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Comparative advantage for research and development across industries in OECD countries

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by

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Comparative Advantage for Research and Development Across Industries in OECD Countries

Abstract

This paper explores the empirical relevance of the concept of comparative advantage and of the factor proportions theory of international trade and specialisation for the distribution of research and development (R&D) activities across seventeen industries in fourteen OECD member countries over the period from 1970 to 1989. The paper first discusses bivariate correlations between countries' R&D intensities across industries and industries' R&D intensities across countries which confirm that the average R&D intensity is a characteristic feature of individual industries as well as of individual countries. Using the analysis of variance technique, the paper then shows that the type of industry and the country of its location are determinants of the observed human capital intensity in R&D, measured here either by the ratio of university graduates in R&D to other R&D personnel or by the ratio of R&D scientists and engineers to other R&D personnel. Finally, the paper uses multiple regression analysis to examine — separately for each industry in the sample — the impact of a country's human capital endowment, production specialisation, size and of time on the degree to which the country specialises in a particular industry's R&D activities. While the results of these regressions are generally not inconsistent with the factor proportions theory, they do reveal strikingly distinct patterns of R&D specialisation for computers, electrical machinery and radio, television and communication equipment, the industries most closely connected to the fast changing microelectronic technologies.

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1 Introduction

Is the notion of comparative advantage relevant for the allocation of R&D activities across countries and across industries? This question, although of great importance for the desirability and design of industrial and technology policies, seems to have received little scholarly attention so far. As a general theoretical explanation for specialisation in production and trade, the concept of comparative advantage is sometimes used as a catch-all for a variety of sources like differential productivities due to different technologies, the case of Ricardo (1815), differences in factor endowments, the basis of Heckscher-Ohlin theory, or even differences in organisational conventions between countries as recently suggested by Aoki (1993)[1]. To better understand the pros and cons of selective industrial and technology policies it will be important to empirically discriminate between the different potential sources of comparative advantage. The present paper is an empirical exploration of factor proportions as a potential source of comparative advantage in R&D activities.

Recent advances in the theory of economic growth have emphasised the importance of the creation and adoption of new technical knowledge in determining the distribution of industrial production across interdependent economies as well as in raising productivity. Knowledge capital created by industrial research and development and the capacity to absorb and apply new technical knowledge in the production sphere are thought to be additional factors in determining countries' production specialisation across industries. This thinking rests on the assumption that industries can be distinguished by the intensity with which they rely on innovation and the adoption of new technology. Only if industries can be consistently classified into high-, medium and low-technology industries, can countries' differential innovative abilities constitute an important

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[1] Aoki (1993) argues that comparative advantage for innovative activities in different kinds of technological environments can arise endogenously as differentiated modes of information processing in firms and R&D laboratories emerge from the evolutionary interaction of managers within their respective systems. In his analysis the relative magnitudes of systemic risk at the macro level and of idiosyncratic risk at the micro level of a given technological environment determine which mode of information processing is more efficient.

source of comparative advantage for high-tech versus low-tech industries.[2] This is a central theme of much recent theoretical work on endogenous technological change in open economies, like that of Grossman and Helpman (1991), but also of earlier empirical work on the technology factor in international trade, like that of Dosi et al (1990).

With respect to R&D outputs, it is needless to say that much of it is industry-specific. So too are some of the inputs, like highly specialised scientists, at least in the short run. But apart from this, R&D may be specific to individual industries also in the sense that it is not an economically homogeneous activity across industries in which any kind of R&D output can be generated efficiently by much the same combination of inputs: teams of scientists, engineers and technical support staff in equal proportions and all equipped with a capital stock of approximately equal value per employee, consisting of laboratories with all the necessary instrumentation. Instead, R&D activities in different industries seem to have different relative resource requirements. Consequently, not only the overall level of R&D activities in any particular country but also the relative distribution of a country's R&D activities across different industries may reflect comparative advantages distinct from those for the production of tangibles in the corresponding industries.[3]

Of course, the possibility that comparative advantages for production and for R&D in one and the same industry are economically and geographically distinct can only arise if the output of R&D is internationally tradable, at least to some

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[2] A widely used measure is R&D intensity, either defined as the ratio of business enterprise R&D expenditure to sales or to value added. On this criterion aerospace (aircrafts), computers, electronics, pharmaceuticals (drugs and medicines), professional instruments and electrical machinery are usually classified as high technology industries. See, for instance, OECD (1992a), p. 125.

[3] In a previous empirical analysis of factor endowments and international innovation patterns Davidson (1979) concludes that countries tend to concentrate their innovative activities in those industries whose production intensively uses their most expensive factors. This, he argues, might lead to trade patterns conflicting with Heckscher-Ohlin theory. But he does not consider the possibility — to be examined here — that differential factor costs in the R&D of different industries can also be an important influence. To measure patterns of innovations in eight selected industries he relies on a (University of Sussex) data base of product and process innovations deemed "by knowledgable sources" to be of commercial and technical significance.

extent. If it was not, then patterns of specialisation in R&D would be fully determined by countries' patterns of specialisation in the production of tangibles, thus ultimately by the comparative advantages for the different manufacturing products. But in reality, the generation and application of new technical knowledge need not always happen in the same place. Within firms R&D is often concentrated in centralised laboratories whereas the application of new technical knowledge takes place in all plants wherever they may be located. The pervasive activities of multinational enterprises, the pre-eminent capitalist institution geared towards the transfer of technology across national borders, testify that profitable opportunities for international trade in technical knowledge exist and are indeed exploited, although perhaps not fully. Moreover, there is evidence of a considerable and increasing international trade in patents and licences for new technology also between unrelated firms in the OECD countries (Vickery, 1986).

This raises the question whether sources of comparative advantage for the R&D activities in individual industries which are distinct from the country-specific determinants of the related manufacturing activities can be identified empirically. Looking at individual industries, what actually determines the allocation of their R&D activities across countries? To the extent that part of the industry-specific technical knowledge is not tradable, or tradable only at very high transaction costs, R&D activities should be geographically tied to industrial production. But to the extent that *tradable* technical knowledge is generated, other factors may become important co-determinants of the allocation of industry-specific R&D activities across countries. Countries with above average endowments of university-educated engineers, for instance, might have a comparative advantage in those R&D activities which require the most intensive use of scientists and engineers and relatively little use of technical and other support staff.[4] These

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[4] In the medium run, scientists and engineers — at least the majority of them — are assumed to be sufficiently mobile across technical fields so as not to be constrained to work in only one particular industry. For example, aircraft engineers can do useful work also in other transport engineering, the knowledge of pharmacists can be of use in general chemical or food research and electrical engineers can apply their skills just as well to computers or machinery as to radio, television and communications equipment. Also relevant in the medium run is the mobility of students of science and engineering. Cohorts of students often concentrate their studies on those fields in which the most job openings and the highest salaries are expected.

countries would then have a greater share of their total manufacturing R&D devoted to the most human capital intensive R&D activities. Analogously, countries with a relatively low percentage of university educated engineers in the labour force might specialise in R&D activities which are comparatively less demanding of human capital, but more labour intensive. Of course, if other factors were important co-determinants of comparative advantage in R&D, these would make things more complicated. Nevertheless, any relevant factor which is and remains characteristic of countries in the long-run, could — at least in principle — be identified in empirical cross-country studies.

The alternative hypothesis would be that patterns of specialisation in R&D are not directly determined by relative factor endowments, but instead are the outcome of a unique historical process. Economic historians like Nathan Rosenberg (1994), Brian Arthur (1989) and Paul David (1988) have argued that such processes are path dependent, so that future patterns of specialisation in R&D would remain unpredictable even if the likely future movements of all relevant factor endowments were known.

Any empirical study of these issues will have to cope with several theoretical and methodological difficulties, including the question of exogeneity of factor endowments with respect to specialisation patterns, the Heckscher-Ohlin assumption of complete immobility of the relevant factors across borders while maintaining the assumption of full mobility of factors within countries, and the difficulties of measuring human capital endowments of countries and human capital requirements of production.

The present value of the human capital endowments of the richest OECD countries may well have surpassed the present value of their respective endowments with physical capital. But much of this immense stock of human capital is unusable in R&D. To measure the relevant portion of human capital in a pragmatic way, this study simply takes the full-time equivalents of R&D scientists and engineers employed in a country, as defined in the "Frascati Manual" of the OECD (1981).[5]

It is the assumption of this paper that many scientists and engineers are not so specialised that they can be employed only in the R&D of one particular industry. At the same time, it is assumed that scientists and engineers do not migrate in large numbers across international borders in search of higher income opportunities. Although there is some evidence that scientists and engineers are more mobile within the English-speaking industrial countries than across countries with different languages, in general, people's cultural ties tend to be effective breaks on the mobility of human capital.[6] The assumption of no international mobility of human capital may therefore be a good approximation for the purposes of this paper.

Section 2 of this paper presents a preliminary exploration of some of the relevant data on R&D activities in OECD countries which bear on the questions discussed here. Section 3, then, goes on to examine the relevant hypotheses more carefully within the framework of regression analyses. Section 4 concludes.

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[5] These are scientists or engineers engaged in the conception or creation of new knowledge, products, processes, methods and systems, including managers and administrators engaged in the planning and management of the scientific and technical aspects of research work (OECD, 1981, p. 67).

[6] It is noteworthy that recent empirical research of Feldstein and Horioka (1980) as well as Sinn (1992) suggests that even the international mobility of financial capital remains much lower than was once thought by many advocates of the abolishment of capital controls and of free exchange rates.

2 The distribution of R&D activities across industries in OECD countries

The present study looks at 14 OECD member countries for which more or less comparable data on R&D activities is available for the period from 1970 to 1989, albeit with quite a few deplorable data gaps.[7] These countries are Australia, Belgium, Canada, Denmark, Finland, France, West-Germany, Italy, Japan, the Netherlands, Norway, Sweden, the United Kingdom and the United States. Combined they generated roughly 90 % of total OECD exports throughout the period considered here. Figure 1, panel a, shows countries' relative endowments with R&D Scientists and engineers. It seems that there were four sub-groups of countries in the 1970s, with the United States and Japan being the countries relatively (as well as absolutely) best endowed with R&D Scientists and engineers, West-Germany, the United Kingdom and Australia being almost at a par in the second group, Sweden, Norway, the Netherlands, France and Canada forming the third group, and Finland, Belgium, Denmark and Italy having the smallest share of R&D scientists and engineers in their respective total labour forces. Japan, after overtaking the United States in the late 1970s, has improved its lead in the 1980s. For the other countries, the figures for decades' average endowments with R&D Scientists and engineers indicate that Sweden and Norway have passed both Australia and the United Kingdom, thus moving from sixth and seventh place, respectively, to fourth and fifth place right behind West-Germany. Australia has also been overtaken by France and finds itself at about the same level as Canada which has meanwhile passed the Netherlands. Among the laggards, Belgium seems to have had the biggest relative improvement, overtaking Finland and almost catching up to the level of the neighbouring Netherlands.

Panel b of Figure 1 has the average years of schooling of the adult population in 1975 and 1985, taken from Barro and Lee (1993). Comparing this graph with the previous one suggests that having a high level of formal schooling in the average may provide a fertile breeding ground for scientists and engineers, but that

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[7] The discriptive statistics of this section refer to data averaged over two ten-year intervals, the 1970s and the 1980s, so that data gaps are hidden. See the data appendix for a list of variables and observations included in this study.

schooling alone may not be the whole story to explain why some countries are doing relatively more industrial R&D than others. In fact, there may be a size effect: the three countries best endowed with R&D scientists and engineers, the United States, Japan and West-Germany, are also the three biggest in the group.[8] On the other hand, the economies of France and Italy, also rather big, appear to be constrained by their comparatively low levels of educational achievements in the adult population average.[9] Among the well educated Scandinavian countries and Canada, only Sweden and Norway seem to have translated this advantage into a relative endowment with R&D scientists and engineers comparable to that of the leading big countries.

Hence, this first look reveals something for everybody: For support of the factor proportions version of comparative advantage you can point to the United States, France and Italy, whose ranking in terms of average schooling coincides with that in terms of R&D scientist and engineers endowment. Those who believe in economies of scale and agglomeration in the creation and application of new knowledge can point to the fact that the three leaders in terms of R&D scientists and engineers endowment are also the three biggest economies. Those who believe in country idiosyncrasies and path dependency can point to the diverse Scandinavian experiences where Sweden and Norway seem to have caught up to the global R&D leaders, whereas Finland and Denmark, although equally well educated, keep on lagging in terms of their relative endowments with R&D scientists and engineers.

Clearly, the data, summarily described above, are too much aggregated and too small in number to test any of the competing hypotheses mentioned, but they do

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[8] A size effect may stem from economies of scale associated with the application of new knowledge in production and from positive externalities in the form of knowledge spillovers as emphasised by Romer (1990), or from other kinds of complementarities, like world class technical universities, public research institutions and technology transfer centres, which are sometimes subsumed under the term "technology infrastructure". See Tassey (1992).

[9] A scarce supply of skilled scientists and engineers can become a binding constraint for an economy already at relatively low levels of innovative activity because these are the people which are also needed in the planning and supervision of much of modern manufacturing.

indicate that the resource, which probably has the greatest importance for the allocation of R&D activities, human capital embodied in R&D scientists and engineers, is distributed rather unevenly among countries in the world economy — a picture that emerges already from a small sample of some of the richest OECD countries which are, at the same time, quite similar in so many other respects.

More pertinent information can be extracted from detailed data on the resources devoted to R&D activities in individual industries. Table 1 lists average R&D intensities, defined here as the ratio of current R&D expenditure to value added, in 17 manufacturing industries and 14 countries in the 1970s (panel a) and in the 1980s (panel b). Table 2 and 3 list the corresponding rankings across countries and across industries, respectively. In Table 2 it seems that those countries with a higher ranking in terms of total manufacturing R&D intensity tend to have a higher ranking also in individual industries. In the 1970s as well as in the 1980s, the US had the highest ranking in terms of total manufacturing R&D intensity and Australia the lowest of all sample countries. Most of the other countries (with intermediate rankings) also kept their relative position over time. Among the few countries which did change their ranking slightly are West-Germany, moving form fifth to fourth place, and Japan, moving from seventh to sixth place. For some countries, their rankings in terms of total manufacturing R&D intensity largely coincide with their rankings in terms of relative endowments of R&D scientists and engineers, but notably for Australia, Japan, the Netherlands and Sweden they do not. Japan ranks much lower in terms of R&D intensity than in terms of relative endowment with R&D scientists and engineers, the other three countries much higher.

Perhaps more revealing are the rankings of R&D intensity across industries in Table 3: those industries with a higher (lower) ranking in terms of overall R&D intensity for all countries combined tend to have a higher (lower) ranking also in individual countries. This pattern seems to be remarkably stable for most industries. Exceptions are *ship building* and *aircraft* which have a very high ranking in some countries and a very low ranking in others. *Ship building* is the second most R&D intensive industry in Japan, but among the least R&D intensive industries in Australia, Finland, France and Norway. *Aircraft* is the most R&D intensive industry in France, West-Germany, the US and others, but among the least R&D intensive industries in Finland and Japan. These discrepancies suggest that *ship building* and *aircraft* may be industries in which R&D activities are highly concentrated on a world-wide scale and that the technologically lagging countries in these fields compete either with older technology or with technology licensed from the small group of technological leaders. But in general, R&D intensity appears to be a property of industries which is preserved across countries.

These impressions are supported by the correlations between countries' R&D intensities across industries (Table 4) and between industries' R&D intensities across countries (Table 5). In the 1970s as well as in the 1980s, correlations of R&D intensities across industries are remarkably high. For each country, the correlations with overall R&D intensities, computed for all countries combined, are actually positive and mostly close to unity. Only Sweden's and Germany's R&D intensities in the 1970s are negatively correlated with more than two other countries. The correlations of Table 4 thus support the view that industries are universally distinguishable by the relative intensity with which R&D activities are pursued. Industries with the highest relative R&D intensity, as defined here, *aircraft, radio, television and communication equipment* (RTV), *computers* and *drugs and medicines* are, by the way, among those classified as high-technology industries by the OECD (1992a), p. 125, on the basis of ratios of R&D expenditure to production in the three periods 1972 - 74, 1979 - 81 and 1987 - 89. Also the industries with the lowest relative R&D intensity in Table 1, food, fabricated metals, iron and stone, clay and glass, are consistently classified as low technology by the OECD.

Looking at correlations between the R&D intensities of industries across countries (Table 5), a similar picture emerges. Except for *non ferrous metals* (NFM) in the 1970s, all correlations of individual industries with the total manufacturing R&D intensities of countries are positive. Also, most bivariate correlations between individual industries are positive. The only industry which stands out in both periods as an exception is *radio, TV and communication equipment* (RTV) where countries' R&D intensities are negatively correlated with most other industries. Apparently, the countries making a particularly great R&D effort in *RTV* — relative to their value added in this industry — are not the countries most specialised in R&D generally. On the whole, however, the correlations of tables 4 and 5 suggest that the R&D intensity of country-indexed industries, that is to say the ratio of R&D activities to value added in an industry as observed in a particular country, depends largely on two things: which industry one is talking about and whether the country, where the activities are located, has a comparative advantage in doing R&D.

The high aggregate R&D intensity of some countries does not seem to be merely a statistical artefact concealing totally random patterns in individual industries. Instead, countries which specialise in innovative activity — doing R&D with a comparatively higher intensity relative to their other economic activities in manufacturing — tend to do so throughout all industries. This supports the view that a comparative advantage in R&D is indeed a country characteristic which some of them have and others do not.

But not all R&D activities are of the same kind — another fact which can be exploited in assessing and testing the impact of factor endowments on the allocation of R&D activities across countries. Hence, if countries' unequal relative endowments with R&D scientists and engineers are suspected to be a source of comparative advantage for R&D, this may be relevant not only for the aggregate level of R&D compared to all other economic activity, but also for countries' differential emphasis on R&D in different industries, provided that industries' R&D can actually be distinguished by their intensity of using different factors of production.

Concentrating on human capital intensity, the ratios of R&D Scientists and engineers to other R&D personnel observed in different industries and countries are given in Table 6. These ratios can be considered a first, rough indicator of human capital intensity of R&D activities.[10] Rankings across countries are shown in Table 7, rankings across industries in Table 8. These rankings do mostly not coincide with those in terms of R&D intensity shown in tables 2 and 3. For example, Australia and Japan whose ranking in terms of R&D intensity is low and fairly average, respectively, have the highest rankings in terms of R&D scientists and engineers per other R&D personnel in both periods. Sweden, on the other hand, ranks high in terms of R&D intensity but fairly average in terms of human capital intensity in R&D. Similarly, industries' rankings in terms of R&D intensity and human capital intensity in R&D differ markedly.[11] *Aircraft*, for instance, the highest ranking industry in terms of R&D intensity in both periods ranks only sixteen in terms of human capital intensity in R&D. *Food*, on the other hand, lowest ranking in terms of R&D intensity, has an average ranking in terms of human capital intensity in R&D. Some correspondence prevails, however, in the case of the metal industries, which have low rankings both in terms of R&D intensity and in terms of human capital intensity in R&D, as well as in the microelectronics industries (*office machines and computers*, *electrical machinery* and *RTV*), which have high rankings on both indicators.

