Technovation, 12:4 (1992) 257–278

Applied research and industrial development in East Germany: International comparison by performance indicators

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Abstract

The 'spotlight' trained in this inquiry on East German R&D consists of four differently 'coloured' and differently directed 'light beams':

- *invention activities originating from East German domiciles or company registered offices are analysed insofar as they were duplicated by a patent application abroad in West Europe, indicative of the* portion of East German technology important for export;
- *likewise, East German patents awarded at the US Patent Office were examined in order to identify a non-obvious overseas market for the traditional business dealings of East German combines, thereby obtaining a* strong selection of the economically most important East German technology;
- *East German science dependence is identified by a new quantitative method. The indicator deduced therefrom for science involvement points to the* relative proximity of industrial technology to scientific research;
- *R&D activity in the field of telecommunications was investigated as part of a case study of selected technical work areas in East Germany. The* institutional and regional structures of East Germany in telecommunications *are discussed both in regard to time trends and also at the micro-level.*

The conclusions yielded by this selective approach for the current transitional situation in East German Federal States (Länder) are deduced as carefully as possible; they cannot, in all conscience, be substantiated, as this would fall outside the terms of reference of this hastily conducted inquiry.

1. Introduction

The general approach to formation, processing and interpretation of science and technology indicators is not presented in detail in this paper. In the German-language primary work on which this publication is based, details are given of three methodologies [1–3].

The considerations dictating the use of scientific and technological indicators centre around a cybernetic model in which the research and innovation process is understood to be a highly complex and labyrinthine activity defying description by a sequential or 'linear' model [4]. However, according to the so-called 'Frascati definition', certain phases are distinguishable. Important identifiable phases are primarily (largely public) fundamental research and (largely private) industrial product and process development (industrial technology). The simple idea behind the model is that inputs are observable into this research and innovation 'black box', namely largely financial R&D expenditure plus personnel resources (R&D personnel). On the 'output side', research and innovation events generate returns which consist, for example, of scientific publications (largely in the field of fundamental research), patents (largely in the field of industrial development), and finally new products and processes. Both outlays and returns can be measured quantitatively, *i.e.* statistically. Such measures are, however, fraught with major difficulties, since the measurement specifications are neither subject to a general convention nor derivable from a general science, technology or innovation theory which is not available. Consequently, it has come into use, not to measure research and innovation performance directly, but to use *indicators* representative of the science and innovation process. The use of literature or patent statistics represents the 'returns' indicator, bibliometrics (literature statistics) tending rather to reflect the results of fundamental research, strategic research and science generally, whilst patent statistics are valid within the field of industrial R&D activities. Science and technology indicators are used along these lines in the following chapters. Details about data sources and computation of indicators are available in subsequent sections.

The second section deals with patent activities from inventors and companies having their domiciles or company registered office in East Germany. But only patent applications in other Western European countries, namely the German Patent Office or at the European Patent Office, are considered in order to filter out the internationally important technical trends in East Germany. The activities are divided according to a coarse sectoral model, which divides modern technology into 28 areas. The presence of a patent application in another Western European country guarantees selection of export-significant technology, inventions from the hobby area and those with a possibly ideological basis being suppressed. Foreign currencies were required for overseas patent applications so that at least a rough cost-benefits analysis can be assumed. Also, possible patent activities with significance solely for the protectionist East German home market or the common socialist economic market are excluded. At the same time, the inventions selected exist within the customary western patent system, and were processed in line with the patent law considerations applying in those countries. They may thus be compared to western industrial property rights.

The third section further canalizes the above approach by referring only to East German patent activities in the US. This is merely looking at the 'tip of the iceberg', because only very few East German inventions that appear in the west go through the US application process. The reasons for this are, on the one hand, the ever higher costs of foreign currency, which can be entertained only if subsequent marketing in the US is planned and, on the other, the fact that a non-obvious overseas market for the traditional business dealings of East German combines is involved (such markets also being located very far away distance-wise). In the case of patents at the US Office, inventions actually patented were used as the data basis, whereas in the second section, mere application sufficed as the criterion for quantifying the returns from invention activities from East Germany. As only patent awards are used in the case of US foreign patents, those inventions which have cleared the patentability, novelty and invention status thresholds (per the US system which sets high standards) were selected. This record is divided up into economic sectors of probable use.

In the fourth section, East German technology is evaluated by reference to its science-dependence.

Technological areas differ in terms of their direct dependence on prior scientific work. Lines of technical development with strong affiliations to the field of (public) research can be evaluated on a formal basis via the frequency of reliance on scientific publications in patent document search reports. Prior state of the art *in technology* in patent applications, once again, is usually described by patent documents. Only if scientific knowledge transfers directly into industrial use do patent examiners at patent offices fall back on citation of scientific publications. The indicator deduced therefrom for science involvement can thus enter into the comparative proximity of industrial technology to scientific research.

In the fifth section, a selected technical working area of East Germany is considered. An analysis is conducted of R&D activities in the field of telecommunications. This is tantamount to being a micro-analysis, *i.e.* an investigation of active institutions (public research system, combines) in the field of telecommunications in the broadest sense (*i.e.* including glass fibre optics, communication theory, relevant software, radar, etc.). The institutional structure of East German telecommunications is presented in detail for 1986; chronological trends are shown in summarized form. The field of telecommunications is then divided into 11 sub-areas. This investigation does not cover patents, but is based on publications (from science, combines and so-called grey literature).

Certain conclusions are drawn in the sixth section that in view of the changes taking place in East Federal states cannot be properly substantiated. One limitation is that inquiries relating solely to science and technology indicators, and not underpinned by subjective and other empirical evaluations, are less valuable. The inclusion of quantitative information in other findings would have been preferable, but the terms of reference of this study alone precluded this.

Owing to the fact that, under the terms of reference of this inquiry, a general qualitative and subjective assessment of the source data was out of the question, the attempt was made to consider the direction and intensity of technology development in East Germany from the four various (quantitative) angles mentioned. Thus, it is hoped from experience that the inevitable distortions in science and technology indicators will, to some extent, cancel one another out as the project is undertaken with entirely different approaches and delimitations.

2. Patent activity by East German inventors in Western European countries

Hitherto, East Germany has been subject, in patent law terms, to conditions deviating from those applied in the west, and dictated by socialist ownership principles. Consequently, domestic patent applications at the former Office for Inventions and Patents of East Germany (AfEP) are hardly comparable to those in the west. The main difference lies in the fact that the conventional patent modelled on the western one had very little value other than as the so-called 'economic patent'. Of the 10 073 East German domestic patents applied for in 1989, 10 026 were economic patents and only 47 conventional exclusive patents [6]. Economic patents have therefore accordingly been regarded as the essence of socialism. Inventions were supposed to be used by society as a whole, as competitive attitudes were alien to socialism and a fundamental consensus of interest apparently existed between various social groups and strata [6]. The economic patent did not bring the East German company or patentee any additional profit expectations. Moreover, the company only had very limited decisionary powers, because production targets were predetermined by imposed state plans. The strategic interests of the company were thus distorted (*op cit.*), and consequently it could not be assumed that the scope, technical distribution and commercial importance of patent activity *in* East Germany was comparable to the corresponding parameters for West Germany.

Therefore, another approach has been adopted for this section of the investigation; East German technology has been depicted in terms of its patent activity in other Western European countries. For instance, in 1988, around 600 patent applications were submitted from East Germany to the West German or European Patent Office. Western Europe and the then Federal Republic of Germany, in particular, formed part of the preferred foreign market for East Germany outside the Council for Mutual Economic Aid (CMEA). This is more or less evident from the fact that still only one tenth of patent applications for West Germany have also been recorded at the US Patent Office. The basis used for Western European patent applications by East Germany is a means for circumventing all socialist patent law peculiarities and achieving direct comparability to western countries.

The existence of foreign applications is generally regarded as a criterion for the quality of the respective invention [7]. This particularly applies to East Germany or the entire socialist economic bloc, since the filing of patent applications in Western European countries always entails resort to foreign currencies which are usually only very limitedly available, and then only on special grounds. The assumption can therefore be made that patents for which a foreign application has been made to Western Patent Offices are closely connected to export-relevant technology, and have the corresponding technical and economic ranking.

