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Working Paper

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1. INTRODUCTION

The ways innovative activities take place and are structured and organized within technologies and industries may be quite different. One may find that in certain technologies innovative activities are concentrated among few major innovators while in others innovative activities are highly distributed among several firms; in certain industries large firms do the bulk of innovative activities while in other small firms are quite active; in certain industries new innovators continuously appear while in others only established firms innovate; and so on.

This difference in the structure of innovative activities may be related to a fundamental distinction between Schumpeter Mark I (widening) and Schumpeter Mark II (deepening) sectors. In "The Theory of Economic Development" and in "Capitalism, Socialism and Democracy", Schumpeter proposed two major patterns of innovative activities. The first one, labelled by Nelson-Winter (1982) and Kamien and Schwartz (1982) Schumpeter Mark I, is proposed in "The Theory of Economic Development"(1934). This pattern of innovative activity is characterized by "creative distruction" with technological ease of entry in an industry and a major role played by entrepreneurs and new firms in innovative activities. The second one, labelled Schumpeter Mark II, is proposed in "Capitalism, Socialism and Democracy" (1942). In this work Schumpeter discussed the relevance of the industrial R&D laboratory for technological innovation and the key role of large firms. This pattern of innovative activity is characterized by "creative accumulation" with the prevalence of large established firms and the presence of relevant barriers to entry for new innovators. The Schumpeterian Mark I and Mark II patterns of innovation could be labelled also widening and deepening. A widening pattern of innovative activities is related to an innovative base which is continuously enlarging through the entry of new innovators and the erosion of the competitive and technological advantages of the established firms in the industry. A deepening pattern of innovation, on the contrary, is related to the dominance of few firms which are continuously innovative through the accumulation over time of technological and innovative capabilities. (Malerba-Orsenigo,1994).[1]

1 During the last forty years this characterization of innovative activities by Schumpeter has encouraged different scholarly traditions aiming at the empirical verification of the two patterns. The first, and oldest, tradition was mainly centered on the firm. It attempted to assess the role of firm size and of monopoly power in innovation (Kamien and Schwartz,1982). The inconclusive results obtained in these empirical analyses are due to the neglected role of opportunity and appropriability conditions in the various industries (Levin, Cohen and Mowery, 1985) and of the endogenous relationship between firm size, concentration and technological change (Nelson and Winter, 1982). A second, and more recent, tradition has inserted Schumpeter Mark I and II models according to the specific stage of an industry life cycle. According to the industry life cycle view, early in the history of an industry, when technology is changing very rapidly, uncertainty is very high and barriers to entry very low, new firms are the major innovators and are the key element in industrial dynamics. On the contrary, when industry develops and eventually matures and technological change follows well defined trajectories, economies of scale,

In this paper we want to inquire if Schumpeterian patterns of innovations are technology specific, country specific or both.

Interestingly enough, both hypotheses may be linked to Schumpeter. These are different from an interpretation of the Schumpeterian patterns related claiming that in the early stages of capitalism or in the early stages of the evolution of an industry the pattern of innovative activity is more of a Schumpeter I (widening) type, while later on patterns of innovative activities become more of a Schumpeter II (deepening) type. These two other interpretations refer more to technology specific and country specific factors. One could argue in fact that the technology specific hypothesis may be related to the disctinction between the traditional sectors which characterized the pages of "The Theory of Economic Development" and the chemical and electrical sectors which characterized the pages of "Capitalism, Socialism and Democracy". On the opposite, one could argue that the country specific argument may be related to the distinction between the fragmented and entrepreneurial industrial structure of the Austra of "The Theory of Economic Development" and the concentrated oligopolistic industrial structure of the United States of "Capitalism, Socialism and Democracy".

More in general, it is possible to claim that the first hypothesis ("patterns are technology specific") is related to the working of technological imperatives rather invariant across countries. These imperatives may be related to the specific features of a technology and of its technological regime defined in terms of opportunity, appropriability and cumulativeness and the relevant koowledge base. Inspired by Nelson and Winter (1982), Dosi (1988) and Cohen and Levin (1989), who have pointed out that the conditions of opportunity and appropriability may greatly affect the way innovative activities are carried out in an industry in terms of firm size and industrial concentration, Malerba and Orsenigo (1990) and (1993) have defined technological regimes in terms of opportunity, appropriability, cumulativeness and properties of the knowledge base. They have examined the link between technological regimes and patterns of innovative activities both at the conceptual and the empirical levels.[2]

According to the analysis based on technological regimes, the widening and deepening Schumpeterian patterns of innovation may be seen as the results of well defined regime conditions. Widening patterns are determined by high opportunity and low appropriability conditions, which favour the continuous entry of new innovators in the industry, and by low cumulativeness conditions, which do not allow the persistence of monopolistic advantages in the industry innovators. Deepening patterns are determined by high opportunity, appropriability and cumulativeness conditions, which allow innovators to

learning curves, barriers to entry and financial resources become important in the competitive process and large firms with monopolistic power come to the forefront of the innovation process (Gort and Klepper 1982, Klepper, 1992, Abernathy and Utterback 1975).

[2] Opportunity conditions refer to the ease of innovation by would- be innovators, and are related to the potential for innovation of each technology. Appropriability conditions refer to the ability of innovators to protect their innovations from imitation, and therefore to reap results and profits from their innovations. Cumulativeness conditions refer to the fact that existing innovators may continue to be so also in the future with respect to non innovators. Finally, knowledge base conditions refer to number and type of basic and applied sciences necessary to innovative activities, and to the tacit or codified, simple or complex, specialized or pervasive dimensions of knowledge underpinning innovation in an industry.

continuously accumulate technological knowledge and capabilities and to build up innovative advantages over non-innovators and potential entrants (Malerba-Orsenigo, 1993).

These patterns of innovations ought to be rather invariant across countries. This is so because the appropriability and cumulativeness conditions, the two dimensions of technological regimes that affect the widening and deepening patterns of innovation, are rather similar across advanced industrialized countries (see Malerba and Orsenigo 1990 and Heimler-Malerba-Peretto 1993 for an analysis of the Italian and American cases). Opportunity conditions among advanced countries are less similar, because these conditions are related to the level and range of university research, the presence and effectiveness of science-industry bridging mechanisms, vertical and horizontal links among local firms, user-producer interaction and types and levels of firms innovative efforts (Nelson,1993).

On the contrary, the second hypotheses ("patterns of innovation are country specific") may be related to the working of major differences among countries in their historical industrial development, in the competence and organization of their firms and in the architecture and policies of their specific national systems of innovations. The contributions of Freeman (1982), Nelson (1993) and Lundvall (1993) have shown that major differences exist across countries in their institutional architectures, public policies and competences and that these have major effects on international technological performance.

In this paper we discuss Schumpeterian patterns of innovative activities for 6 large industrialized countries (Germany, France, the United Kingdom, Italy, United States and Japan) and for 49 technological classes. We greatly expand the analysis done in a previuos paper. In Malerba-Orsenigo (1994) using a smaller set of countries (Germany, France, the United Kingdom and Italy), of technological classes (33), of firms (only those firms patenting for which we found economic data) and a different database (OTAF-SPRU data base on American patents for the period 1968-86) we found that technologies differ quite drastically in the way innovative activities are structured and organized at the firm level according to the Schumpeter Mark I and Schumpeter Mark II levels. Chemicals and electronics have characteristics of the Schumpeter Mark II model, whilst mechanical industries show a Schumpeter Mark I model (Malerba-Orsenigo, 1994). Using patent data we also found remarkable similarities for the same technological class across four large European countries: Germany, France, United Kingdom and Italy. This lead us to propose that the specific features of a technologies and the relevant technological regimes may act as imperatives in shaping the structure of innovative activities rather similarly across countries.

The paper is organized in the following way. Section 2 presents the data, while Section 3 introduces the main measures used to identify the two Schumpeterian patterns of innovative activities. Section 4 discusses the hypotesis regarding the technological specificity of the Schumpeterian patterns of innovation and Section 5 the one regarding the role of country specific effects. Finally in Section 6 a discussion trying to relate some of the dimensions of the Schumpeterian patterns of innovation to countries' technological specialization is done.

2. DATA

Patent data have been used to investigate this issue. Criticisms of the use of patent data are well known. Not all innovations are patented by firms. Patents cannot be distinguished in terms of relevance unless specific analyses on patent renewals or patents citations are done. Finally, different technologies are differently patentable and different types of firms may have different propensities to patent. However, patents represent a very homogeneous measure of technological novelty across countries and are available for long time series. They also provide very detailed data at the firm and the technological class levels. As a consequence, they are an invaluable and unique source of data on innovative activity.