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[10] Worries that this indicator might be misleading in the presence of important other factors — physical capital for instance — may actually be unwarranted. Brockhoff (1988) finds in regression analyses that the number of persons employed in R&D can in fact serve as a rather good indicator of real R&D expenditure. These regressions lend some support to one of the crucial asumption of this paper — that non-human factors are of minor importance in R&D. Only on the basis of this asumption, as well as on the assumption of no factor intensity reversals, can industries' R&D activities be completely and transitively ordered according to their human capital intensity alone, and the "chain of comparative advantage" can be invoked. Each country will tend to export R&D services from the segment of industries, in which this country has a comparative advantage due to its relative endowment with human capital, and import R&D services of other industries.

[11] This is hardly surprising given the complex causality for industries' R&D intensity discussed in the theoretical and empirical literature on industrial organisation and R&D. The main causal factors considered in this literature are the expected market size, technological opportunities stemming from favourable supply side conditions, and the degree of appropriability of quasi-rents on innovations, which depends partly on the system of intellectual property rights and the market structure of a given indutry. For a theoretical review and an empirical exploration into the determinants of R&D intensity see Pakes and Schankerman (1984).

Table 9 gives the coefficients of bivariate correlations between countries' human capital intensity in R&D across industries as well as of the correlations of each country's human capital intensity in R&D with all countries' combined human capital intensity of R&D across industries. After eliminating — for lack of sufficient data — the Netherlands as well as the United States, the remaining countries have mostly positive correlations with the overall ratios and directly with the other countries in the sample. In the 1970s, though, Canada, Denmark, Japan and Sweden have negative correlations with the overall ratios, whereas in the 1980s only Sweden displays a slightly negative correlations coefficient with the overall ratios. Assuming industry-specific R&D production functions being identical across countries, several potential exlanations for the high percentage of negative correlations remain: there might be factor intensity reversals, increasing returns due to economies of agglomeration in R&D[12], or important additional R&D production factors other than R&D personnel and scientists and engineers.

A more unified picture emerges from the table of correlations for human capital intensities in R&D between industries and across countries (Table 10). All correlations of individual industries with the overall ratios are highly positive in both the 1970s and the 1980s. Negative correlations between individual industries are rare. Most industries' ratios of R&D scientists and engineers to other R&D personnel and the countries' ratios in total manufacturing are also positively correlated with the relative R&D scientists and engineers endowments of countries. All this is consistent with the prediction of factors proportions theory of international trade that countries, while specialising in the production of those goods which make relatively intensive use of the abundant factor, also tend to use the abundant factor more intensively whenever smoothly convex production technologies permit factor substitution as a response to changing relative factor scarcities. But the negative correlations of the relative R&D scientists and engineers endowments with the ratios of R&D scientists and engineers to other R&D personnel in the *iron*, *computer* and *ship building* industries in the 1970s as well as with the *iron* and *computer* industries in the 1980s are puzzling.

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[12] For an empirical test of tendencies towards the international agglomeration of R&D see Cantwell (1991).

The factor proportions theory of international trade considers three basic (non-exclusive) possibilities for an open economy to respond to changes in the factor endowments relative to the trading partners which may be relevant for the allocation of resources in R&D activities: above average endowments of scarce human capital in the form of R&D scientists and engineers can be allocated, first, so as to generally increase the human capital intensity of all R&D activities, second, to increase the R&D intensity equally in all industries, or third, to shift the pattern of specialisation to those activities for which factor endowment relations let a comparative advantage emerge.

The above discussion of empirical data on some of the relevant factor endowments, on R&D intensities and on relative input requirements in R&D has shown that countries actually make use of the first two possibilities mentioned. For a preliminary examination of the third possibility, charts of R&D intensities in each country, relative to the respective industry's overall R&D intensity across all countries, are presented in Figure 2 and of normalised R&D intensities in each industry, i.e. R&D intensities relative to the respective country's total manufacturing R&D intensity, in Figure 3. These charts are designed to make visible any simple patterns of R&D specialisation across industries — should they exist — which conform to the factor proportions version of comparative advantage. In fact, the charts provide a rough illustration of, first, how countries' strengths in R&D across industries are distributed over the space of human capital intensities in R&D (Figure 2), and second, how the relative degree of R&D specialisation in a particular industry is distributed across countries ranked according to their relative endowment with R&D scientists and engineers (Figure 3).

In Figure 2 — one has to bear in mind — a clear pattern can be expected only for those countries which rank either very high or very low in terms of their relative endowments with R&D scientists and engineers. A case in point are the US which had the highest ranking in the 1970s. As expected the US economy generally seems to have put relatively more emphasis on R&D in industries which make relatively intensive use of R&D scientists and engineers, the exceptions being the high R&D specialisation in motor vehicles and RAP.[13] France as a country with a relatively small endowment with R&D scientists and engineers, by contrast, seems to have put more emphasis on R&D in industries whose R&D makes relatively little use of R&D scientists and engineers, with *RTV* being the exception here. Unfortunately, no fitting patterns can be recognised for any of the other countries.

A glance at the normalised R&D intensities in each industry (across countries) in Figure 3 reveals patterns confirming expectations only in the cases of *drugs and medicines* (DRUG), *rubber and plastics* (RAP) and *electrical machinery* (ELMA). ELMA is the industry with the highest ranking in terms of human capital intensity in R&D in the 1970s as well as in the 1980s. Ignoring Finland and Norway, there is indeed the expected positive relationship between countries' relative endowments with R&D scientists and engineers and countries' R&D intensity in the ELMA industry relative to their total manufacturing R&D intensity in the 1970s. In the 1980s, however, this relationship seems to have broken down. In the case of RAP, one of those industries making the least intensive use of scientists and engineers in their R&D activities, a negative relationship is expected and more or less confirmed by the data.[14] The DRUG industry also shows a negative relationship which is not inconsistent with this industry's fairly low ranking in terms of human capital intensity in R&D. Unfortunately, negative relationships are also recognisable in RTV and *professional instruments*, two industries with high rankings in terms of human capital intensity in R&D. These observations are at odds with the factor proportions hypothesis to explain countries' patterns of specialisation in industrial R&D.

The next section will examine these issues more carefully within the framework of regression analyses which will allow the inclusion of other explanatory

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[13] A possible explanantion for these exceptions is that both the *motor vehicles* and the *rubber and plastics* (RAP) industries are classified as scale-intensive by the OECD (1992a), p. 152. The US, being the biggest economy of all, should naturally have a locational advantage for these industries.

[14] The appearance of two sub groups of observations in the case of RAP suggests that there is another important explanatory variable in the relationship discussed here.

variables, like country size and time trends to capture secular changes in countries' industrial structure.

3 Testing for the determinants of human capital intensity in the R&D of individual industries

The previous section reported bivariate correlations between averages of the ratios of R&D scientists and engineers over other R&D personnel in different countries and in different industries for the 1970s and the 1980s which support the assumption that country-indexed industries can be economically identified by the intensity with which human capital is used in the pertinent R&D activities. To provide a sharper test of this assumption, which is essential for the relevance of comparative advantages based on factor proportions, an analysis of variance has been carried out using yearly data on employment of scientists and engineers as well as of university graduates in R&D activities.[15] Separate regressions of the following type have been run first for each country across industries, and secondly, for each industry across countries:

$$\ln(h) = \mu + \delta_i + \gamma_t + \ln(t) + \varepsilon_{it},$$

where h is either the ratio of R&D scientists and engineers to other R&D personnel or the ratio of university graduates to other R&D personnel, δ denotes country dummies in the industry regressions and industry dummies in the country regressions, γ time dummies controlling for seven three-year periods between 1969 and 1989, t a linear time trend and ε the residuals. On the basis of the residuals from the full model, from the model with dummies for time effects only and from the model with country or industry effects only, F-tests are carried out to test for the joint significance of the respectively omitted dummy variables in each case. The results of the regressions for each country and industry, for which sufficient data have been available, are reported in Tables 11 to 12.

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[15] Full time equivalents of university graduates employed in R&D are a measure of human capital which better captures the relative frequency of formal academic qualifications among R&D personnel. Unfortunately, there are many large gaps in the source data, and for several countries the data on university graduates in R&D are entirely missing. Data on research scientists and engineers are not, however, to be seen as a poor substitute, but may after all be the more appropriate data. R&D scientists and engineers are the people who actually carry out the creation of new knowledege; most of them presumably hold university degrees or have other advanced technical qualifications.

Table 11, panel a, has the results for 13 country regressions in which the dependent variable has been the log of the ratio of R&D scientists and engineers to other R&D personnel. The test statistics for industry effects are larger than the critical value at the 95 % level of significance for all 13 countries, in fact, the test statistics are even larger than the critical value at the 99 % level of significance for all countries except for Australia. Time effects not captured by the linear time trend, on the other hand, are insignificant at the 99 % level except for Japan and Sweden. In other cases than these, time effects are significant at the 95 % level in Canada, Denmark, France, West-Germany, but only just.

Table 11, panel b, displays the results from country regressions using the ratio of university graduates to other R&D personnel as the dependent. Again, all industry effects are highly significant, but time effects are significant only for Belgium and Sweden.

Table 12, panel a, has the results from industry regressions using the ratio of R&D scientists and engineers to other R&D personnel as the dependent. Country effects are highly significant even at the 99 % level for all industries, but time effects are insignificant even at the 95 % level except, perhaps, for Ferrous Metals (IRON) in which case the test statistic just equals the critical value.

Table 12, panel b, finally, displays the results from industry regressions using the ratio of university graduates to other R&D personnel as the dependent. Here, all country effects are significant except those for the *ship building* industry. Time effects, on the other hand, are insignificant for almost all industries. They are significant at the 95 % level only for *ferrous metals* (IRON), *office machines and computers* (COMP) and the *aircraft* industry (AIRC).

Taken together, these results support the assumption that the intensity of using human capital in R&D is a characteristic feature of industries, when holding the country fixed, and of countries, when holding the industry fixed. On the background of this confirmed assumption, it makes sense to pose the question to what extent countries' choices to devote resources to the R&D of particular industries depend on countries' production specialisation in these same industries, and to what extent they depend on whether countries are abundantly or poorly endowed with scientists and engineers.

4 Testing for the impact of human capital endowments on countries' specialisation in the R&D of individual industries

To test for the impact of sectoral specialisation in value added and of the endowment with R&D scientists and engineers on the sectoral specialisation in R&D, regressions have been run for each industry separately, which have the following form:

$$\ln(shrdp_{t-1}) = \beta_0 + \beta_1 \ln(shva_t) + \beta_2 \ln(rdse_t / rgdp_t) + \beta_3 \ln(rgdp_t) + \beta_4 \ln(t) + \varepsilon_t .$$

In these regressions the dependent is the (lagged[16]) share of an industry in the corresponding country's total R&D personnel in manufacturing.[17] Independent variables are the corresponding share of the industry in total manufacturing value added (*shva*), the total R&D endowment of the country, scaled on the country's real GDP (*rdse/rgdp*), real GDP (*rgdp*) as a scale variable[18], and time (t)[19]. The data are entered as averages over five year periods from 1970 to 1974, 1975 to 1979, 1980 to 1984 and 1985 to 1989 in the case of the independent variables, and of the periods from 1969 to 1973, 1974 to 1978, 1979 to 1983 and 1984 to 1988 in the case of the dependent variables. This is done to reduce serial correlation as well as to alleviate the problem of data gaps of which there are

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[16] A one year lag in variables averaged over five-year intervals means that relationships are assumed to be close to contemporaneous. Longer lags might be justified if one were to estimate the effects of R&D on productivity or other variables of the tangible side of the economy. Yet even for this case, empirical studies, like that of Griliches and Lichtenberg (1984), tend to find only shortly lagged and contemporaneous correlations between R&D expenditures and productivity growth. In the present context, one-year lags are taken into account only to acknowledge that R&D activities logically precede the other economic activities with which they are economically connected.

[17] Expressing the variables as shares is done to avoid regressing country size on country size and to alleviate the heteroscedasticity problem. This same purpose is pursued when scaling countries' R&D endowments on countries' real GDP.

[18] Included in the regression to capture scale effects which might be of particular importance for the allocation of R&D in some industries.

[19] Included in the regression to capture the effects of long-run structural change, which might cause some industries to become generally more R&D intensive and others to become less so over time.

more for some countries than for others.[20] For all industries, separate regressions for two sub periods, the 1970s and the 1980s, as well as a regression over the entire twenty-year period have been run, and conventional Chow-tests carried out to test for structural stability over time. The hypothesis of structural stability can not be rejected for any of the industries at the 95 % level of significance. Results of the regressions over the full period are reported in Table 13.

Some of the estimates of coefficients which capture the impact of value added and countries' endowments with R&D scientists and engineers may be difficult to interpret in some cases due to multi-collinearity[21], but they are certainly suggestive of how industries differ with respect to the determinants of countries' specialisation in R&D. Four cases can be distinguished: First, industries in which both value added specialisation and endowments with R&D scientists and engineers have a positive impact on specialisation in R&D. Second, industries in which countries' endowments with R&D scientists and engineers are insignificant but a positive impact of value added is highly significant, in other words, industries in which R&D activities are closely tied to production. Third, industries in which endowments with R&D scientists and engineers are highly significant, but value added specialisation insignificant, industries which may be distinguished by the greater international mobility of their R&D output. Fourth, industries in which neither endowments with R&D scientists and engineers nor specialisation in value added seems to be an important (positive) determinant in R&D allocation. These may be industries in which historical and path-dependent processes of allocating R&D activities dominate.

Industries of type 1 are *drugs and medicines* (DRUG), *non-ferrous metals* (NFM), *ship building* (SHIP), *motor vehicles* (MOTV) and *other transport* (OTRA).[22]

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[20] Aggregation over five yearly time intervals reduces the danger of giving some countries much more weight than others simply because their statistical offices have worked on a more regular basis.

[21] Coefficients of bivariate correlations between the independent and dependent variables are reported for each industry in Table 14.

[22] Interpretations have to be treated with caution, not least because the sample size is small. Moreover, in *ship building* the case of Japan may dominate the impact of all other countries, while in the case of *other transport* Sweden is an extreme outlier.

Interestingly, of these only *ship building* and *other transport* show a significant *positive* impact of the country's relative endowment with R&D scientists and engineers on the R&D specialisation in the industry. This is consistent with *ship building's* high ranking in terms of human capital intensity in R&D, but inconsistent with the fairly low ranking of *other transport*. The case of Sweden seems to be the outlier which disturbs the picture. However, since *other transport* is an industry formed as a statistical residual, not much weight should be given to the results in this case. Strength in R&D for *drugs and medicines*, *non-ferrous metals* and *motor vehicles*, by contrast, seems to be associated with below average relative endowments with R&D scientists and engineers. And these industries have relatively low average ratios of R&D scientists and engineers to other R&D personnel, ranking ten, eleven and seventeen among the seventeen industries included in the sample. This is consistent with the factor proportions hypothesis of trade and specialisation. In the case of *drugs and medicines* and *non-ferrous metals*, the significant negative effect of size, measured by real GDP is also striking, whereas in the case of *ship building*, the significant positive time effect is striking. In the case of *other transport*, the coefficient on value added, which is much greater than unity in absolute size, may be interpreted as pointing to positive scale effects from the production side, perhaps in the form of cumulative learning effects.

Industries of type 2, where R&D is closely tied to production and where countries' relative endowments with R&D scientists and engineers have no significant effect, are *food, beverages and tobacco* (FOOD), *chemicals* (CHEM), *rubber and plastics* (RAP), *ferrous metals* (IRON), *machinery nec* (MACH), *aircraft* (AIRC) and *professional instruments* (PROF). Apart form the significant positive effect of the share in value added, the FOOD and PROF industries have a negative size effect, the CHEM and AIRC industries a negative time effect, and the IRON and the MACH industries a negative size effect but a positive time effect.

None of the industries falls into the third group. Those industries in which the industry's share in total manufacturing value added does not help to explain the industry's share in R&D employment are either cases for which the regression is clearly misspecified, the case of *stone, clay and glass* (SCG), or industries in which neither specialisation in value added nor endowments with R&D scientists and engineers are a significant determinant, that is to say type 4 industries. To this group belong *fabricated metals* (FABM), *office and computing machinery* (COMP), *electrical machinery* (ELMA) as well as *radio, TV and communication equipment* (RTV). Of these, COMP seems to have a positive time effect, ELMA a negative size effect, RTV a positive size effect and FABM a negative size and a positive time effect.

In this group of industries — strikingly comprising the entire microelectronics complex — specialisation in R&D does not seem to be associated with patterns of strengths and weaknesses in production, nor with relative endowments of R&D scientists and engineers. These industries thus seem to offer the most scope for historical explanations for the observed patterns and dynamics of specialisation in R&D activities.

5 Concluding remarks

The results of multiple regression analyses reported in this paper do not appear to be inconsistent with the factor proportions hypothesis of specialisation in R&D for those industries in which countries' endowments with R&D scientists and engineers do have a significant effect. However, for most industries they do not. Among these, there is a group of industries in which R&D activities seem to be closely tied to production. Several of this group are well-established, some even traditional industries: *chemicals*, *machinery nec*, *aircrafts* and *professional instruments*, are all among the higher ranking industries in terms of R&D intensity, but they are nevertheless industries which have in recent years relied more on gradual technological development than on revolutionary technological breakthroughs. By contrast, in the entire microelectronics group — which has probably experienced the fastest and most radical technological change of all industries in the twenty years from 1970 to 1989 — specialisation in R&D does not appear to be associated with specialisation in production, nor with countries' relative endowments with R&D scientists and engineers.[23] Instead, a significant part of the variation in countries' share of their total R&D personnel allocated to these industries seems to be associated with structural change over time in the case of *office and computing machinery*, an industry which enjoyed spectacular growth in the 1970s and 1980s, and with country size in the case of ELMA and RTV.

A drawback of the regression analysis in this paper is that it has pooled cross section and time series data. Although the latter has been averaged over four five-year intervals, there is no assurance that observations from one country on any particular variable are independent in the time dimension. The effects discussed here, stem primarily from variation in the cross-country dimension, which consist of only 14 cases, however. It would seem to waste information contained in each country's time series if one did only pure cross-section regressions with the data at hand. But there may well be better ways of simultaneously exploiting the information from cross-section and time-series to answer the questions posed. For

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[23] Incidentally, this also seems to hold for fabricated metals, certainly for the greater part a rather traditional industry.

example, it might be more appropriate to estimate separate cross-country equations for each subperiod by using the technique of seemingly unrelated regressions. In such a model one could constrain the parameters of interest to be the same for all periods, so as to use the information from the whole sample efficiently.

Another drawback of the regression analysis in this paper, however, would not be solved by adopting the seemingly unrelated regression technique: Since estimation would essentially concentrate on cross-section variation, any important dynamic effects on which the data might contain interesting information would continue to be ignored. To resolve this problem, new co-integration techniques for panel data, like those recently developed by Quah (1994) and Levin and Lin (1992, 1993), promise to capture some of the dynamic effects which lead to countries' patterns of technological specialisation by exploiting all the available information about how the variation in the relevant variables over a cross section of countries changes over time. Applying these new techniques will be a task for future research.

