalia
Source: IFO (Institut für Wirtschaftsforschung) (1988: 3)

for single firms, especially small ones. The cooperating partners of the general contractors add their highly specialized competence to the planning and realization of the projects. In North Rhine-Westphalia, approximately 220 firms of the environmental technology complex are suppliers of special components (see Figure 12.3).

In contrast to the coal, iron, and steel complex, the cooperating firms of the general contractors have to be well equipped with their own boundary-spanning and strategic entrepreneurial functions, that is, R&D and marketing. The role of cooperating firms consists not simply of supplying components produced according to the blueprints of the general contractors: it is also to develop solutions for problems that are only roughly specified by the general contractors and that evolve only in the course of the planning and production phase. Obviously, only firms with their own research and engineering capacities are able to meet this high demand for flexibility. This applies especially with respect to mechanical engineering of high complexity and microelectronic control systems, areas that account for about 50 per cent of the orders in plant engineering (see Table 12.2). The relative functional autonomy and broad problem-solving capacities of the cooperating firms provide redundancy on the firm level. The relative functional autonomy of individual firms, especially with regard to the boundary-spanning functions R&D and marketing, encourages the openness and

reflectivity of the entire network since information stemming from different sources and evaluated against different backgrounds flow together.

Table 12.2 Structure of orders in plant engineering (shares in total volume of orders)

(a)	30% plant infrastructure
(b)	20% steel engineering and machine components of low complexity
(c)	20% mechanical engineering of high complexity
(d)	30% control systems and system know-how

Source: Expert interview at Krupp, 23 May 1988

Redundancy on the regional level: loose coupling

Cooperation in the environmental technology complex differs in a second important aspect from cooperation in the coal, iron, and steel complex. The specific characteristics of plant engineering and environmental technology do not allow for the intensive and rigid interfirm linkages that characterize the coal, iron, and steel complex. Rather, firms are 'loosely coupled' in networks. From the perspective of the general contractors, there are several arguments against having highly dependent project partners.

First, such partners will be threatened in their existence as soon as cooperative relations are interrupted, even if this is only for a short time. Interruptions, however, are characteristic of plant engineering because demand is rather discontinuous. Yet the loss of project partners entails high costs in searching for new partners for cooperation.

Second, the general contractors offer their clients not only hardware but also 'co-specialized assets' permitting the greatest possible degree of utilization of the capital-intensive plants (Teece 1986). Above all, these co-specialized assets include training of the plant operators, maintenance services, and spare-part guarantees. Since these co-specialized assets would also have to be provided by the project partners, the interest that general contractors have in the stability of their cooperation partners becomes understandable.

Finally, if project partners cooperate with several partners, it will allow general contractors to realize economies of scale. Individual system components can be offered at a cheaper rate if utilized repeatedly.

Loosely coupled networks create opportunities for sharing the learning experience of cooperating partners that results from their exchange relations with third parties. Loose coupling thus increases the learning capacity of networks: 'The premise that all economic exchanges must also be occasions for reciprocal learning implies that the parties anticipate problems, and that the problems will be solved jointly' (Sabel, Herrigel, Deeg, and Kazis 1989: 389). Moreover, one of the key advantages of loosely coupled networks is their ability to disseminate and interpret new information. Information passed through networks is 'thicker' than information obtained in the market, and 'freer' than information communicated in a hierarchy (Kaneko and Imai 1987). An innovation 'can reach a larger number of people, and traverse greater social distance . . . when passed through weak ties rather than strong' (Granovetter 1973: 1366). Loosely coupled networks are particularly adept at generating new interpretations. It is this ability to generate new interpretations that is essential to the region's capacity for self-organization and learning to learn.

RESISTING ECONOMISTIC TEMPTATIONS: A POLITICAL CONCLUSION

As Weick emphasizes,

> loosely coupled systems may be elegant solutions to the problem that adaptation can preclude adaptability. . . . In loosely coupled systems where the identity, uniqueness, and separateness of elements is preserved, the system potentially can retain a greater number of mutations and novel solutions than would be the case with a tightly coupled system. A loosely coupled system could preserve more 'cultural insurance' to be drawn upon in times of radical change than in the case for more tightly coupled systems.
>
> (Weick 1976: 7)

This cultural insurance is provided by investments in redundancy. However, purely market-oriented considerations will most probably result in low investment in redundancy because of the difficulties of calculating their future returns: 'the economistic temptation'.

> Redundant capacities are difficult to build in markets and through, or against, hierarchies, even if investing in them would open up superior market opportunities. . . . To the extent that individual interests are not sufficiently instructive for investment in redundant capacities, following such interests may be the same as violating them – by letting present, short-term, defensive opportunism deprive actors of their capacity for future, long-term, offensive opportunism.
>
> (Streeck 1991: 36)

In the absence of conclusive market signals as to where redundant capacities are best developed, their generation calls for regional policy that redefines incentives and disincentives of regional actors and actively provides redundancy.