This section deals particularly with East German inventor application activity at the German Patent Office (DPA) or at the European Patent Office (EPO). First, the general patent pattern is presented, and this is followed by an examination of the strengths and weaknesses of East Germany with regard to various fields of technology and presentation of the current trend. Let us start with a few facts about methodology.

2.1. Methodological information

The year of invention (priority year) of the patent document is used as the time basis. The year of invention corresponds to the time of the original domestic application, *i.e.* in East Germany, and hence to the period of invention or origin. The applicant then has a period of 12 months within which to register the invention, with identical priority year, with foreign Patent Offices.

The assessment of strengths and weaknesses in various areas of technology already referred to is based on division of technology into 28 sectors. The modern technology classification used here was constructed by FhG-ISI for the purpose of technology monitoring. It has already been used in several inquiries (for the German Federal Ministry for Research and Technology [2], the Research Committee of the Federal German Parliament [8], the Dutch Economy Ministry [9], the Volkswagen foundation [1], etc.). The International Patent Classification (IPC) with its 60 000 items, was taken as the basis. Fields of technology were usually based on IPC classes, while in exceptional cases IPC subclasses were used for the allocation.

The classification was done with the help of scientists from various Fraunhofer Institutes. It is therefore possible to model modern technology clearly in terms of 28 technological fields (compare Fig. 3 and [2]).

Strengths and weaknesses in individual fields of technology are measured with the aid of the RPA (Revealed Patent Advantage) specialization indicator. The RPA shows whether a country — in this case East Germany — has above or below average engagement in a particular field of technology relative to its other patenting activities. RPA is defined as follows [10]:

$$\mathrm{RPA} = 100 \tanh \ln \left[(P_{ij}/\Sigma_i P_{ij})/(\Sigma_j P_{ij}/\Sigma_{ij} P_{ij})\right]$$

where: P_{ij} = number of patents in country i for a field of technology j,

$\Sigma_j P_{ij}$ = number of all patents from country i at the Patent Office considered (in this case: DPA or EPO),

$\Sigma_i P_{ij}$ = number of patents from all countries i for technology field j,

$\Sigma_{ij} P_{ij}$ = number of all patents from all countries i for all technology fields j.

If the RPA value for a technology field j is zero, then an internationally average application activity exists in the field concerned. Negative values are indicative of below average activities, and positive values reflect above average application activities.

The trends in application activity are measured by linear regressions. The question is raised as to whether existing changes in application behaviour are or are not significant. At the same time, various stages in significance level are considered.

2.2. Structural changes in East German technology

Figure 1 shows all application activities by inventors from East Germany at the DPA or the EPO between 1979 and 1988, and compares them with the trend for domestic application. Two year periods respectively are considered.

Between 1979 and 1982, the number of foreign patents applied for remains more or less constant. A 14% increase is discernible from 1981/82 to 1983/84. For the subsequent period 1985/86, only slight growth in the number of patent applications is in evidence. In 1987/88, the number of patent applications dropped by 5·5% relative to the previous period. The restrained chronological trend is found to be similar to domestic patents, but overdrawn. Both time plots thus correlate with one another in Fig. 1.

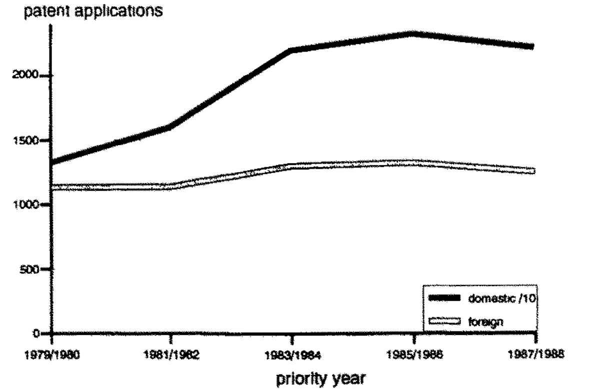

Fig. 1. East German patent activities in Western European countries by priority years 1979–88 in comparison to the domestic trend (shown reduced by a factor of ten).

How can the decline in patent incidence — counter to the international trend — be explained? The primary explanation lies in institutional structural changes. Measured in terms of commitment of financial resources and R&D personnel, East German R&D is centred squarely in the industry sector. This is also reflected in patent incidence. The vast bulk of patent applications come from the company sector. Changes in the percentage distributions of patent applications in the enterprise sectors are reflected in Fig. 2.

From 1981/82 to 1983/84 and subsequent periods, a constant decrease is evident in the percentage patent applications from the economy. Analysis using linear regression yields an almost significant trend, *i.e.* the error probability is 10%. Change in the allocation of R&D personnel and financial resources can be regarded as the most important triggers of structural change. Since 1981, the percentage of R&D employees in the economic sector decreased continuously relative to all R&D employees; in absolute terms it stagnated [11]. This decline is reflected in the falling percentage of the patent applications by the firms, owing to the much greater patent propensity of the company compared to the university and state sector. Likewise, the percentage decline in financial resources for R&D in the industry sector, as reflected in Fig. 2, has also not been without effect. Up to 1985 a slight increase was still in evidence, but thereafter, from 1985 to 1987, there was an 8·6% decline. The decline in both

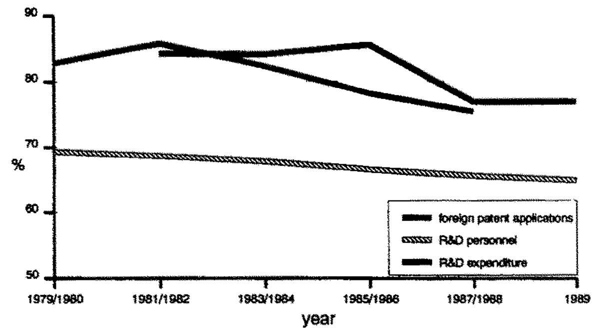

Fig. 2. Respective percentages of firms in national foreign patent applications, R&D expenditures [11], and R&D personnel deployment [11].

resource factors was triggering a drop in the absolute number of patent applications in 1987/88 in the overall number of patent applications, because the two other sectors were unable to make up the shortfall by firms owing to restrained patent propensity. For the decline in the proportion of R&D personnel, and also the percentage financial expenditure on R&D in the industry sector, there is a virtually significant connection with declining percentage in the company sector for all East German patent applications in Western Europe (error probability of less than 10%).

2.3. Specialization profile

By considering activities relative to the 28 technology fields already described, areas should be identified in which East Germany has specialized particularly, or in which it displays weaknesses. Patent activities are therefore evaluated comparatively over the two time periods 1979–1984 and 1985–1988 in order to highlight any shifts. Figure 3 clearly reveals that above average patent activities are present only in few areas. East Germany's particular strengths lie in the fields of paper and printing, textiles, machine tools, handling, optical equipment, and measurement technology. Clear weaknesses, on the other hand, are discernible in the areas of chemistry, electrical engineering, electronics, information technology, and transport and traffic. These pronouncements are equally valid for both time periods. The specialization strategy is therefore unchanged throughout the entire period considered. By the end of the 1980s, weaknesses in electronics, image transmission and information storage are even more obvious than before.

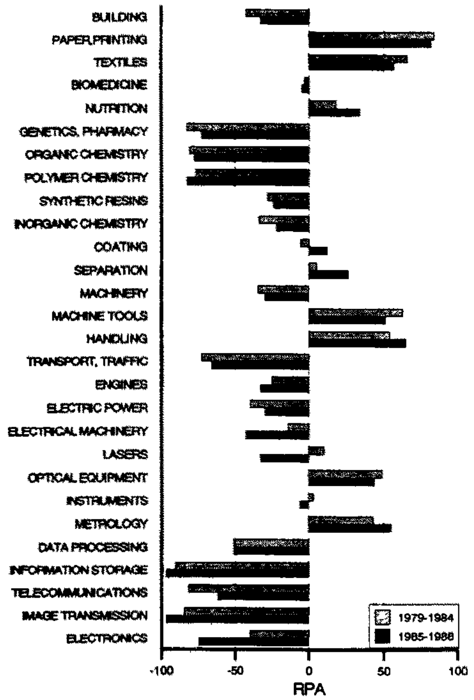

Fig. 3. East German specializations in applied research and technology (RPA indicator) 1979–88.