Data appendix

The data set covers fourteen countries, Australia (AUS), Belgium (BEL), Canada (CAN), Denmark (DK), Finland (FIN), France (FRA), West-Germany (DEU), Italy(ITA), Japan (JAP), the Netherlands (NL), Norway (NOR), Sweden (SWE), the United Kingdom (UK) and the United States (US), and the twenty-year period from 1970 through 1989 — as far as possible. Data gaps are mentioned in the descriptions of the variables below.

Data on Average Years of Schooling in the Adult Population are from Barro and Lee (1993), Table A.2, Appendix, pp. 26-29. Adults are defined as people older than 25 years of age. For Figure 1, panel b, of this paper only the data referring to the years 1975 and 1985 have been taken; they are used as an approximation of the averages for the respective decades. The data source gives these data only at five-year intervals. See Barro and Lee (1993) for their method of estimation.

Data on Value Added by Industry are from the "OECD STAN Database for Industrial Analysis" (1993), Table 2. These yearly data are estimated by the OECD, instead of being a mere compilation of OECD member countries' official data. The estimates are geared towards compatibility with national accounts and towards international comparability. Data for the following cases are missing in the data source (partly because some of the industries have not existed in some of the countries for all or part of the time): in Belgium for MACH, COMP, ELMA, RTV, SHIP, MOTV, AIRC and OTRA throughout, in Canada for PROF throughout, in Denmark for MACH and COMP from 1970 to 1979 and for MOTV and OTRA throughout, in Finland for AIRC and OTRA from 1970 to 1979, in Italy for CHEM, DRUG, MACH, COMP, SHIP, MOTV, AIRC and OTRA from 1988 to 1989 as well as for ELMA and RTV in 1989, in the Netherlands for MACH and COMP in 1989, and in the United States for AIRC and OTRA from 1970 to 1971. As a scale variable value added for the total manufacturing sector is used. This is done because the manufacturing sector is largely identical with the tradable sector, the sector for which the question of international specialisation is relevant.

All other data are from the "OECD Science and Technology Statistics" on magnetic tape (OECD, 1992b). Here is a list of the other variables and missing data:

Data on Total Intramural Business Expenditures on R&D by Industry are from group 25 of the OECD Science and Technology Statistics. Data for the following cases are missing in the data source (partly because some of the industries have not existed in some of the countries for all or part of the time): in Australia for all industries in 1970, 1972, 1974, 1975, 1977, 1979, 1980, 1982, 1983, 1985, 1987, 1989, and for CHEM and DRUG in 1971, RAP, FABM and SCG in 1973, COMP in 1971, 1973, 1988, AIRC in 1971, 1973, 1981, 1988, for IRON, NFM, MACH, ELMA, RTV, SHIP, MOTV, OTRA and PROF in 1971 and 1973; in Belgium for all industries in 1970, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1989, and for COMP from 1970 to 1980; in Canada for all industries in 1970, for MACH, COMP, ELMA and RTV in 1971, and for SHIP, MOTV and OTRA throughout; in Denmark for all industries in 1971, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1986, for FABM and COMP from 1970 to 1978, and for IRON, NFM, MOTV and AIRC throughout; in Finland for all industries in 1970, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1986, 1988, for CHEM, DRUG, ELMA, RTV SHIP and OTRA from 1985 to 1989, for COMP from 1970 to 1978 and 1985 to 1989, for AIRC in 1971 and from 1985 to 1989, and for MOTV throughout; in France for ELMA and RTV from 1970 to 1973; in West-Germany for all industries in 1970, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1986, 1988, for OTRA in 1973, and for DRUG, COMP, ELMA and RTV throughout; in Italy for AIRC from 1970 to 1974 and 1976 to 1977, and for FABM, COMP, SHIP, MOTV and OTRA from 1970 to 1977; in Japan for SHIP and AIRC from 1970 to 1978, and for COMP throughout; in the Netherlands for DRUG from 1970 to 1972 and for FOOD, CHEM, IRON, NFM, FABM, MACH, COMP, ELMA, RTV, SHIP, MOTV, AIRC, OTRA and PROF throughout; in Norway for all industries in 1973, 1976, 1978, 1980, 1986, 1988, for DRUG and OTRA from 1970 to 1971, for NFM from 1973 to 1976, for ELMA, RTV and SHIP from 1970 to 1971 and 1973 to 1976, for MOTV from 1970 to 1978, and for AIRC from 1970 to 1988; in Sweden for all industries in 1970, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1986, 1988, for FABM in 1971, for COMP, ELMA and MOTV from 1970 to 1982, and for AIRC from 1970 to 1982 and 1984 to 1989; in the UK for all industries in 1970, 1971, 1973, 1974, 1976, 1977, 1979, 1980, 1982, 1984, and for OTRA from 1973 to 1989; in the US for CHEM, DRUG and MACH from 1981 to 1985, for FOOD from 1981 to 1986 and 1988 to 1989, for RAP from 1981 to 1989, for SCG from 1981 to 1985 and 1988 to 1989, for IRON from

1981 to 1987 and in 1989, for NFM from 1981 to 1983 and in 1987 and 1989, for COMP from 1970 to 1971 and 1981 to 1989, for ELMA and RTV from 1981 to 1986, for MOTV from 1970 to 1971 and 1986 to 1989, for OTRA from 1970 to 1971 and 1981 to 1989, and for SHIP throughout.

Data on Total R&D Personnel by Industry are from group 29 of the OECD Science and Technology Statistics. Data for the following cases are missing in the data source (partly because some of the industries have not existed in some of the countries for all or part of the time): in Australia for all industries from 1969 to 1975, in 1977, 1979, 1980, 1982, 1983, 1985, 1987, 1989, for RAP, ELMA, RTV and OTRA in 1978, for IRON in 1978, 1984, 1986, for NFM in 1984, 1986, for SHIP and AIRC from 1976 to 1984, and for COMP throughout; in Belgium for all industries in 1970, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1988. 1989, for OTRA in 1971, and for COMP from 1969 to 1980; in Canada for all industries in 1970, 1989, for COMP, ELMA and RTV in 1969, 1971, and for SHIP, MOTV and OTRA throughout; in Denmark for all industries in 1969, 1971, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1986, 1988, and for IRON, NFM, FABM, SHIP, MOTV, AIRC throughout; in Finland for all industries in 1970, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1986, 1988, for CHEM, DRUG, ELMA, RTV, SHIP and OTRA from 1985 to 1989, for AIRC in 1969, 1971 and from 1985 to 1989, for COMP from 1969 to 1977 and 1985 to 1987, and for MOTV throughout; in France for all industries in 1969 and 1984, for SCG in 1976, 1978, for IRON from 1970 to 1974 and in 1976, 1978, 1980, for NFM from 1970 to 1974 and in 1976, 1978, for FABM, ELMA, RTV from 1970 to 1974, for SHIP in 1976, 1978, 1980, for OTRA from 1970 to 1973 and in 1976, 1978, and for PROF from 1970 to 1979; in West-Germany for all industries in 1970, 1972, 1974, 1976, 1978, 9180, 1982, 1984, 1986, 1988, for DRUG, COMP, ELMA and RTV from 1969 to 1987; in Italy for all industries in 1970, 1972, 1974, 1978, for AIRC from 1969 to 1973 and in 1977, for SHIP and MOTV from 1969 to 1977, for FABM and OTRA from 1969 to 1981; for Japan for all industries in 1982, for COMP from 1986 to 1989, for SHIP and AIRC from 1969 to 1978; in the Netherlands for DRUG from 1969 to 1986, and for CHEM, IRON, NFM, FABM, MACH, COMP, ELMA, RTV, SHIP, MOTV, AIRC, OTRA and PROF throughout; in Norway for all industries in 1973, 1976, 1978, 1980, 1986, 1988, for PROF and MACH in 1969, for DRUG, SHIP, OTRA from 1969 to 1971, for NFM in 1969, 1874, 1975, for COMP and MOTV from 1969 to 1977, for ELMA and RTV from 1969 to 1971 and 1974 to 1975, and for AIRC from 1969 to 1987; in Sweden for all industries in 1970, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1986, 1988, for NFM in 1969, 1971, for COMP, ELMA, RTV and MOTV from 1969 to 1981, and for AIRC throughout; in the UK for all industries in 1970, 1971, 1973, 1974, 1976, 1977, 1979, 1980, 1982, 1983, 1984, 1986, 1987, 1988, and for OTRA throughout; in the US for all industries in all years. As a scale variable, the total R&D personnel for each country's total manufacturing sector is used. This is done because the manufacturing sector is largely identical with the tradable sector, the sector for which the question of international specialisation is relevant.

Data on R&D Scientists and Engineers by Industry are from group 26 of the OECD Science and Technology Statistics (1992). Data for the following cases[24] are missing in the data source (partly because some of the industries have not existed in some of the countries for all or part of the time): in Australia for all industries from 1969 to 1975 and in 1977, 1979, 1980, 1982, 1983, 1985, 1987, 1989, for RAP, ELMA, RTV and MOTV in 1978, for IRON in 1978, 1984, 1986, for NFM in 1984, 1986, for SHIP and AIRC from 1976 to 1984, for OTRA in 1978 and 1984, and for COMP throughout; in Belgium for all industries in 1970, 1972, 1974, 1976 and from 1978 to 1989, for OTRA in 1971, and for COMP throughout; in Canada for all industries in 1970 and 1989, for COMP, ELMA, RTV from 1969 to 1971, and for SHIP, MOTV and OTRA throughout; in Denmark for all industries in 1969, 1971, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1986, 1988, for IRON, NFM, FABM, MOTV and AIRC throughout; in Finland for all industries in 1970, 1972, 1974, 1976, 1978 and from 1980 to 1989, for COMP from 1969 to 1977, for AIRC from 1969 to 1971, and for MOTV throughout; in France for all industries in 1970 and 1984, for CHEM, DRUG, MACH, COMP, MOTV from 1969 to 1973, for RAP, FABM, ELMA and RTV from 1969 to 1974, for SCG, NFM and OTRA from 1969 to 1974 and in 1976, 1978, for IRON and SHIP from 1969 to 1974 and in 1976, 1978, 1980, and for PROF from 1969 to 1979; in West-Germany for all industries in 1970, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1986, 1988, for DRUG, COMP, ELMA,

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[24] Missing cases refer to the ratios of R&D Scientists and Engineers to Total R&D Personnel, as used in the present paper.

RTV from 1969 to 1987, in Italy for all industries in 1970, 1972, 1974, 1978, for IRON in 1984, 1986, for FABM and OTRA from 1969 to 1981, for COMP, SHIP and MOTV from 1969 to 1977, for AIRC from 1969 to 1973 and in 1977; in Japan for all industries in 1982, for COMP from 1981 to 1989, for SHIP and AIRC from 1969 to 1977; in the Netherlands for all industries from 1969 to 1978 and in 1980, 1982, 1984, 1986, 1988, for DRUG from 1969 to 1985, and for CHEM, IRON, NFM, FABM, MACH, COMP, ELMA, RTV, SHIP, MOTV, AIRC, OTRA and PROF throughout; in Norway for all industries in 1973, 1976, 1978 and from 1980 to 1989, for DRUG, SHIP and OTRA from 1969 to 1971, for NFM in 1969, 1974, 1975, for MACH in 1969, for COMP and MOTV from 1969 to 1977, for ELMA and RTV from 1969 to 1971 and 1974 to 1975, for PROF in 1969, 1971, and for AIRC throughout; in Sweden for all industries in 1970, 1972, 1974, 1976, 1978, 1980, 1982 and from 1984 to 1989, for NFM in 1969, 1971, for COMP, ELMA, RTV and MOTV from 1969 to 1981, for AIRC throughout; in the UK for all industries in 1970, 1971, 1973, 1974, 1976, 1977, 1979, 1980, 1982, 1983, 1984, 1986, 1987, 1988, for SCG in 1969, for SHIP in 1985, 1989, for OTRA throughout; in the US for all industries in all years.

The source for *Countries' Endowments with R&D Scientists and Engineers* (all fields of science) is group 15 of the OECD Science and Technology Statistics (1992). Missing data have been filled in from linear trend regressions in the case of Canada (1970, 1972 to 1976), the Netherlands (1970, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1986, 1988), Norway (1971, 1973, 1976, 1986, 1988) and Sweden (1970, 1972, 1976, 1978, 1980, 1982, 1984, 1986, 1988), by intrapolation in the case of Australia (1970 to 1972, 1974, 1975, 1977, 1977, 1980, 1982, 1983, 1989), West-Germany (1976, 1978, 1980, 1982, 1984, 1986, 1988) and France (1978, 1980). For Belgium (1970 to 1979) and Finland (1970, 1972 to 1982 1984 to 1989), data on university graduates of science and engineering studies employed in R&D have been used, filling in missing data with fitted values from a linear trend regression.[25] In the case of the United Kingdom (1970 to 1984, 1989), a trend has been extracted from figures on R&D

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[25] For Finland the regression with logarithmic data (from seven observations) has yielded a slope coefficient of 278,28 (50,80), a constant of -543851 (878,98) and an R^2 of 0,86 (standard errors in brackets).

scientists and engineers employed by industry as well as by governments, published by the US National Science Board (1991) in its annual "Science and Engineering indicators", p. 301.[26]

Data on University Graduates in R&D by Industry are from group 30 of the OECD Science and Technology Statistics. Data for the following cases[27] are missing in the data source (partly because some of the industries have not existed in some of the countries for all or part of the time): in Australia for all industries in all years; in Belgium for all industries in 1970, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1988, 1989, for OTRA in 1971, and for COMP from 1969 to 1979 and in 1983; in Canada for all industries in all years; in Denmark for all industries in 1969, 1971, 1972, 1974, 1976, 1978 and from 1980 to 1989, for IRON, NFM FABM, MOTV and AIRC throughout; in Finland for all industries from 1969 to 1978 and in 1980, 1982, 1984, 1986, 1988, for CHEM, DRUG, ELMA, RTV, SHIP, AIRC, OTRA from 1985 to 1989, for COMP from 1985 to 1987, and for NFM and MOTV throughout; in France for all industries in all years, except for NFM, in which case biannual data from 1979 to 1989 are available; in West-Germany for all industries from 1969 to 1978 and in 1980, 1982, 1984, 1986, 1988, for DRUG, COMP, ELMA and RTV from 1979 to 1987; in Italy for all industries from 1969 to 1978, for FABM and OTRA from 1969 to 1981, and for NFM throughout; in Japan for all industries in all years; in the Netherlands for RAP and SCG from 1970 to 1972, for CHEM, IRON, NFM FABM, MACH, COMP, ELMA, RTV, SHIP, MOTV, AIRC, OTRA and PROF throughout; in Norway for all industries in 1973, 1976, 1978, 1980, 1986, 1988, for DRUG, SHIP and OTRA from 1969 to 1971, for NFM from 1969 to 1975, for MACH in 1969, for COMP and MOTV from 1969 to 1977, for ELMA and RTV from 1969 to 1971 and 1974 to 1975, for AIRC from 1969 to 1987; in Sweden for all industries in 1970, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1986, 1988, for NFM from 1969 to 1979 and 1983 to 1989, for COMP, ELMA, RTV and MOTV from 1969 to 1981, and for AIRC throughout; in the UK for all industries from

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[26] The estimated trend regression with logarithmic data (from eleven observations) has a slope coefficient of 2365,138 (192,75), a constant of -4594550 (4620,77) and an R^2 of 0,94 (standard errors in brackets).

[27] Missing cases refer to the ratios of University Graduates to Total R&D Personnel.

1969 to 1980 and 1982 to 1989, for NFM and OTRA throughout; in the US for all industries in all years.

Data on countries' Labour Forces, Nominal Gross Domestic Products (GDP), Purchasing Power Parities and GDP Price Indices are from the economic indicator series — group 94 — of the OECD Science and Technology Statistics, 1992.

Here is a list of all industries, their ISIC codes[28], and of the corresponding abbreviations used in the tables of this paper:

INDUSTRY	**ISIC-CODE**	**ABBREV.**
Food, Beverages, Tobacco	31	FOOD
Chemicals, excluding Drugs	351 & 352 (excl. 3522)	CHEM
Drugs and Medicines	3522	DRUG
Rubber and Plastics	355 & 356	RAP
Non-Metallic Mineral Products	36	SCG
Iron and Steel	371	IRON
Non-Ferrous Metals	372	NFM
Fabricated Metal Products	381	FABM
Machinery, not elsewhere classified (nec), excluding Office and Computing Machinery	382 (excl. 3825)	MACH
Office and Computing Machinery	3825	COMP
Electrical Machinery, excluding RTV	383 (excl. 3832)	ELMA
Radio, TV and Communication Equipment	3832	RTV
Shipbuilding and Repair	3841	SHIP

[28] International Standard Classification of All Economic Activities, United Nations Statistical Paper, Series M, No. 4, Revision 2 (1968).

Motor Vehicles	3843	MOTV
Aircraft	3845	AIRC
Other Transport Equipment	3842, 3844, 3849	OTRA
Professional Goods (Scientific Instruments)	385	PROF
Sub-total electrical group	383	ET
Sub-total chemical group	351, 352, 353, 354	CT

Other abbreviations used:

TOTMANU stands for total manufacturing, MANTOT for manufacturing total, TT for all sectors of an economy. ALL CTS stands for all countries in the sample, ALL IND for all industries in the sample. RDSEND stands for countries' endowments with R&D scientists and engineers relative to the size of the labour force.

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Tables and Figures are reproduced on the following pages.