At least two decisive steps towards the encouragement of redundancy have been taken by the Ruhr and the *Land* North Rhine-Westphalia in the last few years. First, Ruhr politics traditionally focused on a single target. For decades, politics for the coal, iron, and steel complex reflected the self-conception of the dominant coalition that the Ruhr had a special 'production mission' within the national economy. This ideology gave way to an increasing differentiation of political targets. This reorientation was first indicated by the Ruhr programme (*Aktionsprogramm Ruhr*) and later deepened by a further technology programme (*Technologieprogramm Wirtschaft*) and the *Land* initiative for future technologies (*Landesinitiative Zukunftstechnologien*). These programmes are not simply aimed at substituting the support of environmental technologies for the support of the coal, iron, and steel complex; they also cover a broad range of related technology areas. Second, the new Ruhr programmes reveal a shift from a centralized approach based on financial transfer to a decentralized approach including real transfer. The future initiative for the coal, iron, and steel region (*Zukunftsinitiative Montanregion*) marked this shift in instrumental design clearly. Achievement of this initiative's aims – support of innovation and qualification, modernization of infrastructure, and improvement of environmental conditions – is left to the local level. Political and financial support is thus no longer allocated to specific programmes but to specific projects that involve a rather broad range of actors at the local and regional level.

Whereas the traditional attitude was to produce master plans with a single clear-cut target, the new programmes focus on 'enabling conditions'. Above all, this orientation is manifested in the attempts to improve the regional infrastructure supporting institutions involved in the transfer of information and know-how. In fact, the Ruhr has made considerable headway in developing its support infrastructure in recent years. Information and innovative services are provided by the Centre for Innovation and Technology in North Rhine-Westphalia (*ZENIT*), community-owned technology centres such as the *Technologiezentrum Dortmund*, information centres of trade associations such as the Chambers of Commerce and Industry (*Industrie-und Handelskammer*) and the Chambers of Crafts (*Handwerkskammer*), information centres of the unions, and the transfer institutions of the universities.

However, a transformation of this infrastructure into an effective support system for loosely coupled networks seems to depend on two basic conditions. First, the efficacy and efficiency of this support infrastructure is not determined by the mere number and variety of institutions providing innovative services. In other words, the performance of the regional support infrastructure cannot simply be improved through the continued formation of new institutions. Only when these institutions are linked together do their individual information supplies and problem-solving capacities add up to a support infrastructure with a high level of redundancy. After all, connectivity creates a much greater degree of cross-connection and exchange of information than may be needed at any given time. It is exactly this kind of redundant institutional infrastructure that seems appropriate for the initiation and support of loosely coupled networks. Linking together these institutions increases the knowledge about complementarities in regional industry, for these institutions are mostly concerned with a specific clientele. The association of the Chambers of Crafts, for example, is by definition assigned to serve small craft firms. Thus, linking different institutions may uncover potentials for cooperation between firms of different size and technological specialization. Bringing together firms with complementary resources and abilities seems to be especially important in the area of environmental technology and plant engineering:

> They come closest to representing a production type of the future which brings together components of different sectors and contributions from various areas of technology in an interdisciplinary fashion and further develops them into tailor-made applied solutions.
> (GEWOS, GfAH, and WSI 1988: 151)

Second, the formation of new regional institutions and the thickening of the regional infrastructure have cast doubts on its efficiency. These doubts underlie the recommendations to streamline the regional infrastructure in order to reduce overlapping responsibilities and problem-solving capacities. However, streamlining the infrastructure according to a narrow economistic logic of efficiency may have counterproductive effects because 'the fragmented, overlapping and seemingly redundant character of the public and private institutional network . . . is, paradoxically, the most efficient way to provide services to decentralized production', as Herrigel (chapter 11: 232) concludes from his analysis of Germany's most successful regional economy, Baden-Württemberg.

Probably one of the major challenges for the long-term future of the Ruhr is to resist the economistic temptation of rigidly streamlining industry and the politico-administrative system in order to optimize the

fit to a specific economic environment. As the decline of the coal, iron, and steel complex has demonstrated, adaptation may lock a region into its trajectory and undermine its ability to learn and self-organize, that is, it may lead that region into the trap of rigid specialization. The Ruhr did not suffer from a lack of external adaptation, nor of internal coherence. On the contrary, it suffered from a pre-*perestroika* consensus culture, from a lack of constructive conflict, and creative chaos. Perhaps one should bear this in mind when reading accounts that stress the superior adaptation and internal coherence of the successful regional economies of today.

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