2.4. Chronological trends

Can trends be deduced from the state of affairs presented in the preceding section? Measured against the chronological changes in RPA indicator, there is an upward trend for the areas of genetic engineering and pharmaceuticals, process technology, handling plus transport and traffic. Despite increasing activities in these areas, both genetic engineering and pharmaceuticals, not to mention transport and traffic, as previously are among those characterized by patently sub-average activities.

Not quite so marked, but nevertheless positive, are developments in telecommunications technology and measurement technology. The case is the same for telecommunications technology as for genetic engineering and pharmaceuticals and transport and traffic. It is still in the area of below average activities. In the measurement technology area, on the other hand, the existing good position is being further extended.

Negative trends are detected for the technology fields of machine tools, engines and electronics. Despite the slightly downward trend, the machine tools area is still in a good above average position.

The only slightly negative trend, nevertheless, ought to be regarded as a respectful signal, because it correlates with distinct weaknesses in electronics and information technology areas which at times of increasing computerization also affects the machine tools area — key word: CNC machines, among other things — but only leave comparatively scant traces behind. As regards the other technology fields, no clear-cut pronouncements in regard to trend whether positive or negative in direction can be made from the existing data.

2.5. Micro-analysis: Invention activities of combines from the chemical industry

In this section, the application activities of the four major chemical combines, Bitterfeld, Buna, Leuna and Wolfen, are considered. The inquiries relate exclusively to patent applications at the German or European Patent Offices, *i.e.* Western European foreign applications are covered. The period going back to 1968 is depicted.

Putting all four combines together, in all there were 250 patent applications. The contribution by the combines in this figure varied very widely. The Bitterfeld Chemical Combine applied for 36 patents, the Buna Chemical Works accounted for 19 patents. A substantially larger proportion of patent applications originate from the 'Walter-Ulbricht' Leuna Works. In all, 98 patents were applied for by this combine. Amongst the combines considered here, the Wolfen Photochemical Combine, with 97 patent applications, is an equally important technology producer. Overall, no consistent strategic procedure was discernible for the four combines considered with regard to breadth of innovation-oriented activity distribution. The entropy index (equality index S) is used for evaluating the breadth of specialization in various areas [12]. The entropy index gives the equality of activity participation. The entropy is nil if activities are evident in one area only. Small values therefore denote marked limitation and focusing on specific areas, large values are characteristic of a high consistency of activity distribution over all possible patent classes. The index is independent of the number of patent applications.

For the combines considered here, it was discovered that the Buna Chemical Works displayed the most marked niche strategy. All 19 patents related to macromolecular compounds. The entropy index has the value $S = 2{\cdot}0$. Specializing equally strongly in one main area is the Wolfen Photochemical Combine with $S = 2{\cdot}2$. The two other combines pursue a broader-based strategy. For the Bitterfeld Chemical Combine, the entropy index S was found to be 2·7. Broader still is the technological spectrum of the Leuna Works, with $S = 3{\cdot}0$. The divergent approach to chemistry is already evident here. Buna and Bitterfeld with few patent applications are pursuing equally diverse strategies like Leuna and Wolfen with comparatively numerous patent applications. Buna shows the hallmarks of marked niche strategy (few in number and narrow based), whereas the comparatively few patent applications from Bitterfeld are broad-banded. The same is true of Wolfen and Leuna. Wolfen concentrates its comprehensive activities on a comparatively small field, unlike Leuna with its super-diversified palette of patent categories, and hence breadthwise is comparatively innovation-intensive.

Differences between the combines also emerge when financial expenditure on R&D are examined. Thus the percentage R&D expenditure for 1989 at the Leuna works accounted for 1·3% of production, Buna allocated 1·2% to R&D, at Bitterfeld it was 2·6%, and at Wolfen the percentage was 6·3% of production value. Insofar as the personnel employed in R&D are concerned, the differences are not so decisive. Here, too, Wolfen is certainly the largest at 10·6% (1988); then comes Leuna with 7%, Bitterfeld with 6·8% and Buna with 5·3% [13] of total staff.

If development of R&D personnel for the years 1981, 1985 and 1989 is considered (Table 1), then the same trend is identifiable for the combines as for the economic sector as a whole: the percentage of R&D employees has been declining since 1981. At Bitterfeld, the downward trend is evident only from 1985 to 1989, the same applies to Wolfen.

Comparing Western European patent applica-

TABLE 1 Percentage of R&D personnel relative to employees for four chemical combines[a]

	1981	1985	1989
Bitterfeld	7·5	7·5	6·6
Leuna	7·7	7·1	6·9
Buna	6·8	5·7	5·2
Wolfen	9·4	10·5	10·2

[a]Source: R. Lüdigk, 1991 [13].

TABLE 2. Foreign patent applications per million employees for 1988 in the European comparison

Switzerland	584
West Germany	383
France	179
Austria	151
UK	124
Belgium	101
Italy	78
East Germany	73
Spain	12
Greece	4

tions since 1968 (as an R&D return parameter) against R&D expenditure (as an R&D input parameter from 1975 to 1989 owing to the absence of earlier figures), a rough R&D effectiveness indicator is obtained. If the ratio of the two parameters for Buna are set arbitrarily at 1, then the Bitterfeld combine is 1·2 times, Wolfen 3·8 times and Leuna 4·4 times more effective. Since differences in foreign patent propensity, specific patent utility of the respective technology, currency availability and the foreign target markets for the products are not known, it would be precipitate to try to conclude overall that a different operating R&D efficiency is involved.

2.6. International comparison

Considering the Western European patent activities of the former East Germany in absolute terms, then clearly it is much smaller in size than West Germany. Standardization can be obtained by reference to employment. What would be a reasonable yardstick for comparison with export-oriented Western market economies? The authors are of the opinion that the export threshold of the former East Germany to West Germany should be rated higher than between EC countries. Therefore, Western European East Germany patents ought to be compared with those of Western Europeans at the European Patent Office (EPO). Owing to higher fees, it can be assumed that European patent documents for Western European inventions usually exist if the intention is to obtain patent protection in three or more European contracting countries [15]. European patent documents thus have the status of foreign patents for high export thresholds. Table 2 provides a comparison of the corresponding EPO patents of selected countries with the Western European ones from East Germany. Clearly, the innovation intensity of East Germany roughly corresponds to that of some of Europe (Italy), definitely surpasses that of Spain, and is very close to the figures for the UK. East Germany does not compare with the patent-intensive countries (Switzerland, West Germany).

3. Patent activity of East German inventors in the US

3.1. General overview

In the preceding section, the patent incidence of East Germany at the German (and European) Patent Offices was analysed. Now a similar investigation will be conducted on activities at the US Patent and Trademark Office (USPTO). A few differences arising out of patent office procedures have to be taken into account. Analysis of patent activity at USPTO always relates only to existing patent awards, because only these are published by USPTO. Owing to the use of their own national patent classification at USPTO, it is difficult to divide modern technology into 28 technology fields as for the IPC classification. The basis for analysis at USPTO is the Standard Industrial Classification (SIC). Patents have been classified

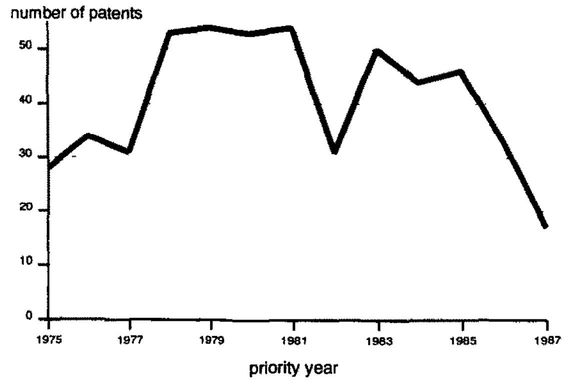

Fig 4. East German patent incidence at USPTO 1975–87 by priority years.

according to SIC categories, and therefore according to their presumed commercial application.

East German patent activity at the USPTO is distinctly lower than in Europe. Once again, low foreign currency availability in East Germany is a contributing factor, so that on these grounds, only high quality patent applications were submitted. Add to this the small market propinquity factor between East Germany and the US.