This paper has used European Patent Office (EPO) data for the period 1978-91. The data refer to patent applications granted by EPO to firms of various countries, with the exclusion of individual inventors. Copatents have been counted as many times as the number of the copantents.

The EPO data base has been elaborated at the firm level (excluding inventors) for six countries: United States, Japan, Germany (Federal Republic), France, the United Kingdom, Italy.[3]

As far as the United States are concerned, 133475 patents and 11476 firms have been considered; for Japan 81217 and 3990 firms; for Germany 108118 patents and 8495 firms; for France 43986 patents and 5671 firms; for the United Kingdom 35175 patents and 6055 firms and for Italy 15175 patents and 3803 firms. In addition, for the four European countries data on the size of the innovators has been gathered. 56% of the German firms, 49% of the Franch firms, 34% of the British firms and 51% of the Italian firms have been covered. Economic data on firms applying for patents concerns size in terms of employees in 1991. Therefore a bias may be present in the analysis in favour of firms active during the early 1990s. Firms part of business groups have been treated in the present analysis as individual companies.[4] Because EPO is located in Germany, German firms are overrepresented in the sample. However because our aim is not to discuss technological performance, but the structure of innovative activity at the industry level, we think that this does not create serious distortion in our results.

49 technological classes are considered in the analysis (see Appendix). These classes have been created starting from the various subclasses (4 digits) of the International Patent Classification (IPC) and grouping them according to specific applications. Because the analysis has been carried out for the period 1978-91, it is possible that a technological class may have moved over the period from a Schumpeter Mark I to a Schumpeter Mark II group.

[3] It must be noted that in the Japanese database individual inventors are very numerous and that several large Japanese corporations patent using the name of their divisions rather than the parent company. This may have created distortion in the data.

[4] Compared to the paper previously mentioned (Malerba-Orsenigo,1994), this paper uses a different database (EPO rather than American Patent Office data), uses a series of data ending in 1991 rather than in 1986, analyzes the whole population of firms applying for patents, examines 6 countries rather than 4 (the United States and Japan have been added) and uses a different and more disaggrgated classification.

3. MEASURES OF PATTERNS OF INNOVATIVE ACTIVITIES

3.1 Single indicators

For each of the 49 technological classes the following indicators have been constructed using patent data:

-CONCENTRATION of Innovative Activities (Concentration ratio of the top 4 innovators) (C4). C4 is quite high in sectors such organic chemicals, macromolecular compounds, agricultural chemicals, aircraft, computers, telecommunications and nuclear technology and is low in clothing, forniture, agriculture, mining, chemical apparatus, industrial automation, industrial machinery and equipment, civil engineering, mechanical engineering and measuring equipment. (see Table 1)

INSERT TABLE 1 ABOUT HERE

-ASYMMETRIES among Innovators (Herfindahl Index) (HERFINDAHL). HERFINDAHL is high for organic chemicals and macromolecular compounds, miscellaneous chemical compounds, electronics components and telecommunications while it is low for clothing, fornitures, agriculture, mining, metallurgy, industrial automation. industrial machinery, material handling apparatus, civil engineering, mechanical engineering, mechanical and electric technologies and sports. (see Table 2)

INSERT TABLE 2 ABOUT HERE

-SIZE of the innovating firms (share of patent applications by firms with more than 500 employees) (SIZE). SIZE is high in inorganic chemicals, organic chemicals, macromolecular compounds, adhesives, agricultural chemicals, computers and other office equipment, while it is low in clothing, furnitures, agriculture and sports. (see Table 3).

INSERT TABLE 3 ABOUT HERE

-STABILITY in the hierarchy of innovators (Spearman rank correlation coefficient between firms innovating in 1978-85 and firms innovating in 1986-91) (SPEATOT). SPEATOT is low for clothing, furniture, agriculture, chemical processes, machine tools, industrial automation, civil engineering and sports, while it is high for gas and oil, organic chemicals, macromolecular compounds, new materials, adhesives, drugs, aircraft, electronics components and telecommunications. (see Table 4).

INSERT TABLE 4 ABOUT HERE

-STABILITY in the hierarchy of firms which innovate continuously (Spearman rank correlation coefficient between the hierachies of firms innovating in both periods (1978-85 and 1986-91) (SPEACORE). SPEACORE has a low positive value or a negative value in furniture, agriculture, mining, agricultural chemicals, chemical processes and machine tools, while it has a high positive value in organic chemicals, macro compounds, computers and office equipment. (see Table 5).

INSERT TABLE 5 ABOUT HERE

-NEW INNOVATORS (share of patent applications to firms applying for the first time in a given technological class in the period 1986-91 compared to the period 1978-85) (NATALITY). It must be noted that this indicator measures innovative birth and not entrepreneurial birth: a new innovator may in fact have been around for quite a long time. NATALITY is low for organic chemicals, macromolecular compounds, electronic components, consumer electronics and telecommunications while it is high for clothing, furniture, agriculture, mining, chemical processes, machine tools, civil engineering, lighting systems and sports.(see Table 6). Please note that NATALITY refers to gross entry (mortality has been calculated but not used in this analysis) and to entry in a specific sector 5

INSERT TABLE 6 ABOUT HERE

SPEATOT, SPEACORE AND NATALITY shed light on the degree of turbulence in each technological class.

3.2 Schumpeterian patterns of innovations

The relationships between these various measures identify the two major Schumpeterian patterns of innovations.

Schumpeter Mark I (WIDENING) is characterized by low concentration and asymmetries in innovative activities and high turbulence (and possibly with firms of smaller size). It includes technological classes such as furniture, agriculture, mining, chemical processes for food and tobacco, metallurgy, industrial machinery and equipment, material handling apparatus, civil engineering, mechanical engineering, mechanical technologies, measurement and control instruments, sports.

Schumpeter Mark II (DEEPENING) is characterized by high concentration and asymmetries in innovative activities and low turbulence (and possibly with firms of larger size). It includes technological classes such as organic chemicals, macromolecular compounds, miscellaneous chemical compounds, agricultural machinery, aircraft, engines, laser technology, optics, computers, electronic components and telecommunications.

Principal component analysis has confirmed this result. Principal component analysis done for all the technological classes has captured in all countries one dominant factor which captures at least 50% of the variance if not more (.49% for Japan, .58% for the United States and .72% for Europe). The dominant factor includes the four measures characterizing the Schumpeterian patterns: C4

5 In a recent research for ENEA and the competitiveness of Italy in high technology we have ditinguished between total entry and actual entry. The first refers to all firms entrants in a technological class, which may have however innovated in other technological classes. The second refers to innovators that innovate for the first time. Most of the entrants are lateral entrants. In the period 1988-91 in high technologies there were 141 total entrants but only 63 totally new innovators and 179 patents applied for by entrants, but only 75 patents by totally new innovators. As a consequence the NATALITY index drops significantly if we consider only totally new entrants. This is so particularly for chemicals (in Italy in 1988-91 from 38 to 12 for firms and from 52 to 20 for patents) and less for electronics (from 44 to 24 for firms) and for mechanics (from 59 to 27). Most of the totally new entrants are small and medium size firms patenting in electro-medical equipment and industrial automation, and (less) in plastic, fibers, fine chemicals, instruments, optical equipment. (Malerba-Orsenigo et al. 1993).

HERFINDAHL and SPEATOT, and NATALITY. In each country, these four measures are characterized by specific relationships. In most technological classes there is a positive correlation between concentration C4, asymmetries HERFINDAHL and stability of innovators' hierarchy SPEATOT, and a negative correlation between these measures and entry of new innovators NATALITY.

4. TECHNOLOGICAL IMPERATIVES AND THE TECHNOLOGICAL SPECIFICITY OF SCHUMPETERIAN PATTERNS OF INNOVATION

The analysis conducted for six countries (eventually grouped into three major areas-United States, Japan and Europe-) clearly show that technological imperatives and some basic conditions of technological regimes structure the patterns of innovative activities in each technological class across countries in a very similar way. This can be seen in various ways.

4.1 For each indicator major similarities exist among countries in the values (highlighted by the Pearson correlation coefficient) and the ranking of technological classes (highlighted by the Spearman correlation coefficient).

