A small explosion: patent in educational and instructional technologies and methods; what do they tell us?

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« *Today it remains astonishing to observe the contrast between fields where improvements in practice are closely reflecting rapid advances in human knowledge – such as ITs, transportation, medical care (surgery and drug therapy) – and other areas where the state of knowledge appears to be far more constraining. The fact is that knowledge is not being developed to the same degree in every sector* » (Nelson, 2003)

I - Introduction

The educational sector is often characterized by experts as a sector suffering from an innovation deficit and a structural inability to advance knowledge and know how at the same rate as what is occurring in some other sectors. Baumol qualifies the educational sector as a non progressive one : productivity rises only very episodically and, as a result, the unit labor costs are increasing all the time. A bunch of literature is devoted to the problem raised by this innovation deficit and productivity stagnation: how to cure the Baumol's disease in the educational sector? The development of an educational science, the connections between research and practices, the processes of knowledge codification and transfer and above all the kind of incentives that teachers and schools need to get to innovate are the "usual suspects" which are empirically studied in order to implement profound changes (see Foray, Murnane and Nelson, special issue of *Economics of Innovation and New Technology*, 2007).

Now only a short look at patent data provides us with a slightly different view of innovation in this sector. Looking at the class G09B of PATSTAT, it becomes clear that patent applications have increased dramatically from the early nineties in the domain of educational and teaching technologies[1]. Not only this growth is animated by very large and diversified companies in electronics, computers or multimedia but we can see also the formation of a population of small firms which are specialized in the development of technological solutions to educational problems and issues. Clearly this trend involves a logic of "co-invention of applications" which is associated

[1] This trend was initially observed and discussed by Cockburn (2002) at the US-Japan Symposium of the Columbia Business School: "I think it is worth noting that there are increasing numbers of patents being issued on methods of pedagogy"

with the general dynamics of ICTs as a general purpose technology. Country's comparisons show the very high contribution of new Japanese, US and Chinese companies to this trend.

The research questions we are dealing with in the paper by investigating in depth this population of firms are the following:

- Do we see here a phenomenon of vertical specialization with the entry of new, small and undiversified firms that are forming a new industry specialized in the development of pedagogical knowledge and innovations?
- The important patenting activity of these companies means for the education sector the need to pay for access to technologies of the kind that used to be obtained for free by schools. This access is now explicitly priced in the form of licensing agreements. Does the substitution of this market for the old arrangement involve efficiency gains?
- How does the "market" respond to these innovations? The educational sector is a very special market which might be not so well adapted to a Schumpeterian and entrepreneurial industry which needs to generate and commercialize a continuous flow of innovation to ensure a sustainable growth and thereby create permanently turbulence and creative destructions in the user sector.

In the section following immediately the introduction, we address the general issue of the education sector as a non progressive sector and we articulate the argument that it is not an *intrinsically non progressive* sector. It is rather *structurally non progressive* meaning that there is no intrinsic limits to productivity growth but some structural problems dealing with the modes and logics of advancing and using knowledge about educational and instructional practices and technologies. In section 3 we propose an overview of the kind of structural problems that create such an innovation deficit. In section 4 we analyze and interpret the patent data that provide us with a slightly different view of the sector. As already said, a quite intensive innovative activity seems to occur. However, the locus of these activities is not within the sector itself but in the supplier industry. The main logic of these innovations deals with the development of ICTs applications and the most interesting fact is that beyond some R&D portfolio diversification of big firms already developing ICTs-based products in entertainment, media and learning, a population of *specialized firms* is emerging and expanding, raising issues about the emergence of a new industry specialized in the creation of pedagogical and instructional technologies. The emergence of such a new industry would change significantly the prospect about innovative activity and productivity growth in the sector. However many questions remain about the conditions and impact of this innovation activity. They are addressed in the final section.

II - Education as a "structurally non progressive sector"

The educational sector is often characterized by experts as a sector suffering from an innovation deficit and a structural inability to advance technical knowledge and know how at the same rate as what is occurring in some other sectors[2] « *Consider the efforts to develop more effective educational practices in schools: even if we do know more about educational practices that we did previously, knowledge creation in this domain has been slow and there have been severe difficulties in diffusing « new and superior » knowledge* » (Nelson, 2003). To use another language, the educational sector is notoriously known as a non progressive sector – a sector in which productivity growth is limited, very sporadic and far smaller in magnitude that what is happening in the progressive part of the economy (Baumol and Bowen, 1965).