Figure 4 shows East German patents at the USPTO for the priority years 1975–1987. Owing to the 'modus operandi' of only publishing patent awards, it is possible that both 1986 and 1987 still do not contain the full complement, since the award, and consequently also publication, may be delayed up to four years, or even more.

Delayed commencement of application activities by East Germany was politically motivated. Only when East Germany in 1970 became party to the International Patent Cooperation was there a definite opportunity to apply for patents officially at USPTO, because the US acknowledges commercial patent rights on a reciprocity basis only. As searches have subsequently found, East German applicants even earlier have discovered ways of securing patent awards at USPTO. However, in those days, patents were not applied for under the East German country code, so they were therefore also not detectable in searches at USPTO using this code. Only during searches for specific applicants it was possible to gain access to these patents which frequently, although not exclusively, were located under the West German country code. Owing to differences in search strategy, it is therefore necessary to differentiate between East German patents with a pre-1974 (unofficial) priority year and a post-1974 (official) priority year.

Invention activity by official East German applicants reached an all-time high between 1978 and 1981. During this period, every year a good 50 later patent awards ensued. Overall, East Germany registered 1028 patent awards at the USPTO. Of these, 528 patents were dated for the 1975–1987 period. The other 495 patents were pre-1975. Since 1982, US patent activity has been declining somewhat. In comparison to Western European activities, it is obvious that the US patent market responded earlier to structural change in East Germany (see section 2, in particular Fig. 1).

3.2. Specialization according to commercial application

Owing to the small number of patent awards, it would be inappropriate for an analysis to be conducted for East Germany on areas with low aggregation level. It is much more reasonable to consider aggregated categories (according to SIC). The mechanical machinery, chemistry, electrical machinery, textile production, foods and scientific equipment areas were selected. There were so few patents available for other possible areas that more searching investigation appeared to be pointless. Within the listing, East Germany's strong points are in the mechanical machinery (including printing technology) and scientific equipment areas, both areas exhibiting relatively constant specialization indicators (RPA values).

From a very good position between 1975 and 1977 to roughly average specialization in 1984/86, activities in the textile production field declined, whilst food technology has also fallen to average levels. In this area, patent activities peaked between 1981 and 1983. Weaknesses in electrical machinery and chemistry are particularly evident. The chemistry area declined from average activity level by 1983, to a distinctly sub-average level between 1984 and 1986. All other branches of the economy used are represented by so few East German patents that overall they can be included among the East German weaknesses.

Regression analysis failed to reveal any clear-cut trends. The values for the quadratic correlation coefficients are still below the 10% error probability area. Trend analyses reveal comparatively constant activities for the areas of scientific equipment and machine construction, while other areas tend to fluctuate.

3.3. Specialization according to R&D intensity

The procedure for analysing US patent activities for East Germany in the high-tech area is as already adopted for western countries [14]. High technology is divided into leading-edge technology and high-level consumer technology. The respective R&D-intensive goods were determined on the basis of R&D intensity, *i.e.* internal and external expenditures on R&D relative to turnover — in the case of sectoral division — or to production value — in the case of product-related classification. Bearing in mind the developments at the end of the 1980s, the cut-off thresholds have been determined as follows (for substantiation see [14]): the area of high-level consumer technology within an R&D intensity of between 3·5% and 8·5% and the leading-edge technology area over an R&D intensity of 8·5%. The high technology area as a whole thus comprises all product areas with an R&D intensity of over 3·5%. The corresponding list contains 57 3-digit groups of goods referenced per the Standard Industrial Trade Classification (SITC III) [14] that has been assigned to the corresponding SIC categories. Using the RPA indicator, once again a specialization profile can be prepared for the high technology area. Figure 5 shows specialization in leading-edge technology and high-level consumer technology for East Germany with respect to time.

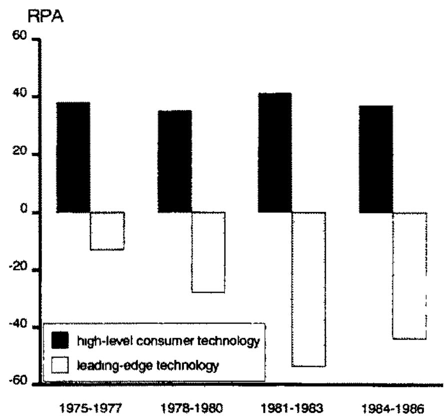

Fig. 5. Specialization of East German US patents for R&D-intensive technologies 1975–86 by priority periods.

Clearly, East Germany's strengths lie in the area of high-level consumer technology whereas its leading-edge technology side is weak. The specialization profile for East Germany in the R&D-intensive technologies in this respect corresponds to that of West Germany, which likewise sets great store by high-level consumer technologies and displays weaknesses in leading-edge technology. However, East Germany's specialization in both areas is more markedly pronounced than that of the then Federal Republic.

Analysis hitherto shows that East Germany's activities particularly concentrate on certain selected areas. This is also true of the high technology area. For smaller countries, the need for specialization in a few areas is a necessity owing to limited R&D facilities, plus it is an established fact that such countries can definitely be on a par with the large countries in these technological niches.

Deviation of technological specialization away from the world average apparently increases with decreasing R&D budget. This relationship is illustrated in Fig. 6. The mean quadratic deviations of the specialization pattern from the 'world standard' (standard deviation) are graphed [14].

A highly significant relationship is obtained between the overall financial expenditure on R&D (GERD according to OECD figures in US$ converted by purchasing power parities), and the

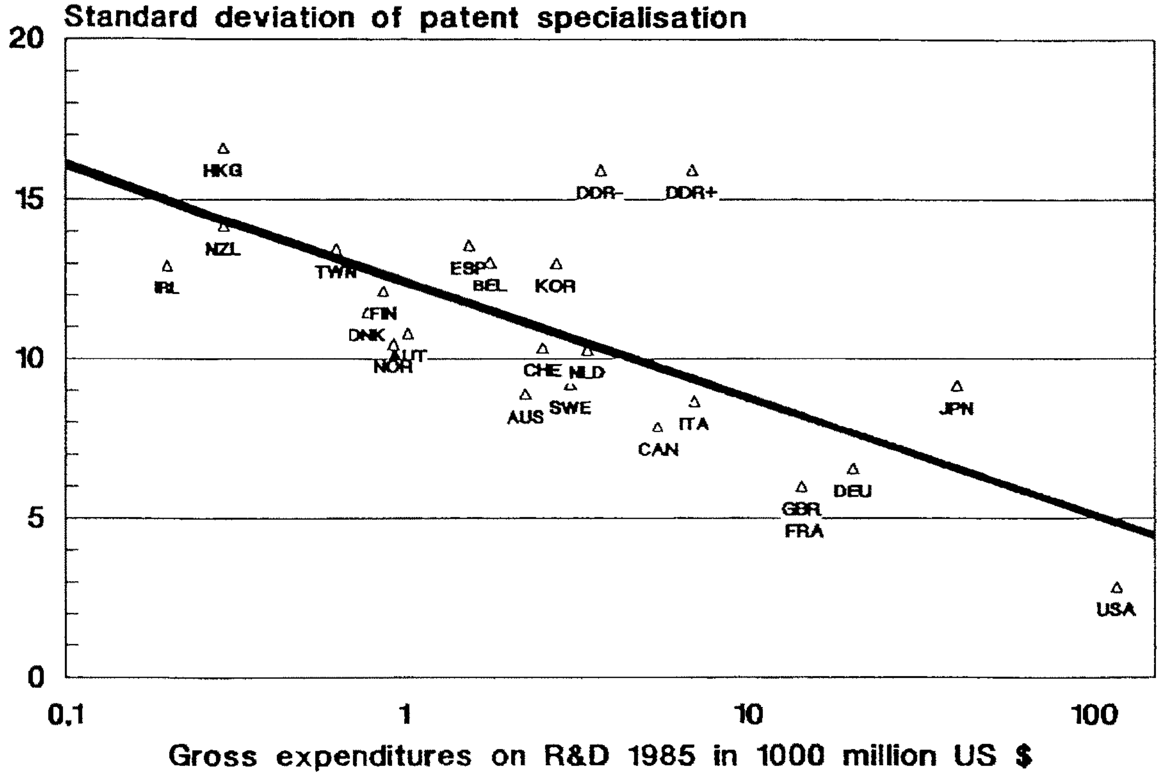

Fig 6 Standard deviation of technological specialization for 1984–86 from the world average as a function of national R&D expenditure for 1985 (country codes by ISO standard: AUS = Australia, AUT = Austria, BEL = Belgium, CAN = Canada, CHE = Switzerland, DEU = West Germany, DDR = East Germany, DNK = Denmark, ESP = Spain, FIN = Finland, FRA = France, GBR = UK, HKG = Hong Kong, IRL = Ireland, ITA = Italy, JPN = Japan, KOR = Republic of Korea, NLD = Netherlands, NOR = Norway, NZL = New Zealand, SWE = Sweden, TWN = Taiwan).