The United States, Japan and Europe, and also the four European countries (Germany, France, the United Kingdom and Italy), show great similarities in relative values and rankings of technological classes in terms of concentration (C4), asymmetries (HERFINDAHL), stability in the ranking (SPEATOT), natality (NATALITY) and SIZE, as the Pearson and Spearman correlation coefficients (not reported here) clearly show.

4.2 The characterization of a technological class as Schumpeter I or Schumpeter II is very similar across countries.

If technological classes are grouped according to measures of Schumpeterian patterns of innovations, major similarities are evident among countries. First of all, in all countries the various dimensions of Schumpeterian patterns are related to each other in a similar way. C4 and HERFINDAHL are positively correlated, while NATALITY is negatively correlated with C4, HERFINDAHL and SPEATOT. In addition, only in Europe and in each of the four European countries considered SPEATOT is positively and significantly correlated with C4 and HERFINDAHL. Second, in all countries, most technological classes show a similar Schumpeterian pattern of innovation. The principal factor (PRIN1) (summing up the relationship between single indicators of Schumpeterian patterns) assumes similar relative values and a similar order across technological classes in all countries considered. Pearson and Spearman correlation coefficient of PRIN1 among various countries (not reported here) show a very significant correlation among most countries.

The classes which were included in the Schumpeter I and Schumpeter II groups are so in all countries. Furniture, agriculture, mining, chemical processes for food and tobacco, metallurgy, industrial machinery and equipment, material handling apparatus, civili engineering, mechanical engineering, mechanical and electric technologies, measurement and control instruments and sport are consistently on the Schumpeter Mark I camp, while organic chemicals, macromolecular compounds, miscellaneous chemical compounds, agricultural machinery, aircraft, engines, lase technology, optics, computers, electronics component and telecommunications are consistently on the Schumpeter Mark II camp.

If the 49 technological classes are grouped in 6 macroclasses (respectively traditional, chemical, mechanic, transport, electric and electronic technologies) and princpal component analysis is done for the 6 macroclasses, major similarities emerge among European countries and between Europe and the United States. (see Tables 7 and 8) Traditional, electric and mechanical technologies have a negative value of the principal component, identifying therefore a Schumpeter Mark I pattern, while electronic, transport and chemical technologies have a positive value of the principal component, idetifying a Schumpeter Mark II pattern. Japan represents the major exception (as it will be discussed in Section 5).

INSERT TABLES 7 AND 8 ABOUT HERE

5. COUNTRY DIFFERENCES HOWEVER STILL PERSIST

The relevant role of technological imperatives and technological regimes however do not totally wipe away differences among countries. Differences persist as a consequence of country specific effects such as national systems of innovation, the specific histories of firms and industries in a certain country and so on. These differences regard concentration, stability or natality; the ordering of the various technological classes according to a specific dimension of a patterns of innovative activity; and the Schumpeterian patterns of innovations

5.1 Japan and Germany emerge as concentrated and stable countries

From a comparison of the average values of the various indicators for Europe, Japan and the United States, Japan emerges as a rather concentrated (C4) and stable country (SPEATOT). The United States and Europe show similar features, although Europe is on average less concentrated and stable than the United States. Interestingly enough, in this respect Japan shows several similarities with Germany.[6] (see Table 9).

INSERT TABLE 9 ABOUT HERE

The stability of Japan is confirmed by the low significant (negative) correlation between natality (NATALITY) and concentration (C4) and asymmetries (HERFINDAHL) (respectively -.27 and -.17) Similarly, C4 and HERFINDAHL are not correlated with stability SPEATOT (respectively -.10 and -.24). It must be noted in fact that in the other countries natality (NATALITY) is negatively correlated with C4 and HERFINDAHL.

[6] Please note that C4 and stability (SPEATOT) are not necessarily inversely related to the dimension of a country in terms of patents. In fact, while among European countries Italy has the lowest number of patents and Germany the highest, they both have rather similar C4 and SPEATOT.

Among the four European countries, Germany and Italy have a high concentration (C4) while France and the United Kingdom have a low concentration. However while in Germany the average size of innovators (SIZE) is the largest among the four European countries, in Italy the average size is the smallest. (see Table 9 again)

In terms of turbulence (SPEATOT and NATALITY), Germany is highly stable (both globally and in the core) with very low natality (here the working of the effect of the location of EPO, favoring the early entry of German firms compared to the firms of the other European countries- particularly Italy- and Japan, may be present), while the other three countries have a higher turbulence (particularly Italy, with high change in the hierarchy of innovators and a high natality).

5.2 Structural differences among technological classes

Some differences emerge also in the relative values and ranking of technological classes among Europe, the United States and Japan (not reported in this paper). In particular, as far as C4 is concerned, Japan has a ranking of technological classes in terms of concentration indexes similar to the United States (and Italy and France) but not with Europe.

As far as the European countries are concerned, the few exceptions regard the relative values of some indicators expressed by the Pearson correlation coefficient. The United Kingdom is different from Italy and France in terms of HERFINDAHL, Italy is different from Germany and France in terms of SPEATOT and Germany is different from France in terms of SIZE.

The stability of the ranking of firms that innovate in both periods (1978-85 amd 1986-91) (SPEACORE) is quite different among the three major areas (United States, Japan and Europe) and among European countries. In particular, the ranking of technological classes in terms of SPEACORE differs drastically across all countries, except for a significant correlation between the United States and Europe (particularly Germany and the United Kingdom) and between Japan and Italy. This indicates how different the degree of competition in the "core" group is across countries even for the same technological class.

5.3 The Japanese peculiarity in the Schumpeterian patterns of innovation

At the level of Schumpeterian patterns of innovation, specific technological classes behave differently in specific countries such as food and tobacco (Schumpeter II only in the U.K but not in the other five countries), inorganic chemicals (Schumpeter I only in Japan) drugs (Schumpeter II in U.K.), chemical treatments and agricultural chemicals (Schumpeter II only in Germany) household electric appliance (Schumpeter I only in the United States and U.K), and so on.

Differences in the relative values of the main principal component factor calculated by Pearson correlation coefficients for the 49 technological classes emerge between Japan and the United States (the Pearson correlation coefficient is barely significant at the .05% level), while major differences exist between Japan and the United Kingdom (the correlation coefficient is not significant: .28) and Germany (the correlation coefficient is equal to .03).

These differences are confirmed if Japan is examined according to 6 macroclasses (traditional, chemical, mechanical, transport, electric and electronic technologies). Compared to the other countries in fact, Japan shows major differences in the value of the principal component (C4, HERF, SPEATOT and NAT) in chemicals and electronics (Schumpeter I instead of Schumpeter II) and traditional sectors (Schumpeter II instead of Schumpeter I). In this last case however the major role played by only one Japanese firm (YKK, patenting extremely heavily in textile and clothing) is responsable for the high value of C4 and HERFINDAHL and the low value of NATALITY.

6. The structural determinants of countries' technological specialization

Finally, in this paper the relationship between structural variables of the patterns of innovative activities and international specialization has been examined.

The major hypotesis to be tested is if those countries which emphasize structural features which are in accordance with the specific Schumpeterian pattern of innovation of a given technological class display also a greater technological specialization in that class. For example, in Schumpeter Mark I technological classes those countries characterized by lower concentration and greater turbulence should also have an international specialization in these classes, while in Schumpeter Mark II classes those countries characterized by higher concentration and lower degree of turbulence should have an international specialization in these classes.

In order to test this hypohesis, technological classes have been grouped according to the value of each of the four indicators of Schumpterian patterns (C4, HERFINDAHL, SPEATOT and NATALITY): 17 Schumpeter Mark I and 15 Schumpeter Mark II classes have been created.

Regressions have been run for the international specialization of a country in term of revealed technological advantages (RTAW). RTAW are the ratio between the world share of a country in a given technological class and the the world share of that country in all technological classes. Dummy variables have been used for Schumpeter I classes (D1) and for Schumpeter II classes (D2). The set of regressors identify the major dimensions of Schumpeterian patterns: HERFINDAHL, SPEATOT and NATALITY. However a negative correlation between NATALITY and RTAW exists because the number of patents of a given technological class in the period 1986-91 appears in the denominator of the first indicator while it is included in the numerator of the second term (total number of patents in the period 1978-91). As a consequence, in another type of regression using NATFIRM- the ratio of the number of firms patenting for the first time during the period 1986-91 with respect to the total number of firms patenting in 1986-91- instead of NATALITY has been run.