Macro-economic implications

The macro-economic implications of the coexistence of these two sectors in the economy are known under the expression of the Baumol's (or cost) disease: while in the progressive sector, productivity rises constantly and so wages are rising accordingly, in the non progressive sector wages cannot remain unchanged just because wages in the two sectors go up and down more or less together. As a result, in the non progressive sector, the labor cost per unit of output rises, and so the costs of production rise steadily and far more rapidly than production costs in the economy as a whole. Implications for financing the non progressive sector are clear cut: what is sufficient for today must be inadequate tomorrow; enough for tomorrow will be insufficient the day after. To quote Baumol, "*faster technical progress is no blessing for the laggards*". This is exactly what is happening in the educational sector where Baumol's predictions seem to be fully right: cost per student has been risen steeply over the years (Baumol, 1993). Yet, on average, many would agree that schools are producing only slightly better results than in the late 1970s (Roza, 2008).

Challenging the theory

While Baumol's theory is really fascinating and has been validated by many empirical tests (see for instance Nordhaus, 2006) we like to challenge it in the following way: Baumol explains that the difference between the progressive and the non progressive parts of the economy is essentially due to what he calls the "technology structure": in the progressive sectors, labor is an input, which is subject to rationalization

[2] - Technical knowledge involves in this case the broad set of both embodied and disembodied knowledge that enable the development of pedagogical practices and instructional technologies.

and optimization; the essence of technical progress is labour saving. In the non progressive sector, the labour is itself the product and cannot be reduced through rationalization strategies and technical progress. As Baumol said: "*Mozart cannot be played quicker and you cannot reduce the number of actors necessary for a performance of Henry IV.*" In this sector (live performance arts), there is some room for improvements in productivity (for example the jet has increased the productivity per man hour of a Symphonic Orchestra) but that area is narrow and highly limited because labour is indeed the end product; the labour component is irreducible[3].

Our challenge to the theory is that the educational sector (as well as some other non progressive sectors) does not fall exactly into the category of live performance arts although they are known and qualified as non progressive.

Live performance arts is an *intrinsically* non progressive sector: limits to productivity are inherent; they are inscribed in the very code of the activity; what makes its essence (you can't play Mozart quicker)

Education or health are of a different kind: they are *structurally* non progressive: there is no intrinsic limits to productivity but serious structural problems regarding the modes of production, development and dissemination of the technologies and technical knowledge. Nothing in the « code » tells the teacher that she must teach 40 hours of geography to 10 years old pupils. To take another example, nothing in the « code » tells the chef that he needs one hour of cooking time to make a *soufflé* . These are written in recipes which provide instructions given a certain state of knowledge advances. The difficulties to advance technical knowledge in order to perform tasks in a more efficient way are at the core of the structurally non progressive sectors.

Following this argument, it seems useful to make a difference between the *intrinsically* non progressive sectors and the *structurally* non progressive sectors. Novel ways of conceptualize the dynamics of industries are only useful if they open the way to new insights. In this case, it becomes clear that the Baumol's disease can be cured under certain conditions (the *structurally* non progressive sectors). In such cases, the problem is twofold: what are the predisposing structural conditions of a progressive sector; can these conditions be met in the sector under consideration.

The fact that some non progressive sectors are *structurally* non progressive (and not inherently non progressive) means that the line

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[3] -Baumol identifies also the so called "asymptotically stagnant" sectors which combine both a technologically sophisticated component and an irreducible labor intensive component, such as TV broadcasting

which divides the two parts of the economy is not fixed once for all and the historical process of growth involves non progressive sectors that change and transform their knowledge processes so that they become progressive. Sometimes this process is obvious because the progress of technologies is obvious and so there are not so much other alternatives for people, organizations, individuals to join the new "epistemic culture" which provides a more efficient methodology to advance knowledge about practices[4].

In some other cases, it is hard because the new epistemic culture is not so obvious and alternative epistemic cultures and communities survive by offering "competitive" alternatives.