degree of specialization or technological niche strategy. For East Germany, the figures had to be adjusted for R&D disbursements quoted only in East German Marks and not convertible into US dollars (at any rate, not using established OECD purchasing power parities). The conversion data for 'DDR-' were obtained using the so-called 'market-basket' (consumption pattern); however, in order to obtain realistically comparable values for the 'DDR+' data evaluation, subsidies available in East Germany were taken into account.

With a few exceptions, all countries are close to the regression. However, the deviating patterns of Japan and also East Germany, plus those of Korea, Spain, Belgium and Hong Kong, are evident.

Bearing in mind the facilities available for R&D, these countries are pursuing a more definite niche strategy. The concentration on selected areas is clearly more strongly emphasized than is reflected by the world average. East Germany is particularly strong in mechanical machinery, and also in instruments. This statement about East Germany is by the way independent of the vagaries of the dollar value of the Eastern mark.

3.4. East German institutions with US-oriented innovation activities

The applicant list (Table 3) covers the ten most important organizations identifiable as patentees at USPTO. Wherever possible, individual firms

TABLE 3 Top ten East German patentees in the US

Name	No. of patents Total	No. of patents Since 1975	Cumulated total (%) Total	Cumulated total (%) Since 1975
Combine Carl Zeiss Jena	232	110		
Combine Polygraph Werner Lamberz Leipzig	194	122	41·2	40·3
Combine Textima Karl-Marx-Stadt	93	59	50·1	50·6
Pharmacentical Combine Germed Dresden	46	27		
Academy of Sciences of the GDR	46	23	59·0	59·3
Combine Micro-electronics Erfurt	33	30		
Combine Fortschritt Landmaschinen Neustadt	30	24	65·1	68·7
Photochemical Combine Wolfen	24	10		
Combine Schwarze Pumpe	22	21		
Leuna Works Walter Ulbricht	22	8	71·7	75·5

have been assigned to the combines. Overall, 103 patent applicants (leaving merely 168 patents unassigned) have been covered. Strikingly, the majority of patent applications, namely over 75%, are contained within the small 'top ten' group. Roughly half of all patents, therefore, originate from only three combines — Carl Zeiss Jena, Polygraph Leipzig, and Textima Karl-Marx-Stadt.

The high percentage once again endorses the statement made earlier concerning the specialization profile of East Germany as a whole. The product range of the Carl Zeiss Jena combine in particular covers fields classifiable within the scientific equipment area, the Polygraph Leipzig and Textima Karl-Marx-Stadt combines belong to the machine construction field. Polygraph primarily produces mechanical and printing machines, while Textima is a manufacturer of textile machinery. For both areas — scientific equipment and also machinery — specialization has been found to be above-average. The combines mentioned are the leading representatives for East Germany in these areas.

The other organizations mentioned in Table 3 come a considerable way behind the first three. They are representatives of various areas, such as chemistry, micro-electronics, mechanical machinery and the Academy of Sciences. The top ten include only the two chemical combines Leuna Works and Wolfen, which are also conspicuously patent-intensive relative to Western European markets (Section 2). The remaining 28·3% (or 24·5% as from 1975) of patent applications are shared among a multitude of small applicants with 1 to 13 patent applications over the entire time period.

4. Science-dependence of East German technology

Evaluation of East German science-dependence in technology entails resort to the results of an investigation into science-intensive technology [2]. Once again, the list of 28 technology fields as already used in section 2 constitute the basis. A so-called 'NPL index' was calculated for each of these technology fields. This indicator suggests to what extent non-patent literature (NPL) has been quoted in search reports from the Patent Office on the prior state of science or technology. The search reports contain both quotations from patent literature, and also from non-patent literature. The assumption is made that references to non-patent literature can be regarded as indicators for science relationship.

The NPL index has been calculated for two year periods. Thus statements can also be made with regard to chronological changes. Furthermore, technology fields have also been considered separately on a country-by-country basis. At the same time, both Olivastro and Narin [16] and also Grupp and Schmoch [2] established that the science-dependence of a technology field is hardly dependent or totally independent of the country. The science-dependence of a technology field is explicable in terms of the nature of the field itself. Consequently, the NPL index which is measured for each technology field internationally is also used for quantifying the science-dependence of East German technology.

The procedure is such that the number of patent applications in a technology field is weighted with the NPL index for the period considered. The *weighted* NPLW indicator represents a facility to assess the closeness to science in actual patent activity per country. It is not so much a matter of whether particularly numerous references to science are contained in the patent literature of a country (because there is little variation between countries), but rather a matter of whether a particular country — the former German Democratic Republic — is more intensively or less intensively active in technical areas with an internationally high science relationship. The NPLW indicator is therefore defined as follows [2]:

$$NPLW_i = \Sigma_j(NPL_j P_{ij})/\Sigma_j P_{ij}$$

Using the same variables as in section 2, NPL_j, the NPL-index, gives the mean, worldwide number of references to non-patent literature per patent in technology area j.

It is obvious from Table 4 that East Germany tends to lag consistently behind the world average in regard to the science-dependence of technology. However, even for East Germany, there is evidence of a highly significant trend of increasing bias towards science-dependent technology.

The constant distancing from world level means that in technology fields with a high scientific involvement, East German patent application activities are proving to be rather below average. One exception is measurement technology. Here, East Germany is above averagely active, and the NPL index points to a high science relationship. Above average activities are also evident in the optical equipment and food areas, for which a comparatively high science involvement has been ascertained. The other fields with above average

TABLE 4. Weighted indicator for the science involvement of East German technology

Period	GDR	World
1979/80	0·41	0·49
1981/82	0·42	0·53
1983/84	0·45	0·57
1985/86	0·48	0·59
1987/88[a]	0·48	0 60

[a] Partly extrapolated.

patent activities such as paper and printing, textiles, machine tools and handling fall in the area with a rather lesser science dependence. In fields with extremely high NPL index values such as data processing, telecommunications technology, image transmission and electronics, patent activities are well below average.

It is important to note, however, that determination of science-dependence is dependent of the definition of field size, *i.e.* on what and how many sub-areas the overall field covers. In practically every field there are sub-areas which have a much higher or lower NPL index than other sub-areas. The value for the entire field is therefore only an average figure. In the analysis conducted above, only the field as a whole was considered. This is explained by reference to the example of the medical laser. For the medical field, an NPL index of 0·21 was obtained and for the laser field this was 1·33 (1985/86, respectively). Medical lasers infiltrate both fields. For this special area, the NPL is 0·84. This means that the value for the special area in both cases deviates comparatively markedly from the field as a whole. Thus, for East Germany, special sub-areas of strong science involvement may have been overlooked.

The rather tenuous science involvement of East German technology is not spectacular in the international comparison. Alongside the marked quasi-scientific R&D systems of the US and UK and the noteworthy research performance of Japan, the conditions in East Germany for continental Europe can be called totally common place. The (former) Federal Republic of Germany, France and other European countries (Italy, Swtizerland, Scandinavia) are of similar ranking [2]. The example of West Germany, moreover, shows that technological competition on international markets is feasible for medium to small participation in science-dependent technology, if other basic conditions are conducive to it — they were not in the case of East Germany. In the case of the enlarged and manifestly huge science operation relative to the size of East Germany it is, however, surprising that technical development has been unable to profit more extensively by this involvement, and has remained comparatively science-impoverished.