Table 1 - panel a: Average R&D intensities in the 1970s

INDUSTRY	AUS	BEL	CAN	DK	FIN	FRA	DEU	ITA	JAP	NL	NOR	SWE	UK	US	ALL CTS
FOOD	0,0050	0,0054	0,0057	0,0075	0,0072	0,0038	0,0022	0,0010	0,0105		0,0090	0,0187	0,0093	0,0081	0,0068
CHEM	0,0231	0,1040	0,0280	0,0465	0,0283	0,0557	0.1321	0,0247	0,0686		0,0465	0,0436	0,0990	0,0685	0,0678
DRUG	0,0334	0,1840	0,0744	0,2211	0,1439	0,1697	0,0000	0,0979	0,0874	0,2455	0,1876	0,2794	0,1442	0,1106	0,1100
RAP	0,0085	0,0142	0,0087	0,0125	0,0273	0,0412	0,0130	0,0218	0,0161	0,0120	0,0169	0,0138	0,0159	0,0416	0,0291
SCG	0,0062	0,0282	0,0040	0,0124	0,0100	0,0152	0,0062	0,0008	0,0198	0,0043	0,0079	0,0212	0,0152	0,0188	0,0140
IRON	0,0142	0,0281	0,0083		0,0182	0,0074	0,0088	0,0031	0,0189		0,0227	0,0581	0,0225	0,0105	0,0124
NFM	0,0050	0,0359	0,0373		0,0684	0,0341	0,0286	0,0185	0,0241		0,0236	0,0426	0,0260	0,0235	0,0252
FABM	0,0062	0,0194	0,0044	0,0055	0,0081	0,0065	0,0040	0,0021	0,0090		0,0170	0,0158	0,0072	0,0100	0,0087
MACH	0,0085		0,0119		0,0288	0,0162	0,0522	0,0060	0,0289		0,0481	0,0631	0,0235	0,0373	0,0312
COMP	0,0206		0,1082		0,2836	0,1112		0,1193			0,1696		0,2106	0,3940	0,2712
ELMA	0,0225		0,0281	0,0230	0,0620	0,0405		0,0076	0,0723		0,0680		0,0620	0,1583	0,0986
RTV	0,1070		0,1566	0,1126	0,1065	0,2111		0,1210	0,1012		0,1630	0,0136	0,1735	0,1979	0,1644
SHIP	0,0011			0,0332	0,0062	0,0054	0,0214	0,0087	0,1058		0,0174	0,0259	0,0284		0,0192
MOTV	0,0173					0,0617	0,0670	0,0585	0,0628		0,0174		0,0518	0,1116	0,0808
AIRC	0,0012		0,1804		0,0147	0,4468	0,9553	0,0636	0,0084				0,4169	0,4401	0,4617
OTRA	0,0051			0,0094	0,0173	0,0112	0,0161	0,0126	0,2742		0,0326	1,3768	0,0001	0,0631	0,1115
PROF	0,0406	0,0755		0,1142	0,0913	0,0416	0,0229	0,0346	0,0602		0,0621	0,0857	0,0400	0,1197	0,0868
TOTMANU	0,0116	0,0308	0,0181	0,0217	0,0186	0,0361	0,0374	0,0136	0,0325	0,0425	0,0236	0,0450	0,0449	0,0642	0,0455

Table 1 - panel b: Average R&D intensities in the 1980s

INDUSTRY	AUS	BEL	CAN	DK	FIN	FRA	DEU	ITA	JAP	NL	NOR	SWE	UK	US	ALL CTS
FOOD	0,0055	0,0068	0,0067	0,0119	0,0144	0,0060	0,0055	0,0018	0,0160		0,0036	0,0178	0,0077	0,0118	0,0092
CHEM	0,0229	0,1083	0,0306	0,0393	0,0348	0,0784	0,1381	0,0367	0,0923		0,0461	0,0946	0,1446	0,0811	0,0864
DRUG	0,0627	0,2310	0,0782	0,2189	0,1868	0,2351	0,1781	0,1446	0,1207	0,2707	0,1966	0,3352	0,2053	0,1464	0,1501
RAP	0,0054	0,0315	0,0086	0,0149	0,0410	0,0451	0,0289	0,0183	0,0329	0,0154	0,0171	0,0270	0,0157	0,0443	0,0298
SCG	0,0064	0,0290	0,0055	0,0181	0,0221	0,0149	0,0167	0,0013	0,0414	0,0051	0,0082	0,0184	0,0114	0,0312	0,0206
IRON	0,0182	0,0328	0,0079		0,0217	0,0206	0,0149	0,0105	0,0344		0,0280	0,0809	0,0193	0,0117	0,0249
NFM	0,0079	0,0346	0,0343		0,0932	0,0300	0,0164	0,0121	0,0607		0,0318	0,0301	0,0307	0,0301	0,0359
FABM	0,0051	0,0246	0,0064	0,0105	0,0124	0,0078	0,0173	0,0059	0,0146		0,0131	0,0167	0,0117	0,0123	0,0118
MACH	0,0191		0,0163	0,0318	0,0549	0,0259	0,0903	0,0112	0,0456		0,0460	0,0785	0,0351	0,0381	0,0400
COMP	0,1399		0,2258	0,2481	0,0959	0,1157	0,1106	0,1941			0,2754	0,3290	0,3039	0,2974	0,1850
ELMA	0,0285		0,0315	0,0512	0,0702	0,0381	0,0923	0,0292	0,1003		0,0597	0,1407	0,0896	0,0600	0,0708
RTV	0,1333		0,2808	0,1317	0,1963	0,2755	0,1821	0,1920	0,1573		0,2406	0,0100	0,3344	0,2603	0,2031
SHIP	0,0045			0,0313	0,0174	0,0133	0,0253	0,0301	0,1478		0,0118	0,0522	0,0046		0,0808
MOTV	0,0394					0,0915	0,0868	0,0649	0,0940		0,0299	0,2044	0,0844	0,1563	0,1049
AIRC	0,0116		0,2148		0,0143	0,3630	0,5525	0,2711	0,0077		0,0124	0,2465	0,3271	0,5129	0,4600
OTRA	0,0124			0,0236	0,0379	0,0349	0,0468	0,0190	0,0485		0,0171	0,6173		0,0662	0,0489
PROF	0,0438	0,0580		0,1455	0,1595	0,0492	0,0335	0,0080	0,1251		0,2347	0,1002	0,0381	0,1820	0,1295
TOTMANU	0,0153	0,0465	0,0300	0,0337	0,0334	0,0526	0,0580	0,0218	0,0550	0,0574	0,0301	0,0776	0,0643	0,0903	0,0652

Table 2 - panel a: Rankings of average R&D intensities across countries in the 1970s

INDUSTRY	AUS	BEL	CAN	DK	FIN	FRA	DEU	ITA	JAP	NL	NOR	SWE	UK	US
FOOD	10	9	8	6	7	11	12	13	2		4	1	3	5
CHEM	13	2	11	8	10	6	1	12	4		7	9	3	5
DRUG	13	5	12	3	8	6		10	11	2	4	1	7	9
RAP	14	8	13	11	3	2	10	4	6	12	6	9	7	1
SCG	10	1	13	7	8	5	11	14	3	12	9	2	6	4
IRON	7	2	10		6	11	9	12	5		3	1	4	8
NFM	12	4	3		1	8	6	11	8		9	2	7	10
FABM	9	1	11	10	6	8	12	13	5		2	3	7	4
MACH	10		9		6	8	2	11	5		3	1	7	4
COMP	8		7		2	6		5			4		3	1
ELMA	9		7	8	4	6		10	2		3		5	1
RTV	8		5	7	9	1		6	10		3	11	4	2
SHIP	10			2	8	9	5	7	1		6	4	3	
MOTV	8					4	2	5	3		7		6	1
AIRC	9		5		7	2	1	6	8				4	3
OTRA	10			9	5	8	6	7	2		4	1	11	3
PROF	9	5		2	3	6	12	11	7		6	4	10	1
TOTMANU	14	8	12	10	11	6	5	13	7	4	9	2	3	1

Table 2 - panel b: Rankings of average R&D intensities across countries in the 1980s

INDUSTRY	AUS	BEL	CAN	DK	FIN	FRA	DEU	ITA	JAP	NL	NOR	SWE	UK	US
FOOD	11	7	8	4	3	9	10	13	2		12	1	6	5
CHEM	13	3	12	9	11	7	2	10	5		8	4	1	6
DRUG	14	4	13	5	8	3	9	11	12	2	7	1	6	10
RAP	14	5	13	12	3	1	6	8	4	11	9	7	10	2
SCG	11	3	12	6	4	8	7	14	1	13	10	5	9	2
IRON	6	3	12		5	6	9	11	2		4	1	7	10
NFM	12	3	4		1	9	10	11	2		5	8	6	7
FABM	13	1	11	9	6	10	2	12	4		5	3	8	7
MACH	10		11	8	3	9	1	12	6		4	2	7	6
COMP	8		6	5	11	9	10	7			4	1	2	3
ELMA	12		10	6	5	9	3	11	2		7	1	4	6
RTV	10		2	11	6	3	8	7	9		5	12	1	4
SHIP	10			3	6	7	5	4	1		8	2	9	
MOTV	8					4	5	7	3		9	1	6	2
AIRC	10		7		8	3	1	5	11		9	6	4	2
OTRA	10			7	5	6	4	8	3		9	1		2
PROF	9	7		4	3	8	11	12	5		1	6	10	2
TOTMANU	14	8	12	9	10	7	4	13	6	5	11	2	3	1

Table 3 - panel a: Rankings of average R&D intensities across industries in the 1970s

INDUSTRY	AUS	BEL	CAN	DK	FIN	FRA	DEU	ITA	JAP	NL	NOR	SWE	UK	US	ALL CTS
FOOD	15	9	11	10	15	17	13	16	14		15	10	15	16	17
CHEM	4	2	7	4	8	6	2	7	6		7	6	5	8	9
DRUG	3	1	4	1	2	3		3	4	1	1	2	4	7	5
RAP	9	8	9	7	9	8	9	8	13	2	14	12	13	10	11
SCG	12	5	13	8	13	12	11	17	11	3	16	9	14	13	14
IRON	8	6	10		10	14	10	14	12		10	5	12	14	15
NFM	14	4	5		5	10	5	9	10		9	7	10	12	12
FABM	11	7	12	11	14	15	12	15	15		13	11	16	15	16
MACH	10		8		7	11	4	13	9		6	4	11	11	10
COMP	6		3		1	4		2	,		3		2	2	2
ELMA	5		6	6	6	9		12	5		4		6	4	6
RTV	1		2	3	3	2		1	3		2	13	3	3	3
SHIP	17			5	16	16	7	11	2		12	8	9		13
MOTV	7					5	3	5	7		11		7	6	8
AIRC	16		1		12	1	1	4	16				1	1	1
OTRA	13			9	11	13	8	10	1		8	1	17	9	4
PROF	2	3		2	4	7	6	6	8		5	3	8	5	7

Table 3 - panel b: Rankings of average R&D intensities across industries in the 1980s

INDUSTRY	AUS	BEL	CAN	DK	FIN	FRA	DEU	ITA	JAP	NL	NOR	SWE	UK	US	ALL CTS
FOOD	14	9	11	12	14	17	17	16	14		17	15	15	15	17
CHEM	7	2	7	6	10	6	4	6	7		6	8	5	7	7
DRUG	3	1	4	2	2	3	3	4	4	1	4	2	4	6	4
RAP	15	6	9	11	8	8	11	10	13	2	11	13	12	10	13
SCG	13	7	13	10	11	14	14	17	11	3	16	14	14	12	15
IRON	9	5	10		12	13	16	13	12		10	9	11	16	14
NFM	12	4	5		5	11	15	11	8		8	12	10	13	12
FABM	16	8	12	13	16	16	13	15	15		13	16	13	14	16
MACH	8		8	7	7	12	7	12	10		7	10	9	11	11
COMP	1		2	1	4	4	5	2			1	3	3	2	3
ELMA	6		6	5	6	9	6	8	5		5	6	6	9	9
RTV	2		1	4	1	2	2	3	1		2	17	1	3	2
SHIP	17			8	13	15	12	7	2		15	11	16		8
MOTV	5					5	8	5	6		9	5	7	5	6
AIRC	11		3		15	1	1	1	16		14	4	2	1	1
OTRA	10			9	9	10	9	9	9		12	1		8	10
PROF	4	3		3	3	7	10	14	3		3	7	8	4	5

Table 4 - panel a: Correlations between countries' R&D intensities across industries in the 1970s

	AUS	BEL	CAN	DK	FIN	FRA	DEU	ITA	JAP	NOR	SWE	UK	US	ALL CTS
AUS	1,00	0,78	0,51	0,58	0,40	0,28	-0,22	0,65	0,18	0,71	-0,13	0,23	0,21	0,15
BEL	0,78	1,00	0,90	0,92	0,83	0,93	0,84	0,92	0,95	0,94	0,90	0,96	0,77	0,90
CAN	0,51	0,90	1,00	0,69	0,46	0,92	0,99	0,83	0,37	0,91	0,23	0,92	0,87	0,90
DK	0,58	0,92	0,69	1,00	0,93	0,80	0,29	0,83	0,11	0,87	-0,05	0,77	0,57	0,60
FIN	0,40	0,83	0,46	0,93	1,00	0,22	-0,12	0,80	0,16	0,83	-0,02	0,38	0,57	0,40
FRA	0,28	0,93	0,92	0,80	0,22	1,00	0,99	0,63	-0,09	0,91	-0,07	0,96	0,81	0,90
DEU	-0,22	0,84	0,99	0,29	-0,12	0,99	1,00	0,68	-0,17	0,47	-0,10	0,99	0,96	0,97
ITA	0,65	0,92	0,83	0,83	0,80	0,63	0,68	1,00	0,16	0,90	-0,01	0,67	0,70	0,63
JAP	0,18	0,95	0,37	0,11	0,16	-0,09	-0,17	0,16	1,00	0,25	0,89	-0,11	0,03	0,07
NOR	0,71	0,94	0,91	0,87	0,83	0,91	0,47	0,90	0,25	1,00	0,04	0,92	0,75	0,81
SWE	-0,13	0,90	0,23	-0,05	-0,02	-0,07	-0,10	-0,01	0,89	0,04	1,00	-0,16	0,07	0,41
UK	0,23	0,96	0,92	0,77	0,38	0,96	0,99	0,67	-0,11	0,92	-0,16	1,00	0,91	0,95
US	0,21	0,77	0,87	0,57	0,57	0,81	0,96	0,70	0,03	0,75	0,07	0,91	1,00	0,96
ALL CTS	0,15	0,90	0,90	0,60	0,40	0,90	0,97	0,63	0,07	0,81	0,41	0,95	0,96	1,00

Table 4 - panel b: Correlations between countries' R&D intensities across industries in the 1980s

	AUS	BEL	CAN	DK	FIN	FRA	DEU	ITA	JAP	NOR	SWE	UK	US	ALL CTS
AUS	1,00	0,86	0,80	0,84	0,72	0,49	0,19	0,63	0,68	0,89	0,20	0,75	0,50	0,38
BEL	0,86	1,00	0,92	0,84	0,71	0,98	0,94	0,97	0,75	0,65	0,96	0,96	0,64	0,82
CAN	0,80	0,92	1,00	0,75	0,55	0,82	0,65	0,93	0,46	0,73	0,45	0,95	0,87	0,80
DK	0,84	0,84	0,75	1,00	0,80	0,71	0,63	0,83	0,68	0,94	0,36	0,78	0,87	0,88
FIN	0,72	0,71	0,55	0,80	1,00	0,45	0,10	0,38	0,70	0,86	0,12	0,47	0,28	0,25
FRA	0,49	0,98	0,82	0,71	0,45	1,00	0,89	0,93	0,20	0,41	0,26	0,89	0,87	0,90
DEU	0,19	0,94	0,65	0,63	0,10	0,89	1,00	0,84	-0,06	0,12	0,27	0,77	0,87	0,94
ITA	0,63	0,97	0,93	0,83	0,38	0,93	0,84	1,00	0,18	0,50	0,33	0,96	0,92	0,91
JAP	0,68	0,75	0,46	0,68	0,70	0,20	-0,06	0,18	1,00	0,70	-0,00	0,28	0,18	0,11
NOR	0,89	0,65	0,73	0,94	0,86	0,41	0,12	0,50	0,70	1,00	0,19	0,60	0,44	0,34
SWE	0,20	0,96	0,45	0,36	0,12	0,26	0,27	0,33	-0,00	0,19	1,00	0,61	0,31	0,29
UK	0,75	0,96	0,95	0,78	0,47	0,89	0,77	0,96	0,28	0,60	0,61	1,00	0,86	0,83
US	0,50	0,64	0,87	0,87	0,28	0,87	0,87	0,92	0,18	0,44	0,31	0,86	1,00	0,98
ALL CTS	0,38	0,82	0,80	0,88	0,25	0,90	0,94	0,91	0,11	0,34	0,29	0,83	0,98	1,00

Table 5 - panel a: Correlations between industries' R&D intensities across countries in the 1970s

	FOOD	CHEM	DRUG	RAP	SCG	IRON	NFM	FABM	MACH	COMP	ELMA	RTV	SHIP	MOTV	AIRC	OTRA	PROF	ALLIND
FOOD	1,00	-0,10	0,58	-0,13	0,53	0,87	0,25	0,56	0,61	0,55	0,55	-0,56	0,37	0,01	-0,25	0,82	0,45	0,39
CHEM	-0,10	1,00	0,21	-0,01	0,42	0,03	-0,07	0,18	0,45	0,50	0,57	0,38	0,27	0,38	0,85	-0,12	-0,22	0,55
DRUG	0,58	0,21	1,00	-0,09	0,28	0,78	0,48	0,55	0,79	0,33	0,01	-0,31	-0,05	-0,01	0,55	0,60	0,37	0,31
RAP	-0,13	-0,01	-0,09	1,00	0,24	-0,32	0,16	-0,04	-0,05	0,61	0,60	0,55	-0,26	0,70	0,18	-0,21	0,28	0,47
SCG	0,53	0,42	0,28	0,24	1,00	0,57	0,20	0,70	0,47	0,67	0,68	-0,14	0,55	0,52	0,11	0,54	0,45	0,50
IRON	0,87	0,03	0,78	-0,32	0,57	1,00	0,30	0,71	0,66	0,20	0,24	-0,70	0,17	-0,43	-0,22	0,91	0,32	0,23
NFM	0,25	-0,07	0,48	0,16	0,20	0,30	1,00	0,19	0,27	0,38	0,06	-0,23	-0,09	0,46	-0,05	0,26	0,40	-0,00
FABM	0,56	0,18	0,55	-0,04	0,70	0,71	0,19	1,00	0,70	0,37	0,56	-0,17	0,13	-0,21	-0,08	0,57	0,34	0,27
MACH	0,61	0,45	0,79	-0,05	0,47	0,66	0,27	0,70	1,00	0,67	0,74	-0,33	0,17	0,19	0,71	0,60	0,35	0,52
COMP	0,55	0,50	0,33	0,61	0,67	0,20	0,38	0,37	0,67	1,00	0,90	0,31	0,54	0,82	0,47	0,59	0,89	0,75
ELMA	0,55	0,57	0,01	0,60	0,68	0,24	0,06	0,56	0,74	0,90	1,00	0,46	0,33	0,71	0,53	0,36	0,58	0,87
RTV	-0,56	0,38	-0,31	0,55	-0,14	-0,70	-0,23	-0,17	-0,33	0,31	0,46	1,00	-0,23	0,34	0,93	-0,73	-0,11	0,25
SHIP	0,37	0,27	-0,05	-0,26	0,55	0,17	-0,09	0,13	0,17	0,54	0,33	-0,23	1,00	0,27	-0,16	0,19	0,12	0,25
MOTV	0,01	0,38	-0,01	0,70	0,52	-0,43	0,46	-0,21	0,19	0,82	0,71	0,34	0,27	1,00	0,42	0,27	0,60	0,81
AIRC	-0,25	0,85	0,55	0,18	0,11	-0,22	-0,05	-0,08	0,71	0,47	0,53	0,93	-0,16	0,42	1,00	-0,25	-0,17	0,61
OTRA	0,82	-0,12	0,60	-0,21	0,54	0,91	0,26	0,57	0,60	0,59	0,36	-0,73	0,19	0,27	-0,25	1,00	0,21	0,28
PROF	0,45	-0,22	0,37	0,28	0,45	0,32	0,40	0,34	0,35	0,89	0,58	-0,11	0,12	0,60	-0,17	0,21	1,00	0,33
ALLIND	0,39	0,55	0,31	0,47	0,50	0,23	-0,00	0,27	0,52	0,75	0,87	0,25	0,25	0,81	0,61	0,28	0,33	1,00