The case of medicine is an interesting one since this sector profoundly transformed its knowledge base to become an "evidence-based" discipline. In his recent book of memory, M.Tubiana (2007) describes this evolution: « *Of course, in 1948, the tools of the evidence-based medicine were not so effective, but the concept was there, full of promise. I came back to France with a lot of hope. Medical practices did look for me as a series of recipes badly interlinked, while not drawing on the extraordinary growth of physiology and biochemistry. French and Wiener medicines were essentially based on discussions at the sik person's bedside… each doctor treated his/her patients according to inspiration and intuition. Of course some of them achieved remarkable results because of their intuition and experience. But the general level was alarming … However, in 1950, the avenues of progress appeared clearly: to transform medicine into an evidence-based discipline. Every patient should be considered as a source information and the conditions were to build robust diagnosis and to keep track of every patient to collect, accumulate and agregate data. It was then necessary to group patients into homogeneous series in order to find why reactions to the same treatment were different…We learned to codify examinations and treatments. Such evolution did occur in a few decades and involved some controversies; but with no convulsion since* ***the power of modern methodologies shorten and reduce the length of debates*** *».*

Tubiana' s recollection of these events show very well how the sector experienced profound changes in the way the practical knowledge and know how of doctors were developed and used.

Another case of sector which is falling recently into the progressive part of the economy involves a set of business services which have experienced an acceleration of labor productivity growth after 1995 (Triplett and Bosworth, 2003). The adoption and use of information technologies create

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[4] - The methodology a community adopts to determine best practice within its domain will reflect its dominant epistemic culture. An epistemic culture can thus be defined as a means of identifying best practice.

dynamic feedbacks such as the development of new practices of human resources management, knowledge management and codification, and service engineering so that information technology capital deepening coupled with organizational capital played a major role in the productivity growth in this sector (ibid).

III - Structural problems in advancing knowledge in the education sector

We started this paper with the famous quotation of Nelson about the fact that technical knowledge is advancing at very different rates across sectors.

One obvious explanation is about resource allocation and the failure of mechanisms that would otherwise properly gauge the intensity of efforts to improve something. For example pharmaceutical companies respond to large markets demand for new drugs to treat hypertension rather than investing in R&D to improve availability of drugs for the victims of malaria; a disease which primarily affects poor countries in which there is almost no market for drugs. So the intensity of demand generates price signals that stimulate profit-motivated efforts to satisfy some wants. But differences in effective demand or market incentives account for only a small portion of the uneven evolution of technical knowledge. In this section we will turn to some structural factors related to the way new technical knowledge is produced, developed (translated into useful innovation), disseminated and effectively used in the educational sector.

A difficult science and a poor link to practices

The main problem points out the difficulty to develop a science which can illuminate practices and provide guidance to their systematic improvement. Formal R&D is of secondary importance both for the training of people and for the generation of useful innovation. What Nelson and Murnane wrote more than 20 years ago on education is still by and large true: educational R&D is very weak in producing practical solutions: « *R&D should not be viewed as creating 'programs that work'; it only provides tidy new technologies to schools and teachers. It is thus a mistake to think of educational R&D in the same way as industrial R&D* » (Murnane and Nelson, 1984). Educational R&D generates too rarely knowledge of immediate value for solving problems and developing applications. There will of course continue to be contributions from social science theory to education. However, the goal of this kind of research is not to provide and develop a repertoire of reliable practices and tools to solve immediate problems that teachers meet daily in their professional life: « *For novice teachers, practical problems in classrooms are not usually perceived to be solvable by drawing upon the psychology of education or child development, that have been studied in universities* » (Foray and Hargreaves, 2003).

This problem of a very weak link between science and the improvement of practices is crucial since it influences both the supply of and the demand for research; and this creates a fundamental inertia in the system caused by the negative externalities which exist between a weak supply and an insufficient demand.

There are three factors explaining the poor role of science as illuminating practices in education:

- On the supply side, educational sciences are just very hard to do. Berliner (2007) wrote about educational research as the hardest science: "*we do our science under conditions that physical scientists would find intolerable"*. Compared to designing a bridge, the science to help change schools and classrooms is harder to do because context cannot be controlled and inherent lack of generalizability across contexts reduces the value of any research method to illuminate a body of practices.[5] There is indeed an educational science but nothing like an applied science or engineering discipline to develop body of knowledge and techniques that illuminates educational practices.