The hypotesis advanced previously is confirmed. In Schumpeter I classes, those countries which are characterized by a greater turbulence (SPEATOT negative and significant) have also an international specialization (RTAW) in these classes. On the contrary in Schumpeter II classes those countries characterized by greater asymmetries and concentration (HERFINDAHL positive and significant) and rank stability (SPEATOT positive and significant) have also an international specialization (RTAW) in these classes. (see Table 10)

In addition another result which requires further future scrutiny emerges as relevant. Those countries characterized by a greater stability of the core group of innovators (expressed by a low natality rate) have also a greater degree of international specialization. This is shown by the negative and significant coefficient of NATALITY in both Schumpeter I and Schumpeter II technology classes. Please notice that stability of the core group of innovators does not imply stability in the hierarchy of innovators both within the core group and for all innovators. In fact stability in the core group may be associated with high degrees of rivalry and hierarchical change within the group. It must be noted that this result is confirmed by the sign of the coefficient (which is however not significant) of NATFIRM.

INSERT TABLE 10 ABOUT HERE

7. Conclusions

This paper has shown that the patterns of innovative activities differ systematically across technological classes, but for each technological class they are remarkable similar across countries. This result suggests that "technological imperatives" and technology-specific factors (closely linked to technological regimes) play a major role in determining the patterns of innovative activities across countries. Two groups of technological classes in which innovative activities are structured and organized in different ways may be identified: "Schumpeter Mark I" and "Schumpeter Mark II". The first represents a "widening" pattern and the second a "deepening" pattern of innovative activities. The former group comprises the mechanical, electrical and traditional technologies; the latter comprises transport, chemical and electronic technologies. In sum, technological imperatives (in terms of specific features of technology and characteristics of technological regimes) shape and broadly determine the specific pattern of innovative activity in a given technological class. They are very important in generating invariances across countries.

Within the major structuring role of "technological imperatives" across countries for a given technological class, for a country specific factors may introduce differences in the structural dimensions of the innovative patterns or even in the characterization of a technological class as Schumpeter I or Schumpeter II. These factors may range from the peculiar history and industrial development of a country, to the level and type of competences and competitiveness of specific firms within the industrial structure, to the type and extent of public policy and the relevant features of the national system of innovation.

A final result regards the relationship between the specific features of the pattern of innovation and international technological specialization. Those countries that show structural features more in tune with the specific pattern characterizing a technological class are also specialized in that class. In widening technological classes higher turbulence induces greater international specialization, while in deepening technological classes greater asymmetries foster greater technological specialization.

Future directions of research include a more sophisticated analysis of the relationship between technological regimes and patterns of innovative activities; the analysis of the role of technological imperatives in small countries; the study of net entry and lateral entry and the possible changes in the type of a Schumpeterian pattern during the technology life cycle.

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APPENDIX

TECHNOLOGICAL CLASSIFICATION

1) Food, tobacco

2) Clothings, shoes

3) Furnitures

4) Agriculture

5) Mining

6) Gas, hydrocarbons, oil

7) Inorganic chemicals

8) Organic chemicals

9) Macromolecular compounds

10) New materials

11) Adhesives, coatings, synthetic resins

12) Bio-chemicals, bio and genetic engineering

13) Miscellaneous chemical compounds

14) Chemical, analytical, physical processes

15) Drugs

16) Medical preparations

17) Natural and artificial fibres; paper

18) Chemical treatment of natural or artificial fibres and paper

19) Agricultural chemicals

20) Chemical processes for food and tobacco

21) Metallurgy

22) Machine tools

23) Industrial automation

24) Industrial machinery and equipments

25) Agricultural machinery

26) Vehicles, motocycles, other land vehicles

27) Aircraft

28) Railways, ships

29) Materials handling apparatus

30) Civil engineering, infrastructures

31) Engines, turbines, pumps

32) Mechanical engineering

33) Mechanical and electric technologies

34) Household electric appliances

35) Lighting systems

36) Measurement and control instruments

37) Laser technology

38) Optics and photography

39) Computers, data processing systems

40)Other office equipments

41) Electrical devices and systems

42) Electronic components

43) Consumer electronics

44) Telecommunications

45) Multimedial systems

46) Decorative and figurative arts, sports, toys

47) Ammunitions, weapons

48) Nuclear technology

49) Others

Table 1

Concentration ratio (C4) by technological class and country

CODE	USA	JAP	GER	FR	UK	IT	Av	Std
1	34,7	30,5	32,3	19,2	70,7	38,4	37,6	17,5
2	27,5	80,4	22,6	30,1	16,1	58,7	39,2	24,9
3	12,6	22,0	9,2	18,0	10,2	15,0	14,5	4,9
4	19,4	19,5	16,0	16,2	16,5	15,9	17,2	1,7
5	36,7	37,1	16,3	57,3	23,3	60,0	38,4	17,6
6	48,3	29,0	30,6	48,6	51,6	51,9	43,3	10,6
7	21,6	12,0	39,5	40,8	42,1	36,4	32,1	12,3
8	19,4	19,4	68,8	32,8	53,9	25,5	36,6	20,3
9	33,8	20,3	73,9	42,7	56,5	52,8	46,6	18,7
10	23,5	19,8	24,4	32,2	28,9	31,9	26,8	5,0
11	26,2	22,5	63,7	27,5	44,8	36,7	36,9	15,5
12	12,8	20,8	41,9	36,3	39,3	39,2	31,7	12,0
13	68,9	50,9	81,1	41,9	89,1	60,7	65,4	17,9
14	15,5	9,2	20,6	21,5	30,4	14,2	18,6	7,3
15	13,9	20,1	31,6		46,5	18,8	26,2	13,1
16	13,1	33,2	30,9	15,0	20,5	20,9	22,3	8,2
17	32,3	32,5	20,5	22,1	24,2	33,0	27,4	5,8
18	26,9	25,4	48,5	19,7	32,3	20,6	28,9	10,6
19	25,5	31,2	69,4	42,6	46,6	44,7	43,3	15,2
20	27,8	20,2	25,4	13,6	43,5	29,2	26,6	10,1
21	18,5	28,2	21,5	19,4	23,5	19,8	21,8	3,6
22	20,5	22,7	31,9	31,1	25,2	36,8	28,0	6,2
23	18,0	60,8	17,0	17,8	21,6	19,2	25,7	17,3
24	8,5	11,8	12,2	11,9	9,9	17,5	12,0	3,0
25	82,8	37,5	43,0	51,1	36,1	41,4	48,7	17,6
26	29,7	38,7	25,0	39,4	37,0	38,6	34,7	6,0
27	57,0	48,7	58,3	66,9	56,0	58,8	57,6	5,8
28	18,2	45,2	25,1	32,4	18,1	36,3	29,2	10,7
29	10,7	13,2	10,0	7,8	14,4	13,6	11,6	2,5
30	12,1	19,1	7,7	10,7	6,8	15,1	11,9	4,6
31	21,7	36,5	38,1	39,2	38,9	38,3	35,5	6,8
32	17,1	30,3	12,9	24,5	31,5	20,6	22,8	7,4
33	19,2	21,4	12,5	20,0	15,6	24,3	18,8	4,2
34	14,2	47,0	22,3	36,5	15,9	25,3	26,9	12,7
35	34,6	53,0	49,3	44,6	37,8	35,4	42,4	7,7
36	11,5	23,2	28,9	20,3	12,5	19,4	19,3	6,6
37	33,7	48,4	47,9	53,1	45,6	63,0	48,6	9,6
38	41,6	45,1	50,3	36,0	29,1	38,3	40,1	7,4
39	47,8	40,9	54,0	34,4	22,4	63,9	43,9	14,7
40	62,4	40,2	49,4	38,5	44,5	92,0	54,5	20,3
41	22,1	33,5	38,3	18,6	17,5	18,1	24,7	8,9
42	34,7	53,2	52,4	42,9	31,6	49,0	44,0	9,2
43	29,4	47,4	51,1	44,5	31,5	41,8	40,9	8,8
44	40,3	58,8	61,4	35,2	35,9	58,7	48,4	12,5
45	55,7	63,9	68,9	60,9	79,4	91,7	70,1	13,3
46	13,7	17,4	12,0	27,4	10,2	19,5	16,7	6,2
47	29,7	63,9	55,7	45,4	46,0	35,1	46,0	12,6
48	80,0	64,3	54,1	75,4	66,2	85,7	70,9	11,6
49	19,1	40,5	22,1	15,9	16,3	19,6	22,2	9,2