Table 5 - panel b: Correlations between industries' R&D intensities across countries in the 1980s

	FOOD	CHEM	DRUG	RAP	SCG	IRON	NFM	FABM	MACH	COMP	ELMA	RTV	SHIP	MOTV	AIRC	OTRA	PROF	ALLIND
FOOD	1,00	0,13	0,34	0,39	0,68	0,63	0,62	0,31	0,44	0,30	0,68	-0,50	0,55	0,79	-0,15	0,56	0,39	0,50
CHEM	0,13	1,00	0,41	0,33	0,39	0,23	-0,10	0,63	0,58	0,20	0,67	0,15	0,19	0,39	0,59	0,31	-0,32	0,71
DRUG	0,34	0,41	1,00	0,25	0,03	0,73	0,10	0,53	0,54	0,35	0,61	-0,33	-0,15	0,60	0,19	0,73	0,05	0,44
RAP	0,39	0,33	0,25	1,00	0,68	0,12	0,48	0,39	0,36	-0,23	0,28	0,08	0,30	0,55	0,34	0,06	0,21	0,55
SCG	0,68	0,39	0,03	0,68	1,00	0,27	0,52	0,61	0,39	0,09	0,51	-0,17	0,82	0,49	0,05	0,08	0,34	0,51
IRON	0,63	0,23	0,73	0,12	0,27	1,00	0,12	0,48	0,54	0,43	0,78	-0,75	0,32	0,63	-0,18	0,93	0,14	0,37
NFM	0,62	-0,10	0,10	0,48	0,52	0,12	1,00	0,22	0,20	-0,20	0,26	0,03	0,32	0,26	-0,41	-0,04	0,49	0,05
FABM	0,31	0,63	0,53	0,39	0,61	0,48	0,22	1,00	0,92	0,25	0,89	-0,32	0,38	0,51	0,20	0,47	0,11	0,44
MACH	0,44	0,58	0,54	0,36	0,39	0,54	0,20	0,92	1,00	0,01	0,82	-0,43	0,15	0,47	0,22	0,52	0,15	0,49
COMP	0,30	0,20	0,35	-0,23	0,09	0,43	-0,20	0,25	0,01	1,00	0,40	-0,05	0,15	0,48	0,07	0,55	0,34	0,43
ELMA	0,68	0,67	0,61	0,28	0,51	0,78	0,26	0,89	0,82	0,40	1,00	-0,45	0,43	0,66	0,10	0,76	0,11	0,65
RTV	-0,50	0,15	-0,33	0,08	-0,17	-0,75	0,03	-0,32	-0,43	-0,05	-0,45	1,00	-0,32	-0,41	0,24	-0,74	-0,00	0,01
SHIP	0,55	0,19	-0,15	0,30	0,82	0,32	0,32	0,38	0,15	0,15	0,43	-0,32	1,00	0,34	-0,09	0,13	0,19	0,38
MOTV	0,79	0,39	0,60	0,55	0,49	0,63	0,26	0,51	0,47	0,48	0,66	-0,41	0,34	1,00	0,44	0,79	0,11	0,84
AIRC	-0,15	0,59	0,19	0,34	0,05	-0,18	-0,41	0,20	0,22	0,07	0,10	0,24	-0,09	0,44	1,00	0,06	-0,28	0,64
OTRA	0,56	0,31	0,73	0,06	0,08	0,93	-0,04	0,47	0,52	0,55	0,76	-0,74	0,13	0,79	0,06	1,00	-0,03	0,49
PROF	0,39	-0,32	0,05	0,21	0,34	0,14	0,49	0,11	0,15	0,34	0,11	-0,00	0,19	0,11	-0,28	-0,03	1,00	0,14
ALLIND	0,50	0,71	0,44	0,55	0,51	0,37	0,05	0,44	0,49	0,43	0,65	0,01	0,38	0,84	0,64	0,49	0,14	1,00

Table 6 - panel a: Average ratios of R&D Scientists and Engineers to other R&D personnel in the 1970s

INDUSTRY	AUS	BEL	CAN	DK	FIN	FRA	DEU	ITA	JAP	NL	NOR	SWE	UK	US	All CTS
FOOD	1,19	0,25	0,73	0,44	0,86	0,37	0,38	1,40	0,99	0,37	0,58	0,76	0,42		0,77
CHEM	1,19	0,17	0,87	0,47	0,47	0,27	0,24	0,87	0,84		0,40	0,87	0,53		0,57
DRUG	0,81	0,25	1,26	0,52	0,93	0,37		0,63	0,89		0,91	1,07	0,52		0,72
RAP	1,01	0,21	0,97	0,18	0,64	0,13	0,41	0,27	0,89	0,29	0,33	1,10	0,50		0,56
SCG	0,94	0,22	0,69	0,37	1,21	0,28	0,47	0,66	0,67	0,57	0,57	0,97	0,67		0,61
IRON	0,63	0,24	0,81		0,98	0,31	0,36	0,77	0,57		0,50	0,45	0,74		0,54
NFM	0,86	0,24	0,58		0,27	0,23	0,37	0,65	0,83		0,52	0,98	0,62		0,65
FABM	0,60	0,18	0,88		0,97	0,38	0,45		1,01		0,42	0,76	0,59		0,79
MACH	0,63	0,13	0,75	0,16	0,82	0,23	0,57	0,76	1,13		0,54	0,65	0,42		0,76
COMP			0,91		3,39	0,88		0,79	0,92		1,32		0,62		0,83
ELMA	0,67	0,22	0,38	0,22	0,63	0,29		0,73	1,18		0,51		0,57		0,93
RTV	0,91	0,15	0,91	0,20	0,89	0,46		0,72	1,07		0,50		0,62		0,82
SHIP		0,56			2,92	0,64	0,95	0,85	1,16		0,89	0,61	0,71		0,81
MOTV	0,21	0,09				0,18	0,28	0,14	0,38		0,52		0,36		0,32
AIRC		0,24	0,71		0,89	0,31	0,68	0,81	2,78				0,40		0,38
OTRA	1,00	0,24		0,10	0,65	0,30	0,20		0,99		0,31	0,22			0,73
PROF	0,70	0,28	0,83	0,24	0,73		0,45	0,54	1,16		0,64	0,71	0,59		0,84
ALL IND	0,75	0,18	0,73	0,29	0,74	0,32	0,45	0,49	0,87	0,40	0,49	0,49	0,50		0,60

Table 6 - panel b: Average ratios of R&D Scientists and Engineers to other R&D personnel in the 1980s

INDUSTRY	AUS	BEL	CAN	DK	FIN	FRA	DEU	ITA	JAP	NL	NOR	SWE	UK	US	All CTS
FOOD	1,33		0,84	0,50		0,45	0,34	0,92	1,34	0,39		0,82	0,64		0,95
CHEM	1,22		1,19	0,52		0,34	0,28	0,95	1,19			0,82	0,61		0,75
DRUG	1,01		1,15	0,56		0,45	0,37	0,79	1,16	0,36		1,46	0,67		0,83
RAP	1,05		0,82	0,23		0,17	0,32	0,61	1,48	0,39		0,95	0,89		0,78
SCO	0,76		0,81	0,38		0,34	0,34	0,86	0,94	0,88		0,67	0,77		0,75
IRON	1,08		1,02			0,38	0,40		0,70			0,47	1,13		0,71
NFM	1,05		0,58			0,33	0,41	1,07	1,02			0,70	0,82		0,76
FABM	0,82		0,79			0,41	0,27	0,41	1,62			0,51	0,77		0,89
MACH	0,73		0,73	0,32		0,49	0,59	0,79	1,70			0,55	0,68		1,02
COMP			1,51			1,35	1,55	1,85	1,44			0,39	1,20		1,44
ELMA	0,86		0,72	0,46		0,43	1,01	0,85	2,96			0,71	1,00		1,61
RTV	1,27		1,33	0,31		0,60	1,11	0,92	1,84			0,65	1,19		1,29
SHIP	0,97					0,61	0,72	0,95	1,46			0,67	0,91		1,29
MOTV	0,60					0,20	0,35	0,27	0,59			0,27	0,64		0,42
AIRC	0,86		0,70			0,40	0,71	0,72	1,66				0,69		0,53
OTRA	0,55			0,16		0,34	0,40	0,43	1,82			0,23			0,72
PROF	1,68		0,99	0,46		0,58	0,52	1,31	1,69			0,42	0,82		1,24
ALL IND	1,00		0,96	0,38		0,43	0,52	0,74	1,26	0,49		0,52	0,83		0,85

Table 7 - panel a: Rankings of the average ratios of R&D Scientists and Engineers to other R&D personnel across countries in the 1970s

INDUSTRY	AUS	BEL	CAN	DK	FIN	FRA	DEU	ITA	JAP	NL	NOR	SWE	UK	US
FOOD	2	13	6	8	4	11	10	1	3	12	7	5	9	
CHEM	1	12	3	8	7	10	11	4	5		9	2	6	
DRUG	6	11	1	9	3	10		7	5		4	2	8	
RAP	2	11	3	12	5	13	7	10	4	9	8	1	6	
SCG	3	13	4	11	1	12	10	7	5	9	8	2	6	
IRON	5	11	2		1	10	9	3	6		7	8	4	
NFM	2	10	6		9	11	8	4	3		7	1	5	
FABM	5	10	3		2	9	7		1		8	4	6	
MACH	6	12	4	11	2	10	7	3	1		8	5	9	
COMP			4		1	5		6	3		2		7	
ELMA	3	10	7	9	4	8		2	1		6		5	
RTV	2	10	3	9	4	8		5	1		7		6	
SHIP		9			1	7	3	5	2		4	8	6	
MOTV	5	8				6	4	7	2		1		3	
AIRC		8	4		2	7	5	3	1				6	
OTRA	1	6		9	3	5	8		2		4	7		
PROF	5	10	2	11	3		9	8	1		6	4	7	
ALL IND	2	13	4	12	3	11	9	8	1	10	7	6	5	

Table 7 - panel b: Rankings of the average ratios of R&D Scientists and Engineers to other R&D personnel across countries in the 1980s

INDUSTRY	AUS	BEL	CAN	DK	FIN	FRA	DEU	ITA	JAP	NL	NOR	SWE	UK	US
FOOD	2		4	7		8	10	3	1	9		5	6	
CHEM	1		3	7		8	9	4	2			5	6	
DRUG	4		3	7		8	9	5	2	10		1	6	
RAP	2		5	9		10	8	6	1	7		3	4	
SCG	6		4	8		9	10	3	1	2		7	5	
IRON	2		3			7	6		4			5	1	
NFM	2		6			8	7	1	3			5	4	
FABM	2		3			7	8	6	1			5	4	
MACH	3		4	9		8	6	2	1			7	5	
COMP			3			5	2	1	4			7	6	
ELMA	4		6	8		9	2	5	1			7	3	
RTV	3		2	9		8	5	6	1			7	4	
SHIP	2					7	5	3	1			6	4	
MOTV	2					7	4	5	3			6	1	
AIRC	2		5			7	4	3	1				6	
OTRA	2			7		5	4	3	1			6		
PROF	2		4	8		6	7	3	1			9	5	
ALL IND	2		3	10		9	6	5	1	8		7	4	

Table 8 - panel a: Rankings of the average ratios of R&D Scientists and Engineers to other R&D personnel across industries in the 1970s

INDUSTRY	AUS	BEL	CAN	DK	FIN	FRA	DEU	ITA	JAP	NL	NOR	SWE	UK	US	All CTS
FOOD	2	4	10	3	9	5	6	1	8	2	5	6	14		7
CHEM	1	13	6	2	15	12	12	2	13		14	5	10		13
DRUG	8	3	1	1	6	6		12	12		2	2	11		10
RAP	3	11	2	8	13	16	7	14	11	3	15	1	12		14
SCG	5	9	12	4	3	11	4	10	15	1	6	4	3		12
IRON	12	7	8		4	7	10	6	16		11	11	1		15
NFM	7	5	13		16	14	9	11	14		8	3	6		11
FABM	13	12	5		5	4	5		7		13	7	8		6
MACH	11	15	9	9	10	13	3	7	5		7	9	13		8
COMP			3		1	1		5	10		1		5		3
ELMA	10	10	14	6	14	10		8	2		10		9		1
RTV	6	14	4	7	7	3		9	6		12		4		4
SHIP		1			2	2	1	3	4		3	10	2		5
MOTV	14	16				15	11	15	17		9		16		17
AIRC		6	11		8	8	2	4	1				15		16
OTRA	4	8		10	12	9	13		9		16	12			9
PROF	9	2	7	5	11		6	13	3		4	8	7		2

Table 8 - panel b: Rankings of the average ratios of R&D Scientists and Engineers to other R&D personnel across industries in the 1980s

INDUSTRY	AUS	BEL	CAN	DK	FIN	FRA	DEU	ITA	JAP	NL	NOR	SWE	UK	US	All CTS
FOOD	2		7	3		7	13	7	11	3		4	14		7
CHEM	4		3	2		14	16	5	12			3	16		12
DRUG	8		4	1		6	11	10	13	4		1	13		9
RAP	6		8	9		17	15	13	8	2		2	6		10
SCG	13		9	6		12	14	8	15	1		8	10		13
IRON	5		5			11	10		16			12	3		15
NFM	7		14			15	8	3	14			6	8		11
FABM	12		10			9	17	15	7			11	9		8
MACH	14		11	7		5	6	11	4			10	12		6
COMP			1			1	1	1	10			14	1		2
ELMA	11		12	5		8	3	9	1			5	4		1
RTV	3		2	8		3	2	6	2			9	2		4
SHIP	9					2	4	4	9			7	5		3
MOTV	15					16	12	16	17			15	15		17
AIRC	10		13			10	5	12	6				11		16
OTRA	16			10		13	9	14	3			16			14
PROF	1		6	4		4	7	2	5			13	7		5

Table 9 - panel a: Bivariate correlations between countries' average ratios of R&D Scientists and Engineers to other R&D personnel across industries in the 1970s

	AUS	BEL	CAN	DK	FIN	FRA	DEU	ITA	JAP	NOR	SWE	UK	All CTS
AUS	1,00	0,43	0,14	0,38	-0,25	0,20	-0,20	0,61	0,32	-0,17	0,24	0,13	0,25
BEL	0,43	1,00	-0,03	0,23	0,83	0,71	0,70	0,31	0,20	0,60	-0,12	0,52	0,32
CAN	0,14	-0,03	1,00	0,37	0,24	0,24	-0,25	-0,19	-0,18	0,32	0,37	-0,01	-0,08
DK	0,38	0,23	0,37	1,00	0,23	0,28	-0,09	0,47	-0,50	0,60	0,57	-0,06	-0,27
FIN	-0,25	0,83	0,24	0,23	1,00	0,92	0,82	0,18	-0,00	0,83	-0,16	0,40	0,30
FRA	0,20	0,71	0,24	0,28	0,92	1,00	0,67	0,38	0,08	0,84	-0,29	0,43	0,51
DEU	-0,20	0,70	-0,25	-0,09	0,82	0,67	1,00	0,21	0,50	0,81	0,05	0,22	0,23
ITA	0,61	0,31	-0,19	0,47	0,18	0,38	0,21	1,00	0,27	0,21	-0,24	0,11	0,42
JAP	0,32	0,20	-0,18	-0,50	-0,00	0,08	0,50	0,27	1,00	0,12	-0,15	-0,28	-0,06
NOR	-0,17	0,60	0,32	0,60	0,83	0,84	0,81	0,21	0,12	1,00	0,22	0,25	0,34
SWE	0,24	-0,12	0,37	0,57	-0,16	-0,29	0,05	-0,24	-0,15	0,22	1,00	-0,20	-0,18
UK	0,13	0,52	-0,01	-0,06	0,40	0,43	0,22	0,11	-0,28	0,25	-0,20	1,00	0,41
ALL CTS	0,25	0,32	-0,08	-0,27	0,30	0,51	0,23	0,42	-0,06	0,34	-0,18	0,41	1,00

Table 9 - panel b: Bivariate correlations between countries' average ratios of R&D Scientists and Engineers to other R&D personnel across industries in the 1980s

	AUS	CAN	DK	FRA	DEU	ITA	JAP	SWE	UK	All CTS
AUS	1,00	0,50	0,49	0,45	0,09	0,78	0,02	0,26	0,21	0,39
CAN	0,50	1,00	0,25	0,69	0,52	0,58	-0,14	-0,03	0,49	0,39
DK	0,49	0,25	1,00	0,33	-0,10	0,63	-0,17	0,56	-0,52	0,19
FRA	0,45	0,69	0,33	1,00	0,82	0,83	0,18	-0,17	0,56	0,65
DEU	0,09	0,52	-0,10	0,82	1,00	0,65	0,47	-0,19	0,72	0,72
ITA	0,78	0,58	0,63	0,83	0,65	1,00	0,08	0,02	0,54	0,62
JAP	0,02	-0,14	-0,17	0,18	0,47	0,08	1,00	0,00	0,26	0,67
SWE	0,26	-0,03	0,56	-0,17	-0,19	0,02	0,00	1,00	-0,28	-0,02
UK	0,21	0,49	-0,52	0,56	0,72	0,54	0,26	-0,28	1,00	0,74
ALL CTS	0,39	0,39	0,19	0,65	0,72	0,62	0,67	-0,02	0,74	1,00

Table10 - panel a: Bivariate correlations between industries' average ratios of R&D Scientists and Engineers to other R&D personnel across countries in the 1970s