- On the demand side, most practitioners who are (or should be) involved in the improvement of practices do not believe that the educational problems they are facing in the course of their professional life can be solved by inquiry, by evidence and by science (Elmore, 2002). They do not believe for example that it is necessary to have a developmental theory of how students learn the content and how the pedagogy relates to the development of knowledge and content. Weak incentives for teachers to use research are rooted in deep cultural norm; that teaching is an individual trait: the foundation of the performance involves natural quality, inspiration, talent and not a set of competences acquired over the course of a career (Elmore, 2002). Because of this cultural norm, it is very difficult to make a case for knowledge management, building data bases about evidence on "what works and encouraging teachers to behave as engineers by searching for solutions to problems in cases book.« *Teachers are primarily artisans, working alone in a personally designed environment where they develop most of their skills by trial-and-error tinkering..In short, they learn to tinker, searching pragmatically for acceptable solutions to problems their 'clients' present* » (Foray and Hargreaves, 2003).

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[5] - See the special issue of EINT (Foray, Murnane and Nelson, 2007) about the comparison between educational research and research in the biomedical area.

- Finally, there is a general deficiency of incentives to codify technical knowledge and know how and the resources allocated to codification are weak. Numerous practices remain tacit; not explicated and not articulated, invisible and difficult to transfer. "*There is no more in education than a weak equivalent in the field of pedagogical knowledge to the systematic recording and widespread use of cases found in surgery or law and the physical models in engineering and architectural practice. Such records coupled with comments and critiques of experts allow new generation to pick up where earlier ones left off*" (Foray and Hargreaves, 2003). Some important mechanisms to support the cumulative nature of knowledge and its progressivity and to materialize the potential for spillovers are simply missing. *« The beginner in teaching must start afresh, uninformed about prior solutions and alternative approaches to recurring practical problems. What student teachers learn about teaching is intuitive and imitative rather than explicit and analytical » (ibid.)*

When excessive stocks of knowledge are left in tacit forms, this makes them more costly to locate, to appraise and to transfer. A result may be excessive insularity and waste of resources resulting in the underuse of existing stock of knowledge. This may therefore create private and social inefficiencies.

From knowledge deficit to social inefficiencies

To put it in Nelson's words, the key of success in advancing technical knowledge has been the designing of practice around what is known scientifically. For various reasons, this key is not operating well in education.

As a result, policy makers, industries and the society as a whole are asking schools to make improvements in the presence of an extremely weak technical core. "*Consider what would happen if you were on an airplane and the pilot came on the intercom as you were starting your descent and said, "I've always wanted to try this without the flaps". Or if your surgeon said to you in your pre-surgical conference, "you know, I'd really like to do this way I originally learned how to do it in 1978". Would you be a willing participant in this? People get sued for doing that in the "real" professions, where the absence of a strong technical core of knowledge and discourse about what effective practice is carries a high price"* (Elmore, 2002).

The problem is not so much about the lack of incentives for schools and managers to improve educational practices and technologies; these incentives are there, probably less powerful than in other sectors but pressure for performance of schools, which are channeled trough higher standards and accountability, is increasing and create thereby such incentives. But the problem rather lies in the way practitioners, teachers and administrators try to respond to these incentives and pressures. The problem lies in the failure to translate such pressures into improved practices and instructional know how and technologies. Practitioners do not try to improve practices by relying on a strong technical core of knowledge that should be available in case books and data bases. Instead, they respond to the increased accountability by changing structures; but changing structure does not change practices (Elmore, 2002): that is the big problem with the usual approaches to school improvement. People and schools put an enormous amount of energy in changing structures and usually leave instructional practice (innovation) untouched. People are viscerally and instinctively inclined to move the boxes around on the organizational chart, to fiddle with the schedule. People are attracted to these things largely because they are visible and easier to do than to make the hard changes, which are instructional practice.

IV - A small explosion?