Table 2
Herfindahl index by technological class and country

CODE	USA	JAP	GER	FR	UK	IT	Av	Std
1	0,05	0,04	0,04	0,02	0,38	0,05	0,10	0,14
2	0,03	0,48	0,02	0,04	0,02	0,26	0,14	0,19
3	0,01	0,03	0,01	0,01	0,01	0,02	0,01	0,01
4	0,02	0,02	0,01	0,01	0,02	0,02	0,02	0,00
5	0,05	0,05	0,02	0,10	0,03	0,11	0,06	0,04
6	0,09	0,03	0,04	0,11	0,09	0,08	0,07	0,03
7	0,02	0,01	0,05	0,08	0,07	0,05	0,05	0,03
8	0,02	0,02	0,15	0,04	0,11	0,03	0,06	0,06
9	0,04	0,02	0,19	0,07	0,15	0,10	0,10	0,06
10	0,02	0,02	0,03	0,05	0,03	0,04	0,03	0,01
11	0,03	0,02	0,13	0,03	0,12	0,07	0,07	0,05
12	0,01	0,02	0,06	0,05	0,05	0,05	0,04	0,02
13	0,27	0,16	0,38	0,07	0,61	0,13	0,27	0,20
14	0,01	0,01	0,02	0,02	0,04	0,01	0,02	0,01
15	0,01	0,02	0,04	0,04	0,07	0,02	0,03	0,02
16	0,01	0,04	0,06	0,01	0,02	0,02	0,03	0,02
17	0,05	0,04	0,02	0,02	0,02	0,04	0,03	0,01
18	0,03	0,03	0,07	0,02	0,04	0,02	0,04	0,02
19	0,02	0,06	0,18	0,08	0,09	0,09	0,09	0,05
20	0,03	0,02	0,03	0,01	0,11	0,04	0,04	0,04
21	0,02	0,03	0,02	0,02	0,03	0,03	0,02	0,01
22	0,02	0,03	0,04	0,04	0,03	0,06	0,04	0,01
23	0,02	0,23	0,01	0,02	0,02	0,02	0,05	0,09
24	0.01	0,01	0,01	0,01	0,01	0,01	0,01	0,00
25	0,44	0,06	0,09	0,12	0,06	0,06	0,14	0,15
26	0,03	0,06	0,03	0,05	0,05	0,08	0,05	0,02
27	0,15	0,10	0,13	0,25	0,14	0,13	0,15	0,05
28	0,02	0,07	0,03	0,04	0,02	0,07	0,04	0,02
29	0,01	0,01	0,01	0,00	0,01	0,01	0,01	0,00
30	0,01	0,02	0,00	0,01	0,00	0,01	0,01	0,00
31	0,02	0,05	0,07	0,05	0,06	0,06	0,05	0,02
32	0,01	0,03	0,01	0,02	0,03	0,02	0,02	0,01
33	0,02	0,02	0,01	0,02	0,01	0,03	0,02	0,01
34	0,01	0,08	0,02	0,04	0,01	0,03	0,03	0,03
35	0,05	0,11	0,08	0,09	0,05	0,05	0,07	0,03
36	0,01	0,02	0,04	0,02	0,01	0,02	0,02	0,01
37	0,04	0,08	0,14	0,10	0,10	0,12	0,10	0,03
38	0,06	0,08	0,08	0,06	0,04	0,05	0,06	0,02
39	0,14	0,06	0,15	0,05	0,02	0,15	0,10	0,06
40	0,12	0,07	0,09	0,05	0,09	0,49	0,15	0,17
41	0,02	0,03	0,08	0,02	0,01	0,02	0,03	0,03
42	0,06	0,09	0,19	0,07	0,05	0,16	0,10	0,06
43	0,03	0,08	0,08	0,08	0,04	0,07	0,06	0,02
44	0,05	0,11	0,23	0,05	0,04	0,11	0,10	0,07
45	0,16	0,13	0,19	0,16	0,25	0,39	0,21	0,09
46	0,01	0,01	0,01	0,02	0,01	0,02	0,01	0,01
47	0,03	0,24	0,12	0,07	0,06	0,06	0,10	0,08
48	0,37	0,18	0,12	0,22	0,15	0,20	0,21	0,09
49	0,02	0,06	0,02	0,02	0,02	0,02	0,03	0,02

Table 3

Size index: share of total patent applications of firms with more than 500 employees by technological class and country

CODE	GER	FRA	UK	IT	Av	Std
1	54.3	29.5	81,2	23,2	47,1	26,4
2	37,0	25,0	25,3	1,5	22,2	14,9
3	38,6	38.5	17,6	10,4	26,3	14,5
4	31,3	14,4	15,8	6,1	16,9	10,5
5	46,3	53,1	16,9	42,9	39,8	15,8
6	59,6	60.0	66,2	70,9	64,2	5,4
7	66,8	60,4	61,8	47,7	59,2	8,1
8	82,8	37,9	75,4	54,1	62,5	20,5
9	90,6	57,5	74,5	65,7	72,1	14,2
10	64,9	57,9	57,1	45,1	56,3	8,2
11	73,5	47,8	65,5	47,8	58,7	12,9
12	60,1	33,5	44,4	52,9	47,7	11,4
13	32,8	61,3	94,5	35,7	56,1	28,7
14	56,4	47,7	48,3	23,3	43,9	14,3
15	59,3	37,8	65,6	29,6	48,1	17,1
16	25,7	29,2	25,2	8,6	22,2	9,2
17	59,2	25,9	39,3	21,0	36,3	17,1
18	71,2	27.5	55,9	18.6	43,3	24,5
19	80,5	49.2	57,8	29,8	54,3	21,0
20	61,7	35,3	55,7	29,2	45,5	15,6
21	59,2	40,0	40.2	33,7	43,3	11,0
22	49,7	63,8	37,8	36,8	47,1	12,6
23	53,7	42,3	36,1	15,5	36,9	16,0
24	51,4	41,6	35,3	25,0	38,3	11,1
25	68,2	34,7	30,1	17,2	37,6	21,7
26	53,2	66.2	43,9	48,1	52,8	9,7
27	37,0	18,6	35,1	35,3	31,5	8,6
28	35,2	36,6	32,7	38,1	35,6	2,3
29	41,7	34,6	32,9	21,2	32,6	8,5
30	42,9	33,8	19,5	12,1	27,1	13,9
31	42,4	69,2	42,1	51,3	51,2	12,7
32	56,3	55,5	43,4	31,9	46,8	11,6
33	49,7	42,8	31,6	29,3	38,3	9,6
34	32,5	42,9	23,9	14,6	28,5	12,1
35	50,4	39,1	28,9	25,0	35,8	11,4
36	41,9	35,1	45,2	37,9	40,0	4,5
37	60,3	73,9	60,8	42,6	59,4	12,8
38	54.7	57,8	62,3	35,8	52,6	11,6
39	75.5	54,1	43,0	27,1	49,9	20,3
40	77,5	45.0	45,8	68,4	59,2	16,3
41	62.1	39.7	44,2	34,1	45,0	12,1
42	23,4	45,3	54,4	22,3	36,4	16,0
43	47,2	48.9	48,7	21,7	41,6	13,3
44	24,2	30.4	67,0	52,5	43,5	19,8
45	57,8	65.2	64.7	100,0	71,9	19,0
46	32,9	23,9	15,5	3,7	19,0	12,4
47	45,4	24.6	51,4	27,0	37,1	13,3
48	45.9	80,0	52,9	64,3	60,8	14,9
49	40.1	37.9	33.7	10.9	30.6	13,4

Table 4

Spearman Rank correlation coefficient (SPEATOT) of firms applying for patents

in 1978-'85 with respect to firms applying in 1986-'91 by technological class and country