	FOOD	CHEM	DRUG	RAP	SCG	IRON	NFM	FABM	MACH	COMP	ELMA	RTV	SHIP	MOTV	AIRC	OTRA	PROF	ALLIND	RDSEND
FOOD	1,00	0,82	0,45	0,50	0,61	0,57	0,60	0,72	0,72	0,09	0,66	0,72	0,29	-0,07	0,49	0,86	0,51	0,67	0,08
CHEM	0,82	1,00	0,62	0,77	0,61	0,48	0,84	0,60	0,59	-0,28	0,53	0,73	0,02	0,01	0,54	0,68	0,55	0,68	0,21
DRUG	0,45	0,62	1,00	0,79	0,69	0,53	0,52	0,73	0,71	0,30	0,38	0,74	0,41	0,71	0,43	0,38	0,67	0,74	0,26
RAP	0,50	0,77	0,79	1,00	0,72	0,38	0,75	0,72	0,66	0,12	0,53	0,84	0,21	0,28	0,80	0,61	0,72	0,77	0,46
SCG	0,61	0,61	0,69	0,72	1,00	0,74	0,47	0,73	0,65	0,81	0,49	0,76	0,71	0,33	0,30	0,51	0,53	0,72	0,12
IRON	0,57	0,48	0,53	0,38	0,74	1,00	0,18	0,73	0,58	0,65	0,30	0,68	0,72	0,25	0,19	0,58	0,38	0,68	-0,14
NFM	0,60	0,84	0,52	0,75	0,47	0,18	1,00	0,47	0,55	-0,56	0,71	0,67	-0,28	0,34	0,59	0,45	0,56	0,52	0,44
FABM	0,72	0,60	0,73	0,72	0,73	0,73	0,47	1,00	0,91	0,37	0,71	0,93	0,59	0,46	0,63	0,65	0,87	0,88	0,45
MACH	0,72	0,59	0,71	0,66	0,65	0,58	0,55	0,91	1,00	0,21	0,87	0,93	0,45	0,40	0,77	0,74	0,91	0,90	0,55
COMP	0,09	-0,28	0,30	0,12	0,81	0,65	-0,56	0,37	0,21	1,00	-0,05	0,22	0,97	0,58	0,04	0,02	-0,06	0,33	-0,30
ELMA	0,66	0,53	0,38	0,53	0,49	0,30	0,71	0,71	0,87	-0,05	1,00	0,79	0,20	0,40	0,74	0,86	0,84	0,74	0,75
RTV	0,72	0,73	0,74	0,84	0,76	0,68	0,67	0,93	0,93	0,22	0,79	1,00	0,51	0,34	0,67	0,94	0,91	0,97	0,58
SHIP	0,29	0,02	0,41	0,21	0,71	0,72	-0,28	0,59	0,45	0,97	0,20	0,51	1,00	0,55	0,25	0,43	0,26	0,59	-0,10
MOTV	-0,07	0,01	0,71	0,28	0,33	0,25	0,34	0,46	0,40	0,58	0,40	0,34	0,55	1,00	0,50	0,16	0,52	0,46	0,56
AIRC	0,49	0,54	0,43	0,80	0,30	0,19	0,59	0,63	0,77	0,04	0,74	0,67	0,25	0,50	1,00	0,75	0,75	0,71	0,62
OTRA	0,86	0,68	0,38	0,61	0,51	0,58	0,45	0,65	0,74	0,02	0,86	0,94	0,43	0,16	0,75	1,00	0,79	0,87	0,67
PROF	0,51	0,55	0,67	0,72	0,53	0,38	0,56	0,87	0,91	-0,06	0,84	0,91	0,26	0,52	0,75	0,79	1,00	0,90	0,73
ALLIND	0,67	0,68	0,74	0,77	0,72	0,68	0,52	0,88	0,90	0,33	0,74	0,97	0,59	0,46	0,71	0,87	0,90	1,00	0,56
RDSEND	0,08	0,21	0,26	0,46	0,12	-0,14	0,44	0,45	0,55	-0,30	0,75	0,58	-0,10	0,58	0,62	0,67	0,73	0,56	1,00

Table10 - panel b: Bivariate correlations between industries' average ratios of R&D Scientists and Engineers to other R&D personnel across countries in the 1980s

	FOOD	CHEM	DRUG	RAP	SCG	IRON	NFM	FABM	MACH	COMP	ELMA	RTV	SHIP	MOTV	AIRC	OTRA	PROF	ALLIND	RDSEND
FOOD	1,00	0,91	0,73	0,87	0,62	0,49	0,84	0,75	0,72	0,05	0,60	0,66	0,73	0,54	0,66	0,66	0,90	0,86	0,44
CHEM	0,91	1,00	0,78	0,80	0,86	0,62	0,73	0,63	0,57	0,07	0,40	0,59	0,63	0,50	0,57	0,56	0,78	0,81	0,20
DRUG	0,73	0,78	1,00	0,78	0,47	0,23	0,46	0,46	0,40	-0,55	0,30	0,33	0,30	0,17	0,60	0,34	0,34	0,55	0,33
RAP	0,87	0,80	0,78	1,00	0,71	0,51	0,74	0,85	0,78	-0,24	0,72	0,77	0,71	0,71	0,82	0,75	0,70	0,88	0,64
SCG	0,62	0,86	0,47	0,71	1,00	0,71	0,85	0,68	0,70	0,11	0,56	0,70	0,75	0,56	0,56	0,63	0,77	0,69	0,24
IRON	0,49	0,62	0,23	0,51	0,71	1,00	0,62	0,41	0,16	0,20	0,05	0,51	0,43	0,90	0,11	0,32	0,57	0,67	-0,19
NFM	0,84	0,73	0,46	0,74	0,85	0,62	1,00	0,53	0,55	0,15	0,45	0,48	0,64	0,56	0,56	0,46	0,81	0,69	0,08
FABM	0,75	0,63	0,46	0,85	0,68	0,41	0,53	1,00	0,91	0,05	0,87	0,85	0,87	0,69	0,82	0,94	0,70	0,89	0,77
MACH	0,72	0,57	0,40	0,78	0,70	0,16	0,55	0,91	1,00	0,25	0,97	0,86	0,93	0,50	0,87	0,97	0,76	0,84	0,81
COMP	0,05	0,07	-0,55	-0,24	0,11	0,20	0,15	0,05	0,25	1,00	0,16	0,38	0,35	0,08	0,04	0,24	0,55	0,30	-0,15
ELMA	0,60	0,40	0,30	0,72	0,56	0,05	0,45	0,87	0,97	0,16	1,00	0,80	0,89	0,52	0,86	0,97	0,63	0,74	0,89
RTV	0,66	0,59	0,33	0,77	0,70	0,51	0,48	0,85	0,86	0,38	0,80	1,00	0,89	0,80	0,84	0,88	0,76	0,93	0,71
SHIP	0,73	0,63	0,30	0,71	0,75	0,43	0,64	0,87	0,93	0,35	0,89	0,89	1,00	0,59	0,70	0,86	0,80	0,89	0,66
MOTV	0,54	0,50	0,17	0,71	0,56	0,90	0,56	0,69	0,50	0,08	0,52	0,80	0,59	1,00	0,58	0,70	0,59	0,81	0,43
AIRC	0,66	0,57	0,60	0,82	0,56	0,11	0,56	0,82	0,87	0,04	0,86	0,84	0,70	0,56	1,00	0,92	0,65	0,78	0,69
OTRA	0,66	0,56	0,34	0,75	0,63	0,32	0,46	0,94	0,97	0,24	0,97	0,88	0,86	0,70	0,92	1,00	0,70	0,86	0,84
PROF	0,90	0,78	0,34	0,70	0,77	0,57	0,81	0,70	0,76	0,55	0,63	0,76	0,80	0,59	0,65	0,70	1,00	0,88	0,37
ALLIND	0,86	0,81	0,55	0,88	0,69	0,67	0,69	0,89	0,84	0,30	0,74	0,93	0,89	0,81	0,78	0,86	0,88	1,00	0,59
RDSEND	0,44	0,20	0,33	0,64	0,24	-0,19	0,08	0,77	0,81	-0,15	0,89	0,71	0,66	0,43	0,69	0,84	0,37	0,59	1,00

Table 11 - panel a: Results from ANOVA on the ratio of R&D Scientists and Engineers to other R&D personnel with test statistics for industry and time effects in each country

COUNTRY	R^2	RSS-FM	RSS-TO	RSS-INO	TEST-IN	IN-DOF-N	IN-DOF-D	TEST-T	T-DOF-N	T-DOF-D
AUS	0,43	11,75	18,34	13,33	2,06	15	55	1,85	4	55
BEL	0,46	10,73	19,87	10,77	3,41	15	60	0,12	2	60
CAN	0,65	9,37	23,93	9,93	28,56	13	239	2,39	6	239
DK	0,82	5,64	27,69	6,87	36,08	9	83	3,03	6	83
FIN	0,74	8,45	28,21	8,73	10,75	15	69	0,75	3	69
FRA	0,95	2,80	46,39	2,97	201,37	16	207	2,11	6	207
DEU	0,70	8,15	25,79	9,08	16,66	16	123	2,34	6	123
ITA	0,61	24,82	61,58	25,40	20,64	16	223	0,86	6	223
JAP	0,83	10,54	40,76	12,03	51,60	16	288	6,79	6	288
NL	0,77	0,73	3,10	0,78	12,97	3	12	0,29	3	12
NOR	0,74	3,00	10,86	3,14	12,06	15	69	1,08	3	69
SWE	0,57	14,45	27,68	17,86	4,70	15	77	4,55	4	77
UK	0,74	3,97	8,44	4,18	6,45	15	86	0,76	6	86

Table 11 - panel b: Results from ANOVA on the ratio of University Graduates to other R&D personnel with test statistics for industry and time effects in each country

COUNTRY	R^2	RSS-FM	RSS-TO	RSS-INO	TEST-IN	IN-DOF-N	IN-DOF-D	TEST-T	T-DOF-N	T-DOF-D
BEL	0,56	28,03	46,09	31,46	6,24	16	155	3,16	6	155
DK	0,89	1,68	15,68	1,82	33,30	9	36	1,02	3	36
FIN	0,81	4,08	20,92	4,30	14,15	14	48	0,87	3	48
DEU	0,89	2,96	24,16	3,02	27,31	16	61	0,43	3	61
ITA	0,82	7,74	40,98	7,88	42,96	15	150	0,90	3	150
NL	0,83	1,20	4,94	1,43	50,72	3	49	1,52	6	49
NOR	0,65	20,60	51,51	25,81	16,03	16	171	7,20	6	171
SWE	0,79	9,00	30,81	9,09	19,89	14	115	0,19	6	115

Table 12 - panel a: Results from ANOVA on the ratio of R&D Scientists and Engineers to other R&D personnel with test statistics for country and time effects in each country

INDUSTRY	R^2	RSS-FM	RSS-TO	RSS-CO	TEST-C	C-DOF-N	C-DOF-D	TEST-T	T-DOF-N	T-DOF-D
FOOD	0,85	4,89	32,59	4,96	55,65	12	118	0,25	6	118
CHEM	0,92	3,48	39,80	3,72	108,17	11	114	1,32	6	114
DRUG	0,89	2,83	25,01	2,89	66,75	12	102	0,39	6	102
RAP	0,84	11,52	69,11	12,30	48,74	12	117	1,33	6	117
SCG	0,77	6,69	26,94	7,21	29,02	12	115	1,49	6	115
IRON	0,81	4,06	20,28	4,61	38,40	10	96	2,20	6	96
NFM	0,59	14,97	34,14	16,31	12,17	10	95	1,42	6	95
FABM	0,82	7,06	35,03	7,88	37,61	10	95	1,83	6	95
MACH	0,88	5,74	43,41	6,19	67,44	11	113	1,49	6	113
COMP	0,83	2,56	6,39	2,73	9,56	8	51	0,58	6	51
ELMA	0,88	5,79	38,96	6,39	45,86	11	88	1,53	6	88
RTV	0,92	4,00	38,36	4,36	68,75	11	88	1,33	6	88
SHIP	0,58	9,64	22,40	10,54	8,52	9	58	0,90	6	58
MOTV	0,78	5,46	20,08	6,28	20,39	8	61	1,51	6	61
AIRC	0,78	7,08	25,71	8,23	24,33	8	74	2,01	6	74
OTRA	0,84	10,47	61,56	11,44	39,04	9	72	1,12	6	72
PROF	0,80	8,19	30,51	8,37	26,28	11	106	0,39	6	106
MANTOT	0,97	0,96	23,93	1,04	244,85	12	123	1,61	6	123
TT	0,97	0,95	22,76	1,02	250,11	12	131	1,53	6	131
CT	0,96	1,50	28,16	1,64	170,22	11	105	1,64	6	105
ET	0,93	3,11	35,14	3,20	110,30	11	118	0,56	6	118

Table 12 - panel b: Results from ANOVA on the ratio of University Graduates to other R&D personnel with test statistics for country and time effects in each country

INDUSTRY	R^2	RSS-FM	RSS-TO	RSS-CO	TEST-C	C-DOF-N	C-DOF-D	TEST-T	T-DOF-N	T-DOF-D
FOOD	0,79	3,17	12,99	3,44	27,89	8	72	1,03	6	72
CHEM	0,90	1,10	8,96	1,38	50,12	7	49	2,09	6	49
DRUG	0,96	0,52	10,72	0,60	104,36	8	43	1,02	6	43
RAP	0,84	6,11	34,68	6,69	40,35	8	69	1,09	6	69
SCG	0,72	4,44	14,71	4,90	19,95	8	69	1,19	6	69
IRON	0,81	2,48	10,57	3,25	26,11	6	48	2,49	6	48
NFM	0,77	2,68	9,95	3,71	18,04	3	20	1,28	6	20
FABM	0,68	3,52	9,97	4,04	13,72	6	45	1,11	6	45
MACH	0,87	2,34	13,79	2,50	35,62	7	51	0,57	6	51
COMP	0,81	4,55	19,81	6,84	12,88	6	23	3,88	3	23
ELMA	0,82	1,63	3,84	2,18	6,22	7	32	1,81	6	32
RTV	0,85	2,47	5,60	3,31	5,78	7	32	1,81	6	32
SHIP	0,32	7,71	9,83	8,27	1,92	6	42	0,51	6	42
MOTV	0,83	5,16	23,15	7,66	20,19	5	29	2,33	6	29
AIRC	0,69	3,24	5,14	6,52	2,45	5	21	3,53	6	21
OTRA	0,70	7,10	19,40	8,74	11,83	6	41	1,58	6	41
PROF	0,76	4,12	9,50	4,50	9,14	7	49	0,76	6	49
MANTOT	0,93	1,09	10,05	1,25	74,27	8	72	1,81	6	72
TT	0,95	0,93	13,94	1,12	127,79	8	73	2,57	6	73
CT	0,96	0,85	14,44	0,98	143,63	8	72	1,83	6	72
ET	0,86	2,22	7,99	2,41	19,26	7	52	0,72	6	52

Table 13: Determinants of Sectoral R&D Specialisation - Results from Multiple Regressions

The regressions are based on data pooled over fourteen OECD countries and four five-yearly periods from 1970 to 1989 for the independent variables, and from 1969 to 1988 for the dependent variable. Missing data imply a badly reduced sample for some industries. For data availability see the data appendix. Below the industry codes in the first column are the industries' rankings in terms of their average ratios of R&D Scientists and Engineers to other R&D personnel in the 1970s and 1980s, taken from the last columns of Table 6, panel a and b.

All variables are in natural logarithms. The dependent is the industry's share of countries' total R&D personnel employed in manufacturing. Independent variables are the industry's share in total value added of countries' manufacturing sector, countries' endowment with R&D Scientists and Engineers relative to the labour force, countries' real Gross Domestic Product in 1985 US-$ at purchasing power parities, and calendar time, ie. the year of observation. Data have been averaged for each of the four five-yearly intervals before taking logarithms.

F-VR denotes the F-test statistics for the joint significance of VALUE ADDED and R&D-S&E ENDOWMENT. F-RT denotes the F-test statistics for the joint significance of RGDP and TIME. F-ST denotes the F-test statistics for structural stability of the full model across the two sub periods, the 1970s and 1980s. Figures in italics are standard errors.

INDUSTRY		CONSTANT	VALUE ADDED	R&D-S&E ENDOWMENT	RGDP	TIME	R^2	RSS	DOF
FOOD	Full Model	-364,92	1,11	0,18	-0,24	49,13	0,37	15,37	46
		253,24	*0,34*	*0,16*	*0,08*	*33,56*			
7 (1970s)			F-VR(2;46) = 5,47		F-RT(2;46) = 5,24		F-ST(5;41) = 0,81		
7 (1980s)									
	Without TIME	5,73	1,10	0,11	-0,20	—	0,34	16,09	47
		2,90	*0,34*	*0,15*	*0,07*				
CHEM	Full Model	411,94	1,63	0,03	0,04	-54,03	0,79	2,45	41
		114,01	*0,15*	*0,06*	*0,03*	*15,11*			
13 (1970s)			F-VR(2;41) = 62,62		F-RT(2;41) = 6,46		F-ST(5;36) = 1,04		
12 (1980s)									
	Without RGDP	364,90	1,68	0,03	—	-47,67	0,78	2,52	42
		105,45	*0,14*	*0,06*		*13,93*			

DRUG	Full Model	**238,52**	**0,94**	**-0,35**	**-0,24**	**-31,15**	0,67	3,10	38
		141,03	*0,12*	*0,07*	*0,05*	*18,63*			
10 (1970s)			F-VR(2;38) = 36,77		F-RT(2;38) = 15,11		F-ST(5;33) = 0,23		
9 (1980s)									
	Without TIME	**2,77**	**0,88**	**-0,31**	**-0,25**	—	0,64	3,33	39
		1,77	*0,11*	*0,07*	*0,05*				
RAP	Full Model	**135,99**	**0,64**	**-0,23**	**0,07**	**-18,86**	0,17	14,16	46
		243,03	*0,40*	*0,14*	*0,09*	*32,21*			
14 (1970s)			F-VR(2;46) = 2,13		F-RT(2;46) = 0,35		F-ST(5;41) = 0,35		
10 (1980s)									
	Without RGDP and TIME	**-4,79**	**0,80**	**-0,22**	—	—	0,16	14,37	48
		2,14	*0,31*	*0,13*					
SCG	Full Model	**228,27**	**-0,26**	-0,06	**-0,08**	**-30,58**	0,05	22,62	46
12 (1970s)		*332,61*	*0,54*	*0,19*	*0,09*	*44,21*			
13 (1980s)			F-VR(2;46) = 0,12		F-RT(2;46) = 1,06		F-ST(5;41) = 0,13		
IRON	Full Model	**-646,03**	**1,47**	**-0,04**	**-0,45**	**86,70**	0,57	8,98	37
15 (1970s)		*287,55*	*0,30*	*0,13*	*0,08*	*38,15*			
15 (1980s)			F-VR(2;37) = 12,49		F-RT(2;37) = 18,35		F-ST(5;32) = 0,66		
NFM	Full Model	**542,62**	**0,79**	**-0,34**	**-0,19**	**-71,66**	0,63	10,96	37
11 (1970s)		*266,67*	*0,13*	*0,14*	*0,08*	*35,31*			
11 (1980s)			F-VR(2;37) = 22,58		F-RT(2;37) = 7,95		F-ST(5;32) = 0,44		
FABM	Full Model	**-411,88**	**0,02**	**-0,09**	**-0,30**	**54,61**	0,38	7,87	35
		244,75	*0,40*	*0,12*	*0,07*	*32,43*			
6 (1970s)			F-VR(2;35) = 0,29		F-RT(2;35) = 10,22		F-ST(5;30) = 0,55		
8 (1980s)									
	Without VALUE ADDED and R&D-S&E ENDOWM.	**-475,72**	—	—	**-0,30**	**63,20**	0,36	8,01	37
		223,96			*0,06*	*29,60*			