5. A typical case: R&D in telecommunications in East Germany

Telecommunications lends itself to citation as a typical example, because in addition to there being a clear-cut connection with application, today the physical fundamentals are becoming ever more important (glass fibres, very large-scale integration, latest software). A multiple paradigm change from the electron transmission medium (copper cable) to light (glass fibres), and from electronic to digital communication, etc., is taking place. The standard of service offered is being extended considerably [3]. The area is among the most science-intensive (see section 4); in the relevant industrial technology, the former German Democratic Republic registers below average in innovative effort (c.f. Fig. 3).

Applied and strategic East German research, but not industrial development, are investigated subsequently using bibliographical methods. Using publication analysis, it is also possible to investigate non-patentable activities in the area of scientific research. In an earlier study, the 'telecommunications' area was divided into nine sub-areas for similar investigations. It is thus possible to make specific pronouncements about activities within the complex 'telecommunications' area. It is also shown which institutions are active in the 'telecommunications' field (micro-level). The nine sub-areas are defined in Table 5. For methods and data, see [3].

5.1. Trends and specialization in telecommunications-related R&D

Figure 7 shows the overall incidence of publications for the years 1973–1987. In this connection, it should be remembered that actual search data at micro-level are only available for years 1975, 1980, 1984 and 1986. The values for other years have been obtained summarily and by interpolation.

TABLE 5. Definition of the telecommunications field[a]

Sub-area code	Heading
TH	Information and communication theory, artificial intelligence
WI	Wired communications (telephone, etc.)
RA	Radio (wireless) communication (satellites, etc.)
IM	Picture transmission (cable TV, etc.) and image communications (facsimile, etc.)
DI	Digital transmission (digital networks, etc.)
FI	Optical communications (fibre optical cables, etc.)
TE	High frequency telemetry (radar, etc.) and telemetering (telecontrol, etc.)
OE	Other equipment (if not included elsewhere, *eg* holography)
SO	Software, services, and policy (frequency administration, etc.)

[a]Source: H. Grupp and Th. Schnöring (eds.), 1990 [3]

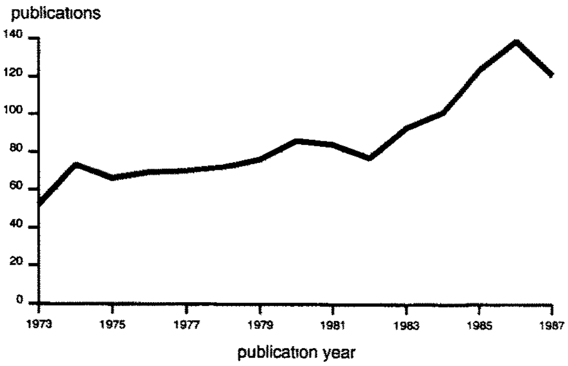

Fig. 7. Publications from East Germany in the field of telecommunications research for the periods 1973–87 (partly interpolated).

Obviously, an almost universal rise in the number of publications is evident over the entire period considered. Only from 1986–1987 does the incidence of publication decline somewhat, which may also be attributable to incomplete data (the search was conducted already in 1988).

With the help of the RLA (Relative Literature Advantage) indicator, which corresponds to the RPA patent indicator already used in section 2, except that publications are used as the basis for RLA assessment instead of patents, pronouncements are made concerning the specialization profile within telecommunications research. The RLA indicator measures the activity of a country in

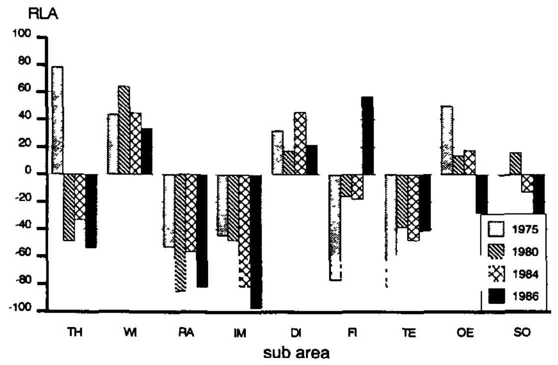

Fig 8 Development, with time, of the specialization indicator for East Germany in telecommunications sub-areas (for sub-area codes, see Table 5).

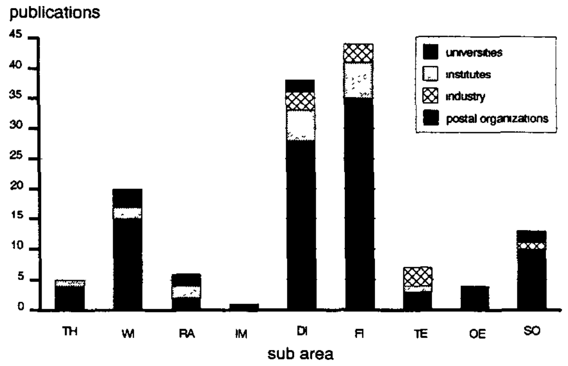

Fig. 9. Micro-level work distribution in telecommunications-related R&D in East Germany in 1986 (for sub-area codes see Table 5).

a specific area of research in comparison to the average activity of the country in all telecommunications sub-areas. It is negative for below-average activity, positive for above-average activity. Where the activity in a sub-area corresponds to the average activity world-wide, then the RLA value becomes zero. Figure 8 shows the development, with time, of specialization in telecommunications sub-areas.

In the theory field, since 1980 activities have been so low that activity is clearly sub-average. However, it should be noted — and this applies equally to all other sub-areas — that in view of the small number of publications overall already minor changes in the absolute figures are markedly affecting the RLA indicator.

Universally above-average activities are apparent in wired communications and digital technology, yet specialization in both sub-areas declined in 1986 in comparison to other years. Work on optical fibre communications has intensified considerably. For the first time in 1986, definitely positive RLA values were apparent corresponding to above-average activities. Below-average activities are evident in radio engineering, and in the image communications and transmission fields, plus telemetering, for the entire period considered.

Figure 9 shows the activities and participating institutions for 1986 only. With a total of 101 publications (73·2%), in 1986 polytechnics and universities had the highest percentage of publication activity in this applied research field. Figure 9 illustrates the division of labor in telecommunications-related R&D for 1986 between polytechnics (and universities), institutes (state facilities), industry and postal organizations. The high percentage of academic research is apparent, but clearly academic research has the broadest coverage of telecommunications sub-areas. No valid pronouncements can be made about the image transmission area.

The specialization profile for 1986 is contained in Fig. 9. In 1986 research — measured on an international scale — focuses on the fields of wired communication, digital communication engineering, and fibre optic communication. Other sub-areas point to markedly below-average activities. Noteworthy it is the impressive international scale of western superpowers in R&D on which this comparative evaluation is based.

5.2. Sectoral distribution

Since universities and institutes have the highest percentage of research in across-the-board telecommunications, the activities of these sectors are shown separately. In this type of enquiry, however, it does not matter whether university research groups are affiliated to physics, electrical engineering or chemistry (glass fibres). Any relevant contri-

TABLE 6 Spread of publications in the telecommunications field over polytechnics and universities (1986)

Name of university	No.	Cumulated %
TU Dresden	23	
HS für Verkehrswesen "Friedrich List" Dresden	22	
TH Ilmenau	12	56·4
Friedrich Schiller-Universität Jena	8	
IHS für Seefahrt Warnemünde	6	
IHS Wismar	6	
Humboldt-Universität zu Berlin	6	82·2
IHS Mittweida	5	
TH "Otto von Guericke" Magdeburg	4	
TU Karl-Marx-Stadt	4	95·0
IHS Zittau	2	
Wilhelm Pieck-Universität Rostock	2	
TH Leipzig	1	100·0

butions to telecommunications have been included, irrespective of classification into established sectors.

In all, 13 polytechnics and universities contributed to the crop of publications for 1986. The three most active facilities yield 56·4% of publications. Assembled in Table 6 are polytechnics' activities for 1986. Leading-edge producers are the same as for the overall period since 1975; their prominent position has not changed. Owing to the few figures available, movements in the lower area are not statistically relevant.