CODE	USA	JAP	GER	FR	UK	ITA	Av	Std
1	-0.30	-0.20	-0.30	-0.40	-0.30	-0.30	-0.30	0,01
2	-0.50	-0.40	-0.30	-0.50	-0.80	-0.50	-0.50	0,01
3	-0.60	-0.60	-0.30	-0.60	-0.70	-0.60	-0.60	0,01
4	-0.70	-0.60	-0.60	-0.70	-0.60	-0.80	-0.70	0,01
5	-0.20	-0.20	-0.20	-0.30	-0.40	-0.80	-0.40	0,01
6	-0.20	-0.10	0,01	-0.20	-0.20	-0.40	-0.20	0,01
7	-0.20	-0.10	-0.20	-0.30	-0.30	-0.50	-0.20	0,01
8	0,01	0,03	0,03	0,00	0,01	0,01	0,01	0,01
9	0,01	0,02	0,00	-0.10	-0.20	0,00	0,00	0,01
10	-0.10	0,01	0,00	-0.30	-0.20	-0.40	-0.20	0,01
11	0,00	0,01	-0.10	-0.30	-0.30	-0.40	-0.20	0,01
12	0,01	0,01	0,00	-0.20	-0.30	-0.30	-0.10	0,01
13	-0.30	-0.30	-0.20	-0.40	0,00	0.70	-0.10	0,03
14	-0.20	0,01	-0.20	-0.30	-0.40	-0.50	-0.20	0,01
15	0,01	0,01	0,01	-0.20	0,00	-0.10	0,00	0,01
16	-0.20	0,00	-0.20	-0.30	-0.40	-0.60	-0.30	0,01
17	-0.10	0,00	-0.20	-0.30	-0.40	0,01	-0.20	0,01
18	0,00	0,01	0,00	-0.30	-0.20	-0.70	-0.20	0,02
19	-0.30	-0.10	-0.20	-0.40	-0.20	-0.60	-0.30	0,01
20	-0.20	-0.20	-0.20	-0.60	-0.40	-0.80	-0.40	0,01
21	-0.10	0,01	0,00	0,00	-0.10	-0.40	-0.10	0,01
22	-0.20	-0.10	-0.30	-0.30	-0.40	-0.40	-0.30	0,01
23	-0.30	-0.10	-0.10	-0.50	-0.40	-0.50	-0.30	0,01
24	-0.20	-0.10	-0.10	-0.40	-0.40	-0.50	-0.30	0,01
25	-0.40	-0.80	0,01	-0.30	-0.50	-0.70	-0.40	0,02
26	-0.30	0,01	0,00	-0.20	-0.40	-0.40	-0.20	0,01
27	-0.20	-0.20	-0.10	0,01	-0.20	-0.70	-0.20	0,02
28	-0.70	-0.10	-0.30	-0.50	-0.60	-0.40	-0.40	0,01
29	-0.20	-0.10	-0.20	-0.50	-0.50	-0.50	-0.30	0,01
30	-0.50	-0.30	-0.20	-0.50	-0.50	-0.60	-0.40	0,01
31	-0.20	0,00	-0.10	-0.20	-0.30	-0.40	-0.20	0,01
32	-0.20	0,00	-0.10	-0.20	-0.40	-0.50	-0.30	0,01
33	-0.30	-0.20	-0.20	-0.20	-0.60	-0.70	-0.40	0,01
34	-0.40	-0.30	-0.20	-0.30	-0.50	-0.40	-0.40	0,01
35	-0.40	-0.20	-0.40	-0.70	-0.70	-0.50	-0.50	0,01
36	-0.20	0,01	-0.10	-0.20	-0.40	-0.40	-0.20	0,01
37	0,00	0,02	0,00	-0.20	-0.20	0,01	0,00	0,01
38	-0.10	0,01	0,00	-0.10	-0.20	-0.30	-0.10	0,01
39	-0.30	0,02	-0.10	-0.20	-0.40	-0.30	-0.20	0,01
40	-0.10	0,02	-0.10	-0.40	-0.50	0,00	-0.10	0,02
41	-0.20	0,01	0,00	-0.10	-0.30	-0.30	-0.10	0,01
42	0,00	0,01	0,01	-0.20	-0.30	-0.20	-0.10	0,01
43	-0.30	0,01	-0.10	-0.30	-0.40	-0.30	-0.20	0,01
44	-0.20	0,00	0,01	-0.10	-0.20	0,01	-0.10	0,01
45	-0.20	0,01	-0.50	-0.20	0,00	0.80	0,00	0,03
46	-0.50	-0.30	-0.50	-0.60	-0.70	-0.70	-0.60	0,01
47	-0.20	-0.40	0,00	-0.10	-0.50	-0.40	-0.30	0,01
48	-0.30	0,00	-0.20	0,01	-0.30	0,00	-0.10	0,01
49	-0.50	-0.40	-0.40	-0.50	-0.30	-0.40	-0.40	0,01

Table 5

Spearman Rank correlation coefficient (SPEACORE) of firms applying for patents in both 1978-'85 and 1986-'91 by technological class and country

CODE	USA	JAP	GER	FR	UK	IT	Av	Std
1	0,65	0,51	0,39	0,02	0,83	0,17	0,43	0,30
2	0,62	0,81	0,34	0,48	0,00	1,00	0,54	0,35
3	0,26	-0,69	0,26	0,54	0,00	0,20	0,09	0,42
4	-0,41	1,00	0,00	0,35	0,24	0,00	0,20	0,47
5	0,39	0,63	0,29	0,25	0,33	0,00	0,32	0,20
6	0,73	0,47	0,61	0,26	0,35	0,35	0,46	0,18
7	0,58	0,32	0,75	0,67	0,50	0,32	0,53	0,18
8	0,73	0,77	0,70	0,48	0,78	0,48	0,66	0,14
9	0,66	0,69	0,56	0,55	0,57	0,86	0,65	0,12
10	0,51	0,46	0,54	0,61	0,46	0,24	0,47	0,13
11	0,63	0,64	0,83	0,59	0,35	0,43	0,58	0,17
12	0,53	0,43	0,78	0,80	0,74	0,45	0,62	0,17
13	0,53	0,49	0,90	0,97	0,68	0,89	0,74	0,21
14	0,61	0,57	0,58	0,59	0,73	0,20	0,55	0,18
15	0,64	0,46	0,77	0,54	0,49	0,09	0,50	0,23
16	0,45	0,51	0,51	0,51	0,38	0,37	0,45	0,07
17	0,39	0,64	0,22	0,37	0,43	0,71	0,46	0,18
18	0,61	0,61	0,60	0,38	0,44	-0,33	0,39	0,37
19	0,37	0,52	0,66	0,63	0,51	-1,00	0,28	0,64
20	0,52	0,41	0,53	-0,05	0,48	-1,00	0,15	0,60
21	0,56	0,64	0,62	0,57	0,65	-0,01	0,50	0,26
22	0,44	0,41	0,59	0,03	0,53	-0,50	0,25	0,42
23	0,51	0,67	0,52	0,51	0,58	0,34	0,52	0,11
24	0,57	0,61	0,56	0,53	0,36	0,48	0,52	0,09
25	0,72	.	0,31	0,33	0,48	1,00	0,57	0,29
26	0,52	0,71	0,57	0,57	0,29	0,23	0,48	0,18
27	0,63	1,00	0,49	0,84	0,14	0,00	0,51	0,39
28	0,42	0,38	0,40	0,33	0,07	0,95	0,42	0,29
29	0,42	0,61	0,48	0,29	0,16	0,42	0,40	0,16
30	0,36	0,27	0,41	0,48	0,29	0,57	0,40	0,12
31	0,63	0,75	0,62	0,47	0,52	0,58	0,59	0,10
32	0,49	0,44	0,40	0,57	0,44	0,80	0,52	0,15
33	0,50	0,57	0,50	0,61	0,27	0,27	0,45	0,15
34	0,26	0,84	0,72	0,62	0,36	0,50	0,55	0,22
35	0,48	0,11	0,68	0,00	0,27	-1,00	0,09	0,59
36	0,57	0,56	0,64	0,64	0,59	0,53	0,59	0,04
37	0,63	0,78	0,06	0,39	0,84	0,71	0,57	0,29
38	0,60	0,64	0,57	0,43	0,72	0,37	0,55	0,13
39	0,60	0,69	0,75	0,23	0,58	1,00	0,64	0,25
40	0,68	0,71	0,65	0,41	0,63	1,00	0,68	0,19
41	0,62	0,66	0,49	0,42	0,62	0,28	0,52	0,15
42	0,60	0,56	0,64	0,51	0,54	0,46	0,55	0,07
43	0,48	0,73	0,73	0,21	0,43	0,77	0,56	0,22
44	0,56	0,71	0,65	0,28	0,58	0,66	0,57	0,15
45	0,75	0,54	1,00	0,00	0,00	1,00	0,55	0,46
46	0,52	0,19	0,26	0,60	0,77	0,19	0,42	0,24
47	0,30	.	0,62	0,83	0,62	0,04	0,48	0,31
48	0,77	0,53	0,82	0,41	0,50	0,00	0,51	0,30
49	0,49	0,84	0,40	0,33	0,23	0,61	0,49	0,22