Table 13 continued

INDUSTRY		CONSTANT	VALUE ADDED	R&D-S&E ENDOWMENT	RGDP	TIME	R^2	RSS	DOF
MACH	Full Model	**-464,70**	**0,56**	**0,15**	**-0,25**	**62,24**	0,54	5,80	36
8 (1970s)		*204,39*	*0,27*	*0,12*	*0,06*	*27,09*			
6 (1980s)			F-VR(2;36) = 4,53		F-RT(2;36) = 9,07		F-ST(5;31) = 0,12		
COMP	Full Model	**-838,71**	**0,16**	**-0,10**	**-0,05**	**110,16**	0,60	1,79	20
		199,32	*0,19*	*0,12*	*0,07*	*26,29*			
3 (1970s)			F-VR(2;20) = 0,46		F-RT(2;20) = 9,89		F-ST(5;15) = 2,06		
2 (1980s)									
	Without RGDP	**-865,81**	**0,08**	**-0,07**	—	**113,55**	0,59	1,84	21
		193,97	*0,15*	*0,11*		*25,63*			
ELMA	Full Model	**-195,38**	**0,42**	**0,04**	**-0,19**	**26,33**	0,27	4,22	30
		202,37	*0,35*	*0,11*	*0,06*	*26,81*			
1 (1970s)			F-VR(2;30) = 1,08		F-RT(2;30) = 4,84		F-ST(5;25) = 0,33		
1 (1980s)									
	Without TIME	**3,36**	**0,39**	**0,01**	**-0,17**	—	0,24	4,36	31
		2,24	*0,35*	*0,11*	*0,06*				
RTV	Full Model	**-28,69**	**0,09**	**0,25**	**0,19**	**3,45**	0,28	8,02	30
		305,99	*0,35*	*0,24*	*0,09*	*40,51*			
4 (1970s)			F-VR(2;30) = 2,19		F-RT(2;30) = 2,04		F-ST(5;25) = 0,66		
4 (1980s)									
	Without TIME	**-2,63**	**0,10**	**0,24**	**0,19**	—	0,28	8,02	31
		2,60	*0,31*	*0,21*	*0,09*				
SHIP	Full Model	**-1205,36**	**0,79**	**0,88**	**-0,14**	**160,85**	0,76	9,60	22
		430,58	*0,27*	*0,30*	*0,19*	*57,17*			
5 (1970s)			F-VR(2;22) = 10,91		F-RT(2;22) = 3,99		F-ST(5;17) = 1,20		

3 (1980s)									
	Without RGDP	**-1095,89**	**0,96**	**0,86**	—	**145,99**	0,76	9,85	23
		401,25	*0,14*	*0,30*		*53,12*			
MOTV	Full Model	**102,52**	**1,32**	**-0,33**	**-0,09**	**-13,69**	0,88	1,73	20
		190,10	*0,14*	*0,11*	*0,09*	*25,20*			
17 (1970s)			F-VR(2;20) = 45,42		F-RT(2;20) = 0,78		F-ST(5,15) = 1,43		
17 (1980s)									
	Without RGDP and TIME	**-3,24**	**1,23**	**-0,28**	—	—	0,87	1,87	22
		1,48	*0,10*	*0,09*					
AIRC	Full Model	**2629,53**	**1,72**	**-0,72**	**0,36**	**-348,55**	0,78	19,69	19
		770,92	*0,24*	*0,42*	*0,32*	*102,58*			
16 (1970s)			F-VR(2;19) = 29,23		F-RT(2;19) = 6,39		F-ST(5;14) = 1,61		
16 (1980s)									
	Without RGDP	**2120,66**	**1,77**	**-0,61**	—	**-279,99**	0,77	21,00	20
		628,13	*0,24*	*0,41*		*83,02*			
OTRA	Full Model	**-1494,60**	**2,12**	**1,88**	**-0,02**	**201,61**	0,53	35,52	25
		755,49	*0,52*	*0,50*	*0,21*	*100,12*			
9 (1970s)			F-VR(2;25) = 9,33		F-RT(2;25) = 2,14		F-ST(5;20) = 1,27		
14 (1980s)									
	Without RGDP	**-1474,02**	**2,15**	**1,90**	—	**198,88**	0,53	35,54	26
		711,73	*0,42*	*0,46*		*94,32*			
PROF	Full Model	**126,14**	**0,73**	**-0,33**	**-0,24**	**-16,54**	0,28	16,94	36
		346,11	*0,22*	*0,18*	*0,12*	*45,89*			
2 (1970s)			F-VR(2;36) = 6,92		F-RT(2;36) = 2,64		F-ST(5;31) = 0,76		
5 (1980s)									
	Without TIME	**1,38**	**0,73**	**-0,30**	**-0,25**	—	0,28	17,00	37
		4,12	*0,21*	*0,16*	*0,11*				

Table 14: Bivariate correlations between the independent and dependent variables

VALUE ADDED denotes industry's shares of countries' total manufacturing value added, R&D-S&E countries' endowment with R&D Scientists and Engineers relative to the labour force, RGDP countries' real GDP at purchasing power parities, TIME the calendar time in years, and R&D-PERS, the dependent, industry's shares of countries' total R&D personnel in manufacturing.

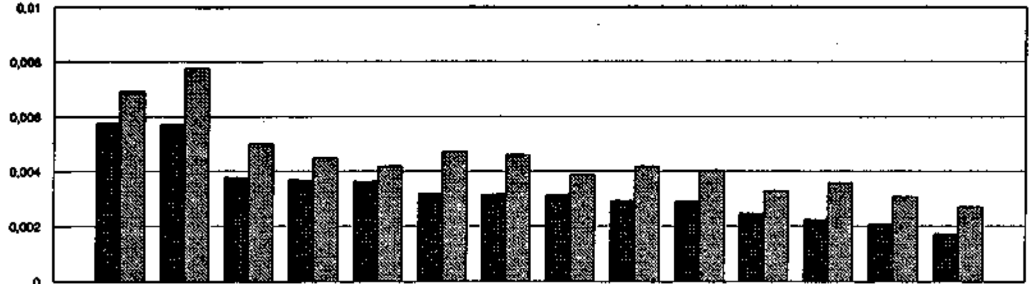
All variables in natural logarithms of averages over five year periods. See notes in main text.

INDUSTRY		R&D-S&E	RGDP	TIME	R&D-PERS
FOOD	VALUE ADDED	-0,42	-0,14	0,06	0,44
	R&D-S&E		-0,14	-0,37	-0,04
	RGDP			0,40	-0,43
	TIME				0,00
CHEM	VALUE ADDED	-0,30	0,37	0,18	0,84
	R&D-S&E		-0,14	-0,35	-0,14
	RGDP			0,42	0,29
	TIME				-0,11
DRUG	VALUE ADDED	0,01	0,64	0,42	0,55
	R&D-S&E		-0,16	-0,33	-0,32
	RGDP			0,41	0,04
	TIME				0,15
RAP	VALUE ADDED	0,12	0,61	0,16	0,32
	R&D-S&E		-0,14	-0,37	-0,20
	RGDP			0,40	0,31
	TIME				0,10
SCG	VALUE ADDED	-0,30	0,06	-0,20	-0,04
	R&D-S&E		-0,14	-0,37	0,04
	RGDP			0,40	-0,19
	TIME				-0,15
IRON	VALUE ADDED	0,16	0,16	-0,45	0,38
	R&D-S&E		-0,20	-0,37	0,10
	RGDP			0,41	-0,53
	TIME				-0,27
NFM	VALUE ADDED	-0,13	-0,16	0,05	0,68
	R&D-S&E		-0,20	-0,37	-0,20
	RGDP			0,41	-0,41
	TIME				-0,22
FABM	VALUE ADDED	0,05	0,06	-0,08	-0,06
	R&D-S&E		-0,20	-0,40	-0,09
	RGDP			0,43	-0,54
	TIME				0,02

Table 14 continued

INDUSTRY		R&D-S&E	RGDP	TIME	R&D-PERS
MACH	VALUE ADDED	0,35	-0,39	-0,03	0,55
	R&D-S&E		-0,20	-0,44	0,24
	RGDP			0,34	-0,59
	TIME				0,04
COMP	VALUE ADDED	0,40	0,54	0,12	0,13
	R&D-S&E		0,01	-0,38	-0,34
	RGDP			0,05	0,00
	TIME				0,76
ELMA	VALUE ADDED	0,33	0,42	0,01	-0,01
	R&D-S&E		-0,13	-0,32	0,16
	RGDP			0,40	-0,45
	TIME				-0,08
RTV	VALUE ADDED	0,63	0,42	0,19	0,43
	R&D-S&E		-0,13	-0,32	0,27
	RGDP			0,40	0,42
	TIME				0,11
SHIP	VALUE ADDED	0,38	-0,87	-0,35	0,80
	R&D-S&E		-0,37	-0,49	0,49
	RGDP			0,46	-0,69
	TIME				-0,12
MOTV	VALUE ADDED	0,02	0,66	-0,12	0,90
	R&D-S&E		-0,16	-0,44	-0,21
	RGDP			0,12	0,57
	TIME				-0,05
AIRC	VALUE ADDED	-0,13	0,17	0,07	0,80
	R&D-S&E		-0,03	-0,34	-0,15
	RGDP			0,56	0,02
	TIME				-0,27
OTRA	VALUE ADDED	-0,51	-0,47	-0,00	0,47
	R&D-S&E		-0,14	-0,44	0,17
	RGDP			0,41	-0,38
	TIME				-0,00
PROF	VALUE ADDED	0,03	0,64	0,22	0,35
	R&D-S&E		-0,07	-0,38	-0,21
	RGDP			0,42	0,00
	TIME				0,02

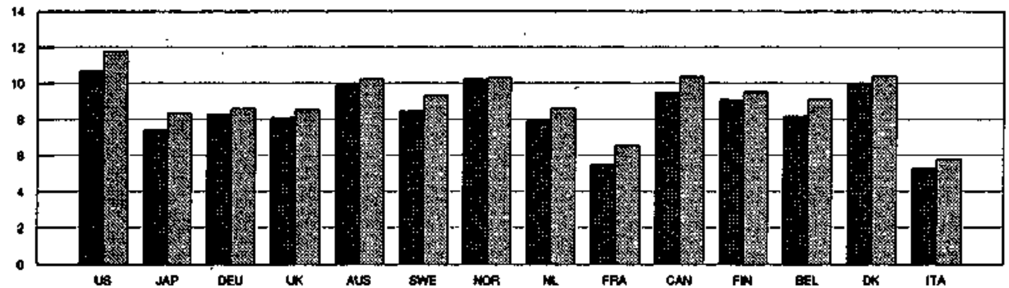
Figure 1 - panel a: Countries' relative endowments with R&D Scientists and Engineers



	US	JAP	DEU	UK	AUS	SWE	NOR	NL	FRA	CAN	FIN	BEL	DK	ITA
Averages 1970s	0,0057	0,0057	0,0038	0,0037	0,0036	0,0032	0,0031	0,0031	0,0029	0,0029	0,0024	0,0022	0,0021	0,0017
Averages 1980s	0,0069	0,0078	0,0050	0,0045	0,0042	0,0047	0,0046	0,0039	0,0042	0,0040	0,0033	0,0036	0,0031	0,0027

Shares of employed R&D Scientists and Engineers in total labour force. Averages for all countries combined: 0,0045 in the 1970s and 0,0058 in the 1980s. Data Source: OECD, partly based on own estimates.

Figure 1 - panel b: Average Years of Schooling in the Adult Population



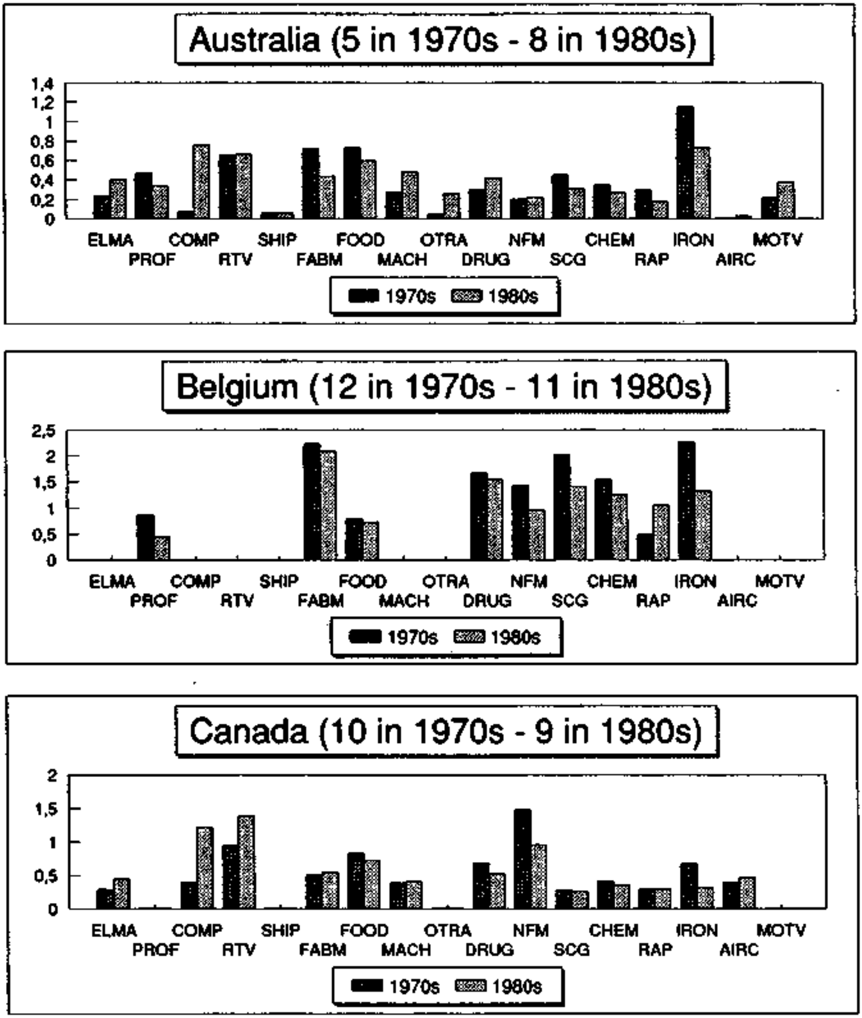
1975 1985

Adult population comprises people older than 25 years. Data Source: Barro and Lee, 1993.

Figure 2:

R&D intensities relative to the industry average over all countries plotted on industries ranked by their average ratios of R&D scientists and engineers to other R&D personnel in the 1970s

Rankings of countries by their relative endowments with R&D scientists and engineers are in brackets behind countries' names.



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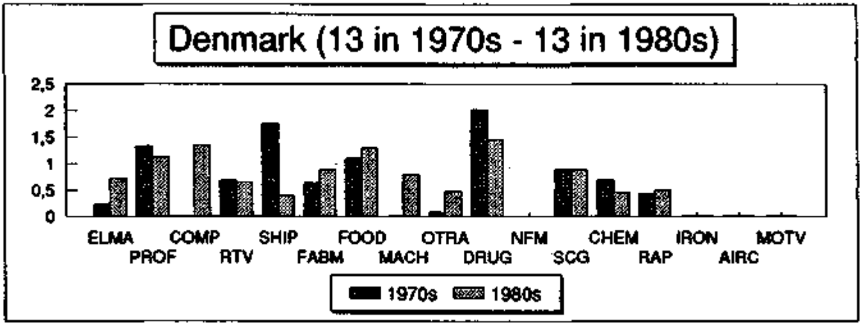

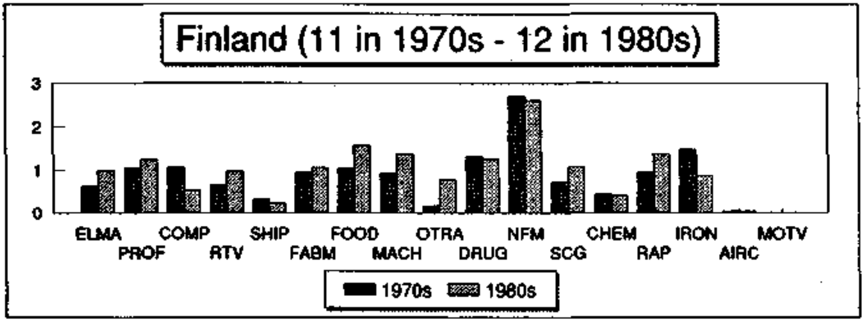

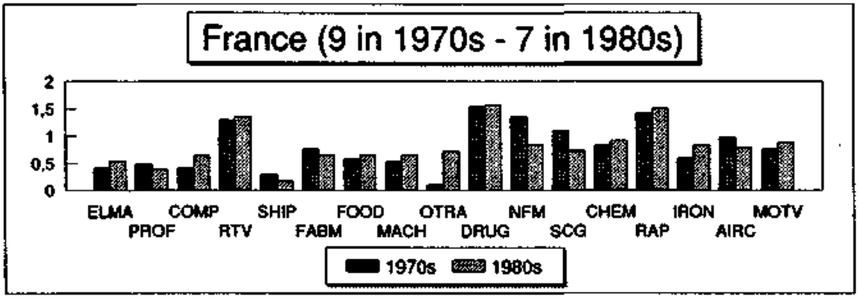

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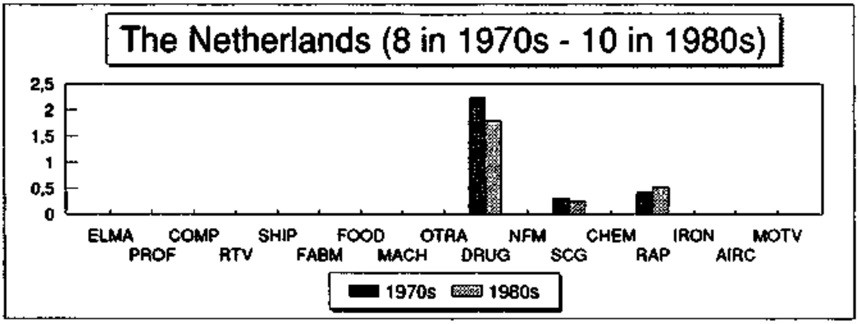

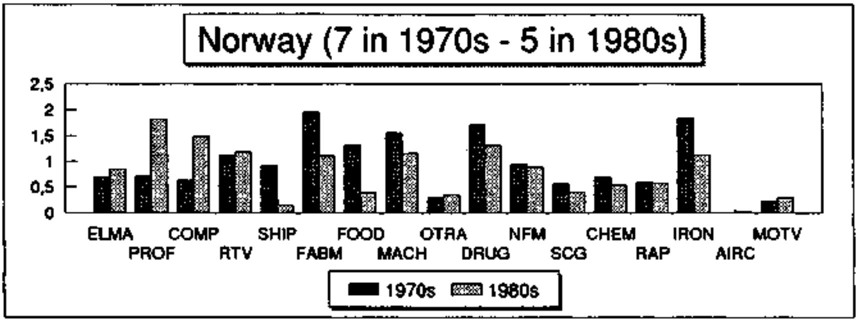

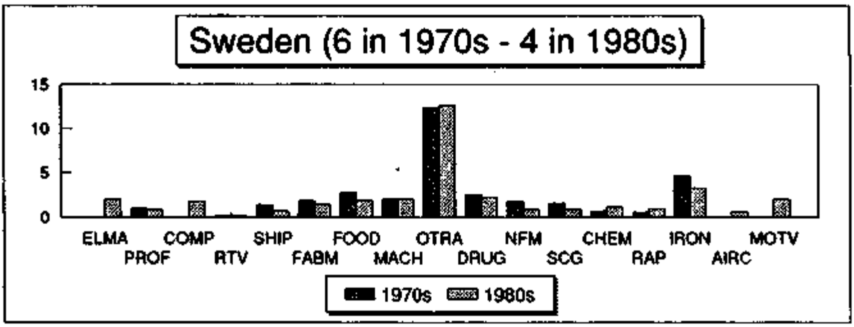

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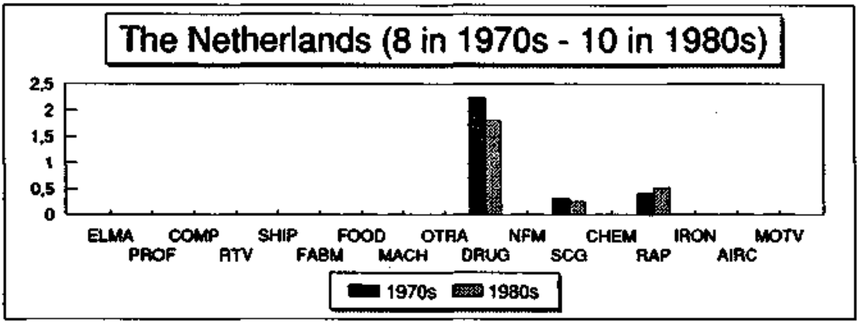