Like polytechnics and universities, the state institutes are strong in the theory field; then come radio engineering, digital telecommunications engineering, fibre optic communication, telecontrol engineering, and signal technology. Below average activities are registered in wired communications. No publications could be found in other fields. Publications assignable to the state institute sector are mostly (1986 = 88%) from various institutes of the Academy of Sciences.

In 1986 in all only nine publications could be discovered for industry. Of these, five originated from the Combine Nachrichtenelektronik Berlin, three from the Berlin Combine Automatisierungsanlagenbau, and one from Dresden Robotron Combine. These three combines also hold most of the publications which overall were researched for the industrial sector. The few activities of industry in 1986 concentrate particularly on digital engineering, fibre optic communications and telecontrol and signalling technology. The rest of the publications stem from the postal institutions.

5.3. International comparison of the R&D structure

In a preliminary investigation, R&D structures in telecommunications were compared for ten countries other than East Germany. Apart from major economies, this also included (technologically) smaller countries such as Spain, The Netherlands, Sweden, and South Korea. In the comparison with major countries, deviations from the basic pattern of work distribution were displayed by the smaller countries. The equipment-producing telecommunications concerns (Japan, West Germany) or state or private network operators (US, UK, France) respectively dominate R&D events in larger countries [3].

In the smaller western industrial countries mentioned, equipment producers (often subsidiaries of foreign concerns) and network operators do not adopt any dominating R&D stance (existing network monopolies notwithstanding), as they do not have any R&D centres of their own, or such centres are inadequate. Polytechnics and state R&D organizations of various guises fill the gap. A similar situation was found to apply to East Germany. This technologically isolated socialist country is no exception in this respect and is, in terms of R&D structure in the telecommunications field, barely distinguishable from western countries of comparable magnitude. The findings are illustrated in Fig. 10.

5.4. Regional R&D structure

The geographical distribution of R&D activities in the telecommunications field is then examined. In this connection, the four participating sectors are examined in Fig. 11.

The 'southern preponderance' of economic and

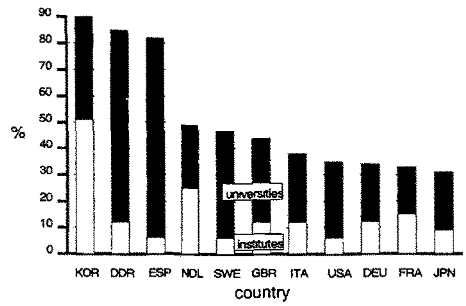

Fig 10. Publications from polytechnics and research institutes in the general field of telecommunication as percentages of national publications for 1986 by eleven countries (for ISO country codes see legend to Fig. 6).

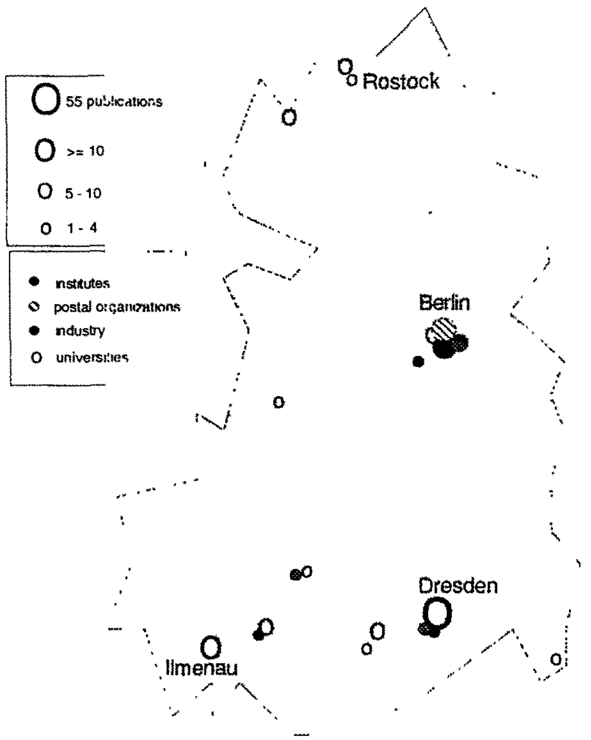

Fig 11. Geographical distribution of R&D activities in the telecommunications field for 1986 by four sectors

research activities in East Germany being claimed for overall economic performance is also evident in the field of telecommunications through the marked dominance of the southern territories in the higher education sector. Here a total of 86% of publications is allocatable to the present-day Federal States of Saxony and Thuringia, Saxony at 66% yielding most of the publications (1986). However, in other sectors the picture is quite different. In the industrial sector, respectively 50% of publications are assignable to Berlin and Saxony. Berlin is unequivocally dominant in the institutional area (82%), as well as in postal institutes (100%).

6. Conclusion

Overall, East Germany offers an average European potential in innovation-oriented R&D activities comparable to Southern Europe. This is remarkable in a not very export-oriented, hitherto scientifically isolated country of central Europe. However, a real decline in innovation-oriented activity is detectable in the second half of the 1980s, running counter to the international trend. On the US patent system it is evident earlier than in Western Europe. The departure from current trends is largely explicable by (deliberate?) changes in institutional structures, yet no national down turn efficiency is detectable.

Particular technological strengths of East Germany lie in printing technology, textile technology, machine tools, handling, optics and measurement technology; in mechanics and instrumentation generally. East Germany displays particular technological weakness in chemistry, electronics, information technology, and traffic engineering. The chemical combines, despite central control, did not pursue an innovation-oriented standard pattern in applied research and technology.

The specialization profile for East Germany is entirely similar to that of West Germany, but at a lower level; the two German research systems avoid over-intensive activity in electronic leading-edge technologies. In a uniform all-German R&D system, therefore, integration of mechanical technology with moderately high innovation potential is on the agenda.

Apart from earlier espousal of different economic systems, a major difference exists between the new and old Federal States in terms of the magnitude of the hitherto separate economies. As a small country with a highly isolated R&D system, East Germany's innovations reflect pursuit of a particularly marked niche strategy of a type not embarked upon by other countries of comparable magnitude. Research policy and industrial technology management ought, therefore, to examine continued justification of the main niche areas pursued hitherto, and future integration of the remaining Eastern research potential into a henceforth larger whole.

The science-affiliation of East German technology over the last ten years, despite increasing bias towards science-dependent technology, has lagged consistently behind the world average. However, this is by no means unusual for continental Europe — even the former Federal Republic. With the expanded, large state science operation it is, however, surprising that technical development has not benefitted more intensively from it.

In applied research for telecommunications, polytechnics, universities, and also state institutes are essentially more decisive than the combines or the postal system. This is absolutely par for the course for smaller, isolated R&D systems, but has no counterpart in major western industrial countries. Adaptation losses in all-German telecommunications research are probable. East Germany is introducing research strengths into wired communication, including fibre optics and digital engineering. However, there are substantial regional disparities in the R&D system of East Germany between the polytechnic and university sector and other sectors active in telecommunications.

What can be deduced from the emphasis on applied research and industrial development in this article for other areas of research? Although the industrial sector, in particular, has been spotlighted, and this to some extent reflects world average structures, it is scarcely conceivable that the relevant fundamental research — which has not been considered here — will be totally different. The importance of polytechnics and universities and state institutes for the company sector lies in concrete cooperation over projects, and also in the field of personnel recruitment for industrial R&D. To the extent that applied research and industrial development in East Germany according to the present analysis would tend to appear to be on a world average, the scientific system cannot depart entirely from standard structures.

Reference has been made in this investigation to limitations. Confirmation of the quantitative explanations would have been desirable. Nevertheless, perhaps the authors have managed to show in an illustrative way how and where science and technology indicators can be employed. The data submitted is extensible to other fields, later periods, and other aggregation levels. It may provide valuable assistance with a study of the transitional situation, because other empirical methods are difficult to apply in this situation.

Certain *research matters* potentially suitable for future investigation had to be left *open* in the study. In principle, science and technology indicators, unlike other parameters from research statistics, are perhaps not subject to capital cost 'devaluation'. They are, therefore, eminently suitable for continuous monitoring of the substantial structural change in East Germany from 1989 onwards, when the price system changed completely. In the case of continuation of patent statistics, a systematic retroactive comparison of foreign to domestic patents could and should be envisaged so that factors like *straightforward domestic patents* and hence *technical production* can be evolved distinctly from targeted technology strategies on *overseas marketing*, and hence procurement of foreign currency.