Table 6

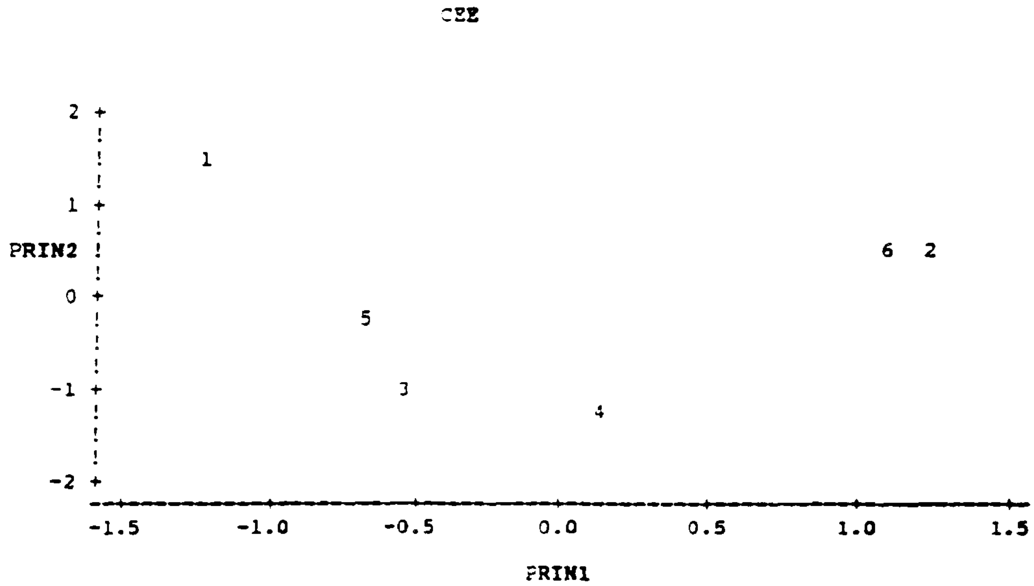
Index of new innovators by technological class and country

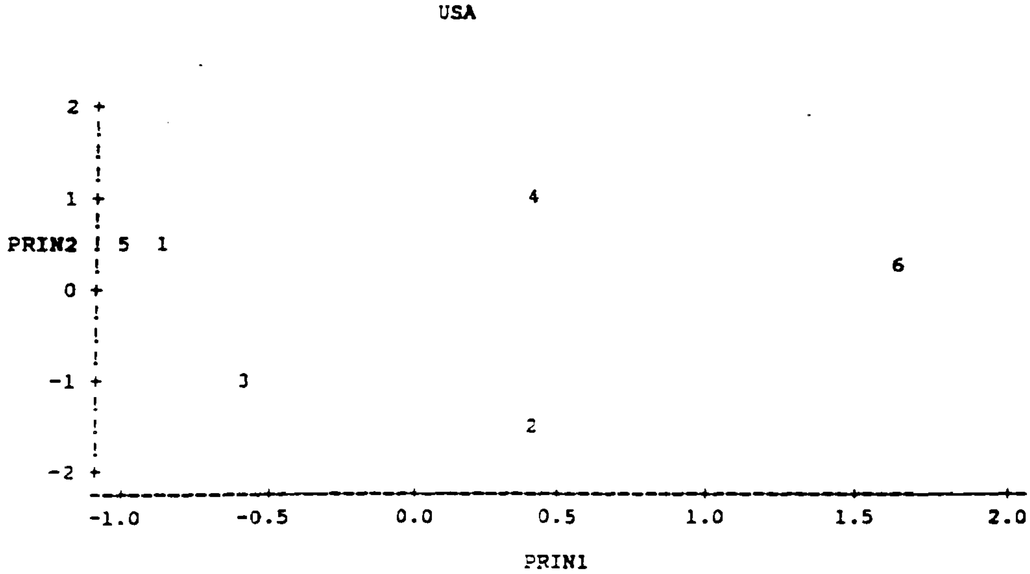
Share of total patent applications by firms patenting for the first time in the period 1986/'91

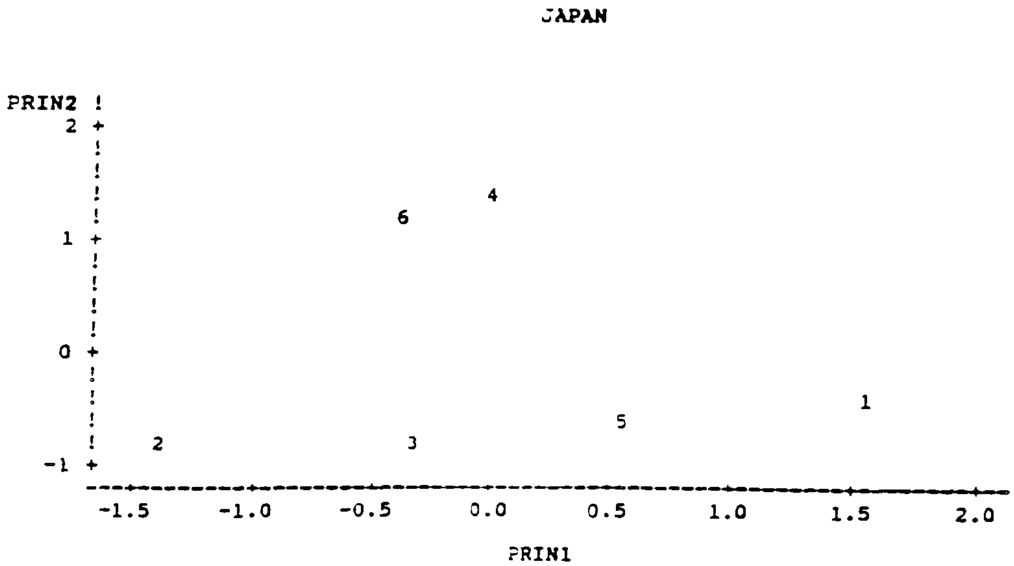
CODE	USA	JAP	GER	FR	UK	IT	Av	Std
1	0,24	0,58	0,42	0,67	0,20	0,56	0,45	0,19
2	0,50	0,27	0,62	0,48	0,86	0,43	0,53	0,20
3	0,78	0,83	0,62	0,82	0,80	0,84	0,78	0,08
4	0,77	0,88	0,68	0,83	0,67	0,95	0,80	0,11
5	0,26	0,72	0,56	0,41	0,62	1,00	0,60	0,26
6	0,12	0,44	0,19	0,28	0,23	0,59	0,31	0,18
7	0,34	0,54	0,29	0,42	0,37	0,78	0,46	0,18
8	0,12	0,13	0,02	0,14	0,12	0,19	0,12	0,05
9	0,10	0,15	0,06	0,24	0,18	0,34	0,18	0,10
10	0,26	0,36	0,28	0,31	0,40	0,75	0,39	0,18
11	0,24	0,32	0,08	0,45	0,36	0,81	0,38	0,25
12	0,29	0,33	0,14	0,38	0,40	0,52	0,34	0,13
13	0,34	0,36	0,13	0,62	0,09	0,55	0,35	0,21
14	0,29	0,39	0,37	0,36	0,38	0,82	0,43	0,19
15	0,30	0,30	0,20	0,34	0,23	0,51	0,31	0,11
16	0,38	0,40	0,36	0,54	0,51	0,83	0,50	0,18
17	0,31	0,40	0,48	0,51	0,68	0,41	0,46	0,13
18	0,26	0,38	0,25	0,64	0,29	0,93	0,46	0,27
19	0,45	0,62	0,21	0,49	0,32	0,86	0,49	0,23
20	0,35	0,67	0,54	0,78	0,49	0,91	0,62	0,20
21	0,28	0,30	0,28	0,29	0,36	0,68	0,37	0,16
22	0,37	0,53	0,46	0,51	0,69	0,73	0,55	0,14
23	0,42	0,22	0,38	0,47	0,58	0,70	0,46	0,17
24	0,32	0,39	0,32	0,48	0,44	0,65	0,44	0,12
25	0,14	0,97	0,13	0,30	0,62	0,74	0,48	0,35
26	0,34	0,17	0,19	0,29	0,28	0,47	0,29	0,11
27	0,30	0,75	0,39	0,18	0,36	0,91	0,48	0,28
28	0,82	0,43	0,45	0,63	0,71	0,74	0,63	0,16
29	0,36	0,52	0,43	0,61	0,61	0,65	0,53	0,11
30	0,62	0,62	0,44	0,59	0,71	0,77	0,62	0,11
31	0,24	0,21	0,20	0,21	0,29	0,50	0,27	0,12
32	0,34	0,37	0,35	0,30	0,37	0,73	0,41	0,16
33	0,46	0,45	0,40	0,35	0,63	0,76	0,51	0,16
34	0,62	0,48	0,33	0,46	0,72	0,69	0,55	0,15
35	0,63	0,39	0,44	0,89	0,82	0,91	0,68	0,23
36	0,30	0,31	0,25	0,39	0,44	0,62	0,38	0,13
37	0,32	0,40	0,43	0,51	0,46	0,53	0,44	0,08
38	0,13	0,15	0,16	0,31	0,27	0,52	0,26	0,15
39	0,16	0,12	0,27	0,29	0,48	0,53	0,31	0,16
40	0,11	0,10	0,20	0,42	0,42	0,20	0,24	0,14
41	0,23	0,25	0,22	0,35	0,44	0,59	0,35	0,14
42	0,17	0,17	0,16	0,29	0,32	0,34	0,24	0,08
43	0,26	0,07	0,15	0,36	0,33	0,44	0,27	0,14
44	0,23	0,12	0,09	0,30	0,27	0,29	0,22	0,09
45	0,26	0,26	0,71	0,71	0,31	0,50	0,46	0,21
46	0,63	0,65	0,65	0,62	0,84	0,80	0,70	0,09
47	0,39	0,61	0,15	0,39	0,36	0,51	0,40	0,15
48	0,12	0,25	0,19	0,08	0,34	0,85	0,30	0,28
49	0,64	0,66	0,63	0,69	0,62	0,84	0,68	0,08