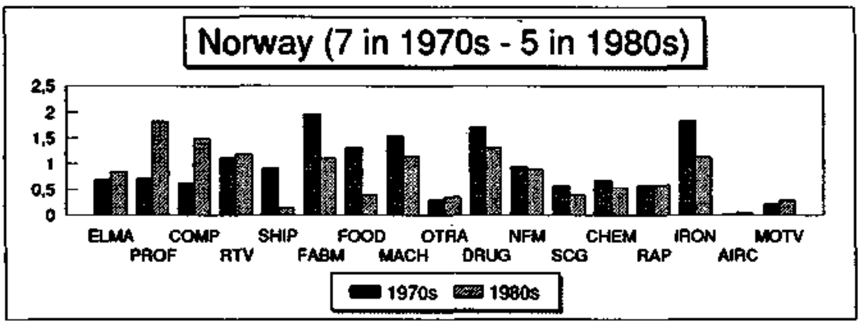

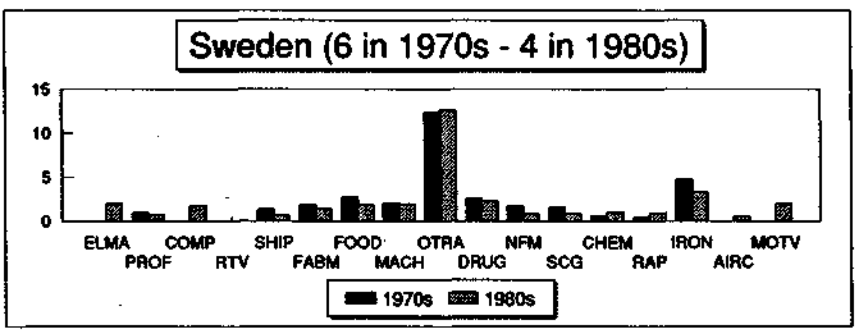

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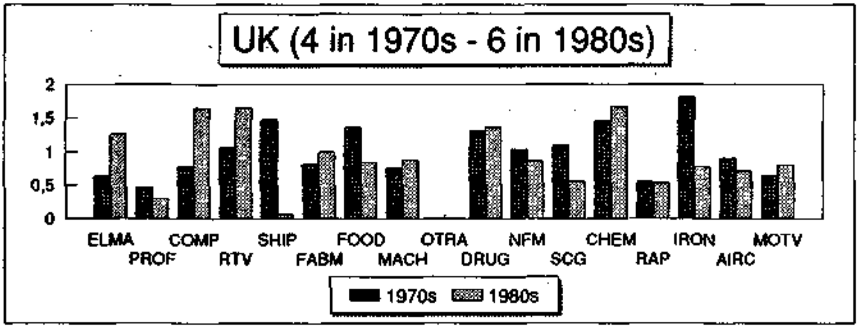


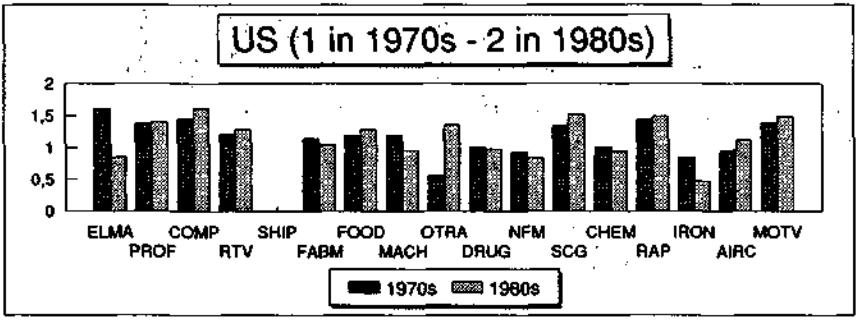
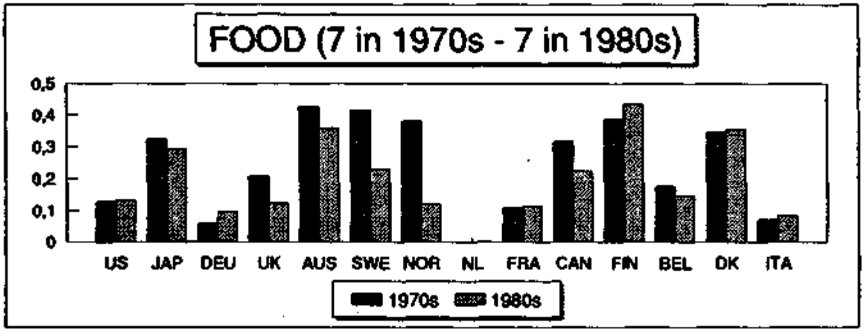
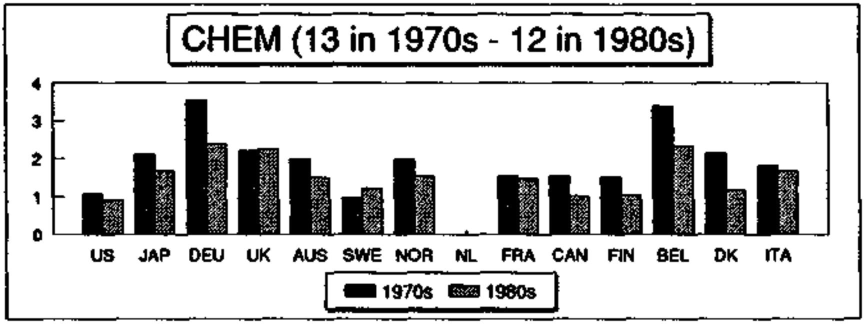


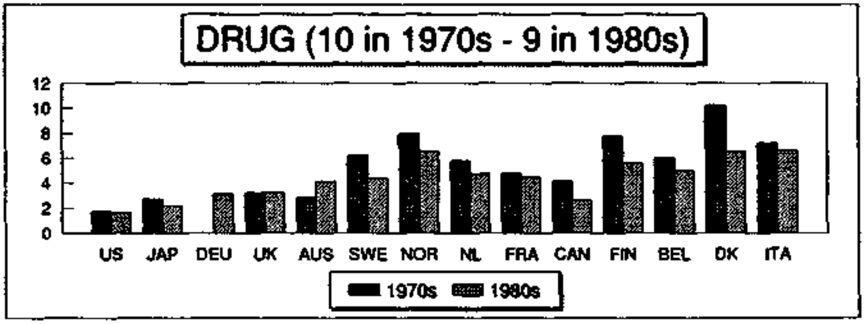
Figure 3:

R&D intensities relative to the country averages over all industries plotted on countries ranked by their relative endowments with R&D scientists and engineers in the 1970s

Rankings of industries by their average ratios of R&D scientists and engineers to other R&D personnel are in brackets behind industries' names.







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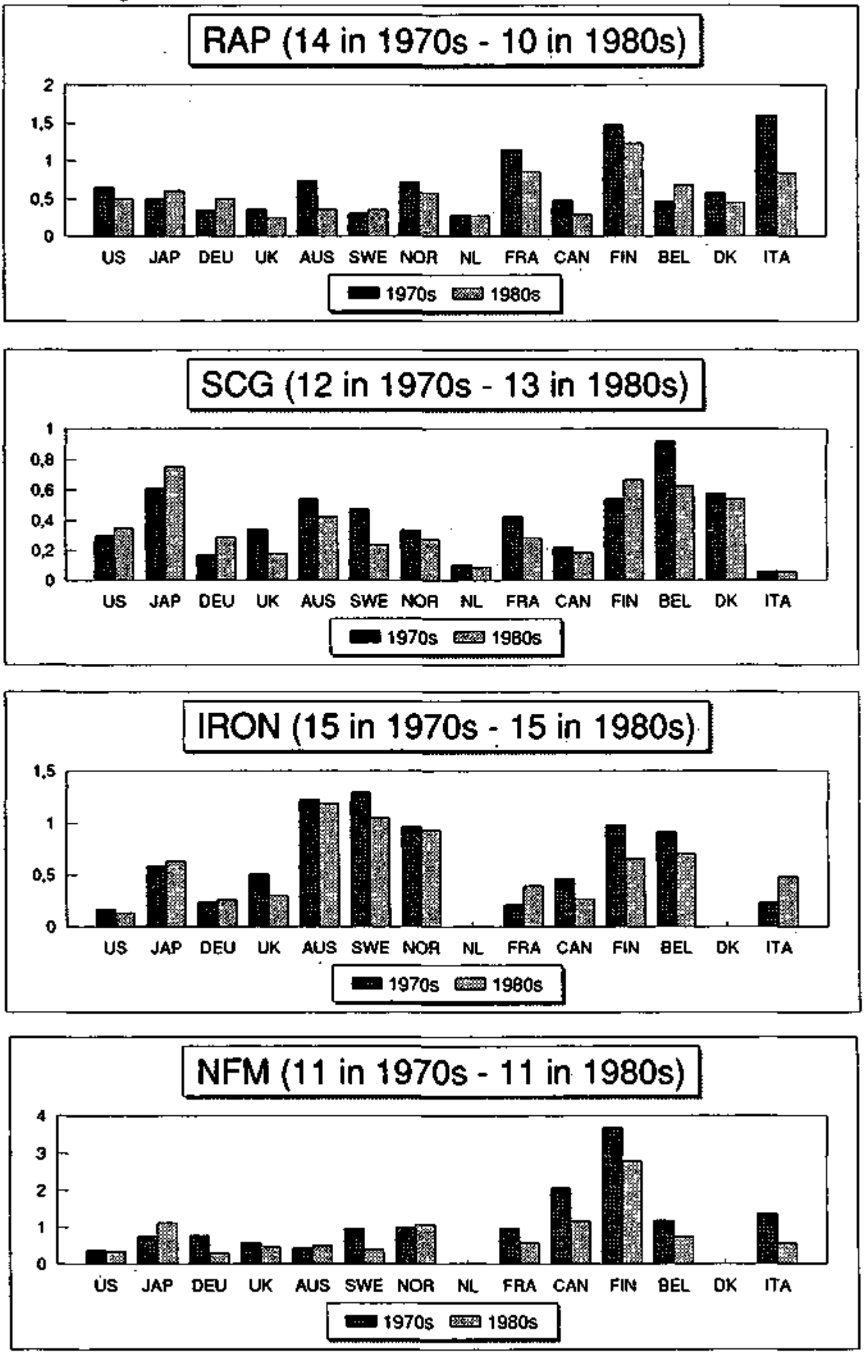

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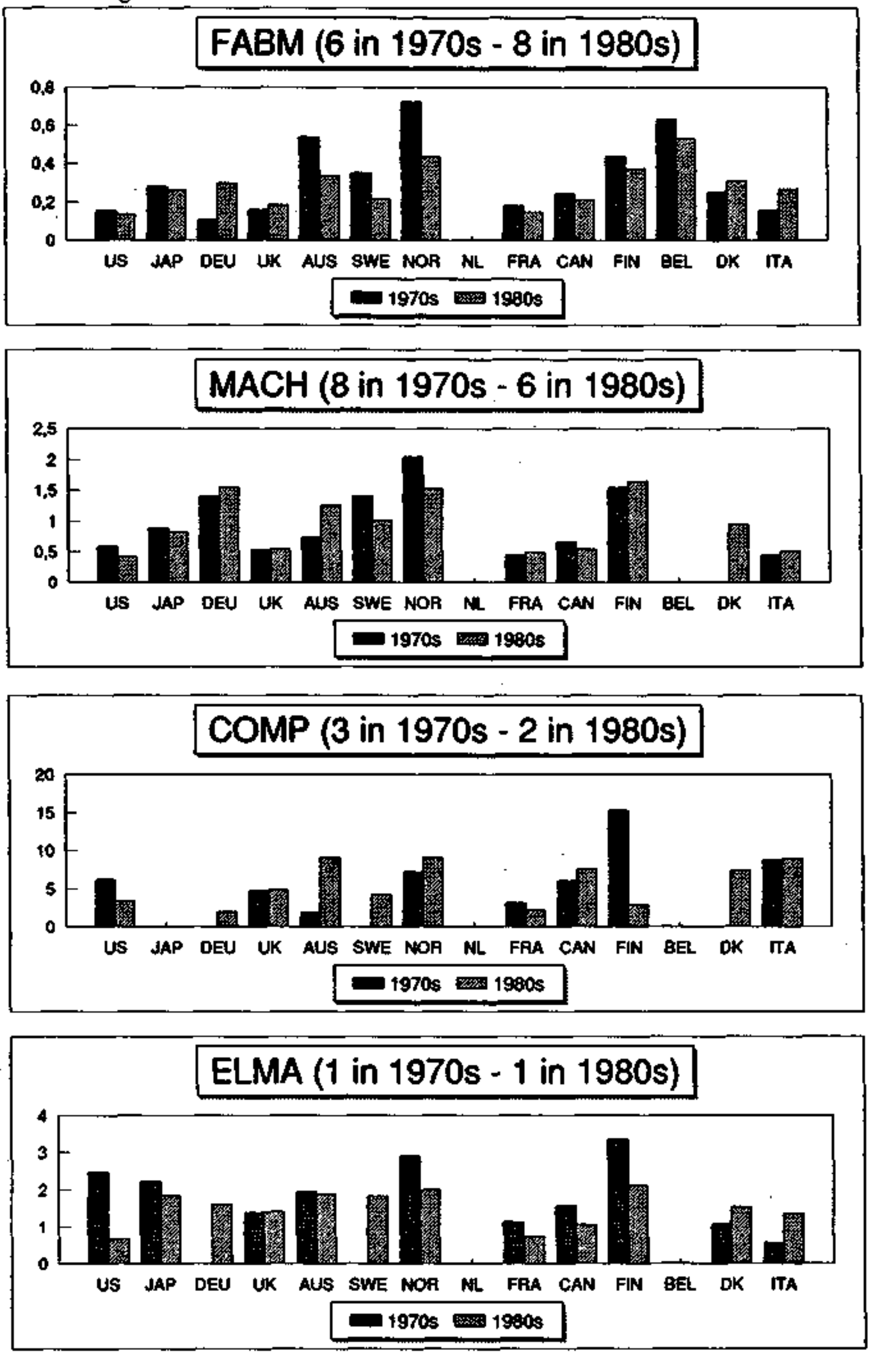

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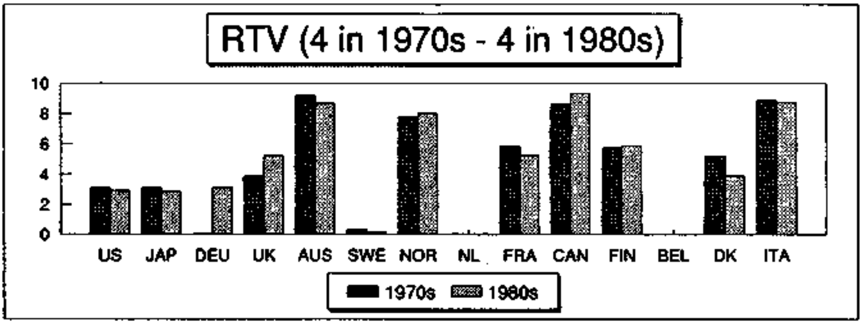

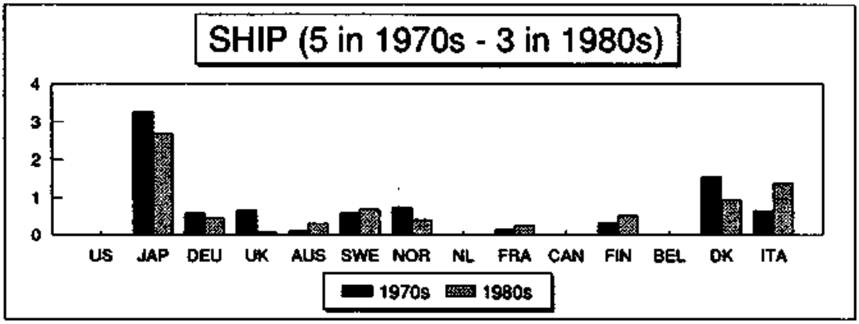

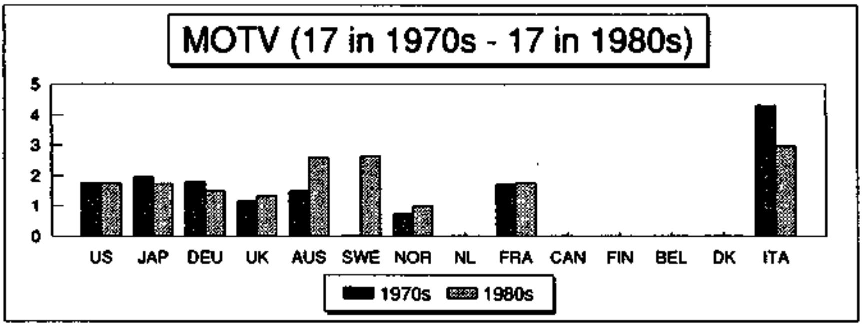

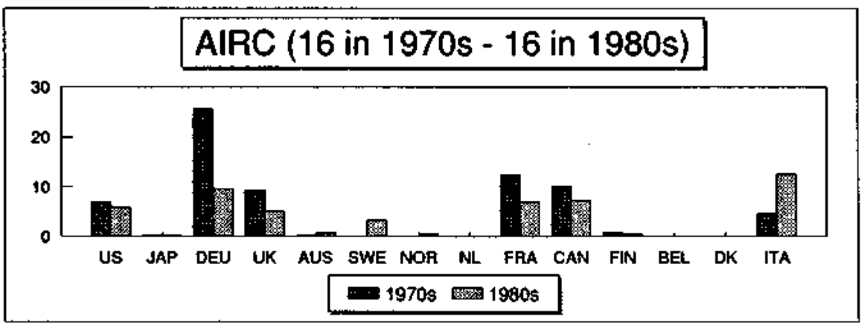

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