It has already been mentioned that, in fact, the indicators require validation by discussion with experts. They are specialists and are competent in their particular speciality. Therefore, systematic interrogation of selected experts in a pre-determined field, *e.g.* telecommunications, is suggested as a means for *qualitatively* identifying the East German R&D *structures* in this area; such a field investigation has already been carried out for ten other countries

[3], but this has so far not been done for East Germany. Because each area of applied research exhibits peculiarities, a *comparable analysis as for telecommunications, i.e.* an expert interrogation supported by publications and patents, ought to be scheduled for an entirely different area of applied research, *bio-technology or material research,* say. Then there would be several qualitative and quantitative case studies from which common denominators reliably applicable to *general structures of applied research and industrial development* might be concluded.

This article has been published in order to provide interested specialist circles with an insight as quickly as possible into a hitherto little discussed, extremely isolated R&D system. The unanswered questions are numerous. However, even now it is apparent that overall the R&D system for East Germany alone is a variable for elucidating the technical and economic problems of East Germany can hardly be taken into account, as the structures are too similar to those of the economically more successful countries. Recent macro- and micro-economic studies on industrial R&D in East Germany [19, 20] rather show that the innovative products were not appropriate to market conditions, and that the knowledge of markets and productivity were insufficient. A reorientation to meet the requirements of a market economy is needed with respect to resources (manpower, skills, investment, etc.), instruments (management, organization, operational structures), and behaviour. Thus, in addition to the structural transformation of the economy, a great deal also depends on a 'mental restructuring'.

Acknowledgments

The underlying project [17] has been performed jointly for the Stifterverband für die Deutsche Wissenschaft (an industrial association to support German Science) and the Wissenschaftsrat (German Science Council). The authors are grateful indeed to the Stifterverband for financial support.

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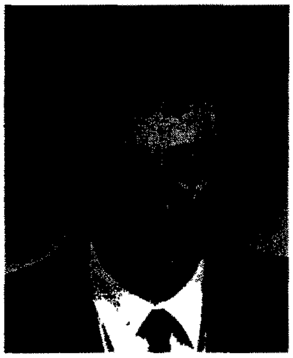

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Le recherche appliquée et le développement industriel en Allemagne de l'Est: une comparaison internationale par l'entremise des indicateurs de performance

RÉSUMÉ

Cette enquête sur la recherche-développement en Allemagne de l'Est se compose de quatre parties différemment orientées:

- Les activités d'invention originaires des domiciles ou des sièges sociales sont analysées, étant donné qu'elles auraient été réproduites par des applications de brevet d'invention à l'étranger en Europe de l'Ouest, indicatives de la *portion de technologie en Allemagne de l'Est qui est importante pour l'export*;
- Les brevets provenants de l'Allemagne de l'Est conférés par l'Institut National de la Propriété Industrielle aux Etats Unis (US Patent Office) ont été également examinés pour ainsi identifier un marché étranger pour les rélations commerciales traditionelles des coalitions en Allemagne de l'Est qui ne soit pas évident. Cela nous donne une *forte selection des technologies les plus importantes au niveau économique en Allemagne de l'Est*;
- La dépendance sur la science en Allemagne de l'Est est identifié par une nouvelle méthode quantitative. L'indicateur entiré à partir de cette méthode pour le rôle participatif de la science suggère une *rélative proximité de la technologie industrielle à la recherche scientifique*;
- L'activité en recherche-développement dans le domaine des télécommunications a été examinée comme partie d'une étude de cas des zones choisies de travail technologique en Allemagne de l'Est. Les *structures institutionelles et régionales en télécommunications en Allemagne de l'Est* sont discutées par rapport aux tendances de temps aussi qu'au niveau micro.

Les conclusions produites par cette façon sélective d'aborder la situation de transition actuelle dans les états fédereaux d'Allemagne de l'Est (Länder) sont entirées de manière très soigneuse; elles ne peuvent pas en conscience être justifiées, puisque cela tomberait hors des points de référence de cette enquête hâtivement menée.

Angewandte Forschung und industrielle Entwicklung in Ostdeutschland: Internationaler Vergleich mittels Leistungsanzeiger

ABRISS

Das in dieser Untersuchung auf die F & E in Ostdeutschland gerichtete "Scheinwerferlicht", besteht aus vier unterschiedlich "gefärbten" und unterschiedlich ausgerichteten "Lichtbündeln".

- Erfinderische Aktivitäten mit Ursprung in den Wohnorten oder Handelsbüros Ostdeutschlands werden analysiert, insoweit wie sie von einer Patentanmeldung ausserhalb des Landes in West Europa wiederholt wurden. Dieses soll einen Hinweis auf *den Anteil der Technologie Ostdeuteschlands, der wichtig für den Export ist*, geben.
- Ähnlicherweise wurden von dem US Patentbüro verliehene ostdeutesche Patente untersucht, um einen nicht-augenfälligen Überseemarkt für die herkömmlichen Geschäftshandlungen der ostdeuteschen Unternehmen zu identifizieren. Dabei erhielt man einer *starke Auswahl der Technologie Ostdeuteschlands, die von der Rentabilität her am wichtigsten ist*.
- Die Abhängigkeit der Wissenschaft Ostdeutschlands wird von einer neuen quantitativen Methode identifiziert. Der dadurch abgeleitete Anzeiger für die Beteiligung der Wissenschaft, deutet auf die *relative Nähe der industriellen Technologie zur wissenschaftlichen Forschung* hin.
- F & E Tätigkeiten im Bereich der Fernmeldetechnik wurden als Teil der Untersuchung des ausgewählten technischen Arbeitsbereichs in

Ostdeutschland untersucht. Die *Institutions- und Regionalstrukturen der Fernmeldetechnik in Ostdeutschland* werden in bezug auf Zeittendenzen und auch auf der Mikro-Ebene, diskutiert.

Die Schlussfolgerungen, die von dieser selektiven Methode für den heutigen übergangszustand in ostdeutschen Bundesländern hervorgebracht werden, werden mit äusserster Sorgfältigkeit deduziert. Sie können nicht, mit aller Gewissenhaftigkeit, untermauert werden, da dieses ausserhalb des Aufgabenbereichs dieser in Eile durchgeführten Untersuchung fallen würde.

La investigación aplicada y el desarollo en Alemania Oriental: una comparación internacional por medio de indicadores de aptitud

RESUMEN

Este estudio, centrado en la investigación y desarollo en Alemania Oriental, se compone de cuatro enfoques distintos:

- Se analizan las actividades de invención originarias de domicilios u oficinas de compañías en Alemania Oriental que hayan sido duplicadas por una solicitud de patente al extranjero en Europa Occidental, lo cual indica la *proporción de tecnología en Alemania Oriental que tiene importancia para la exportación*;
- Igualmente, se analizan las patentes de Alemania Oriental concedidas por el registro de la propiedad industrial de los Estados Unidos (US Patent Office) para así identificar un mercado de ultramar no obvio para las relaciones comerciales tradicionales de las asociaciones de Alemania Oriental. Se obtiene así una *selección directa de la tecnología más importante en Alemania Oriental a nivel económico*;
- Se identifica la dependencia en la ciencia en Alemania Oriental por un nuevo método cuantitativo. El indicador de participación de la ciencia que se deduce a partir de este método sugiere una *relativa proximidad entre la tecnología industrial y la investigación científica*;
- Se analiza la actividad en investigación y desarollo en el ámbito de las telecomunicaciones como parte de un estudio de caso de zonas de trabajo técnico escojidas en Alemania Oriental. Se discuten las *estructuras institucionales y regionales en telecomunicaciones en Alemania Oriental* tanto en terminos de tendencias temporales como a nivel 'micro'.

Las conclusiones ofrecidas por este enfoque selectivo de la actual situación transicional en los estados federales de Alemania Oriental (Länder) se deducen meticulosamente; no pueden en verdad justificarse, puesto que tal justificación caería fuera de los terminos de referencia de esta precipitada encuesta.