Table 7

Principal component analysis (C4, Herfindahl, Speatot and Natality) for CEE, USA and Japan







Legend

1 Traditional sectors	4 Transports
2 Chemical sectors	5 Electric sectors
3 Mechanical sectors	6 Electronics

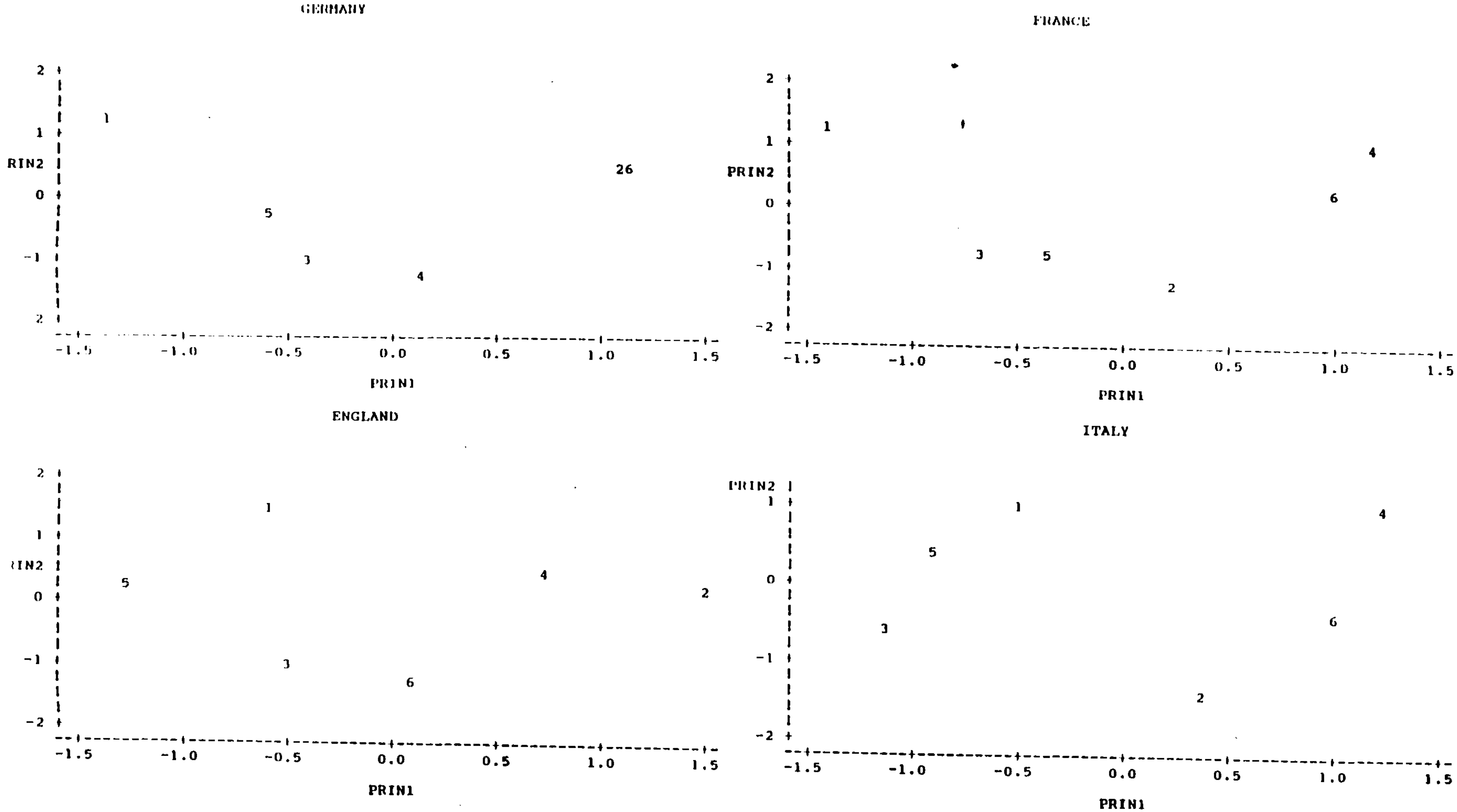
- - + -

PRIN1 Principal Component 1 (C4 . Herf . Speat . Nat)

- - - +

PRIN2 Principal Component 2 (C4 . Herf . Speat . Nat)

Principal component analysis (C4, Herfindahl, Speatot and Natality) for Germany, France, United Kingdom and Italy



Legend

1 Traditional sectors
2 Chemical sectors
3 Mechanical sectors
4 Transports
5 Electric sectors
6 Electronics

PRIN1 Principal Component 1 (C4, Herf, Speat, Nat) PRIN2 Principal Component 2 (C4, Herf, Speat, Nat)

Table 9

Measures of Schumpeterian patterns of innovations

Average and Standard deviations (49 technological classes)

		USA	JAP	CEE	GER	FRA	UK	IT
C4	Av	29,5	34,9	23,7	36,7	32,9	34,0	37,6
	Std	17,7	16,5	14,6	19,7	15,2	18,6	20,1
Herf	Av	0,06	0,07	0,03	0,07	0,05	0,07	0,08
	Std	0,09	0,08	0,04	0,08	0,05	0,10	0,09
Size	Av	-	-	-	52,3	43,9	45,9	33,6
	Std	-	-	-	15,8	14,9	18,2	19,6
Speatot	Av	-0,23	-0,06	-0,26	-0,13	-0,29	-0,36	-0,35
	Std	0,19	0,26	0,16	0,17	0,20	0,19	0,33
Speacore	Av	0,52	0,56	0,51	0,55	0,46	0,47	0,37
	Std	0,18	0,26	0,13	0,20	0,21	0,20	0,50
Nat	Av	0,34	0,41	0,39	0,33	0,45	0,46	0,65
	Std	0,18	0,22	0,17	0,18	0,19	0,20	0,20

Table 10

Factors affecting Revealed Technological Advantages (RTAW) of six countries
(17 Schumpeter I classes and 15 Schumpeter II classes)

Independent Variables	Dependent Variable RTAW	
Dummysch1	1.669*	1.2813*
	[0.5254]	[0.1450]
D1herf	-2.3592	-2.5537
	[2.1921]	[2.0943]
D1spea	-0.6217**	-1.0977*
	[0.3254]	[0.3551]
D1natfirm	-1.075***	
	[0.7927]	
D1nata		-1.1002*
		[0.4006]
Dummysch2	1.1669*	1.1501*
	[0.4330]	[0.1076]
D2herf	2.1235*	1.7335*
	[0.5078]	[0.4977]
D2spea	0.6411*	0.315***
	[0.2455]	[0.2195]
D2natfirm	-0.4529	
	[0.6347]	
D2nata		-0.9746*
		[0.2838]
R squared	0.8529	0.8664
Std Error	0.4293	0.4115
D.o.F.	192	192

RTAW = revealed technological advantage on world patents

Numbers between square brackets indicate the standard errors

* significant at the 1% level
** significant at the 5% level
*** significant at the 10% level