Now only a short look at patent data provides us with a slightly different view of innovation in this sector. Looking at the IPC subclass G09B in PATSTAT, it becomes clear that patent applications have increased dramatically from the early nineties in the domain of educational and teaching technologies[6]. Not only this growth is animated by very large and diversified companies in electronics, computers or multimedia but we can see also the formation of a population of small firms which are specialized in the development of technological solutions to educational problems and issues. Clearly this trend involves a logic of "co-invention of applications" which is generated and animated by the general dynamic of ICTs as a general purpose technology (GPT)

ICTs and the development of educational technologies

The new ICTs are clearly a source of innovation in educational system: ICTs offer potentially a wide range of new tools and instruments to profoundly change the technological, organizational and institutional

[6] - In the present study we consider educational and teaching related technologies as any patent filed under the G09B IPC subclass. This subclass is defined as *Educational or demonstration appliances; appliances for teaching, or communicating with, the blind, deaf or mute; models; planetaria; globes; maps; diagrams*. This subclass covers simulators regarded as teaching or training devices, which is the case if they give perceptible sensations having a likeness to the sensations a student would experience in reality in response to actions taken by him; models of buildings, installations, or the like. But it does not includes simulators which merely demonstrate or illustrate the function of an apparatus or of a system by means involving computing, and therefore cannot be regarded as teaching or training devices; components of simulators, if identical with real devices or machines.

foundations of the sector considered. In this case, the development of ICTs provides opportunities to enlarge the repertoire of instructional technologies. The so-called process of co-invention of applications is not a minor matter since it is the process by which the technology diffuses across a wide range of sectors and specific applications are generated. Case studies reported in CERI (2004) illustrate that the application of ICT in education is not a single innovation, but an array of technologies that can be applied in a variety of ways. ICTs are viewed, also, as enabler of change. The case studies show that schools engage in a series of activities which could not have been done without ICT.

A look at the data

As depicted in Figure 1, it becomes clear that patent applications have increased dramatically from the early nineties in the domain of educational and teaching technologies. Also a positive trend is found for these technologies share of the total production of technologies, which shows that this traditional sector is growing faster in technological terms than the average.

-- INSERT Figure 1 ABOUT HERE --

To understand what is behind this growth, we propose to analyze in depth the available patent data by applying new methodologies. First, to avoid the typical problems of double counting and home biases, we reduce our universe of analysis to only Triadic patent families. Second, we automatically retrieve and consolidate the main applicants by following a similar approach to Raffo and Lhuillery (2009). Last, we screen manually the resulting dataset to increase the quality of the process.

The results prove that an industry is being constituted. The amount of firms producing technologies related to education and teaching – regardless the threshold imposed – has been doubled after a decade since the mid-nineties (Figure 2 a).

During most of the nineties, around 30% of this growth – although with some volatility – was explained by new firms in technological terms (Figure 2 b). This includes brand new firms but also those firms which may be operating in the educational (or other) market but have not yet created any technology. But recently the proportion of new firms has decreased and seems stabilized around one quarter of the gross entry to the educational market. This may suggest that existing (and already technologically active) firms have more and more noticed this technological opportunity and have increasingly allocated resources in to it. A confirmation of this recent trend may imply that this new education industry is transforming from a *creative destruction* pattern to a *creative accumulation* one, in Breschi et al (2000) terms.

-- INSERT Figure 2 ABOUT HERE --

A closer look on the main firms in terms of their educational related technological portfolio shows that more and more the constitution of this industry is now animated by very large and diversified companies. If we observe their core business[7], we can characterize these large companies in four main groupings.

A big deal of them, such as Panasonic, Philips, Sony, Hitachi, Siemens, IBM, Yamaha, Texas Instruments, Canon, Casio, NEC or General Electric, have a wide business scope in electronics, engineering and multimedia. There is no much surprise here. These firms are strong R&D investors in a large range of ICT related areas which are definitely benefiting from scope economies and internal spillovers in order to create educational applications from their already mastered 'generic' technologies.

A second group is constituted by many big companies from the automotive industry, including parts, like Aisin, Honda, Robert Bosch, Toyota, Mitsubishi or Nissan. This group seems far away from its technological field. Nevertheless it gathers more sense when considering the next group, which includes firms like Pioneer, Navteq, Xanavi Informatics, Increment P, Alpine Electronics or Visteon Global. These firms are specialized in DVD, audio and navigation systems mainly for the automotive industry. Hence, this latter grouping somehow implies an intersecting niche between the first two groupings which relies strongly on the development of technologies related to enhancing the user experience and interaction with multimedia and navigation devices. Not surprisingly, these companies have a high share (more than 50%) of their patent portfolio related to educational and teaching technologies. It is clear that the Automobile industry firms from the second group are stakeholders on the future of such technologies.

The remaining main group includes firms from the software and entertainment industry such as Konami, Sega and Microsoft. This group also relies heavily on the development of technologies related to the user experience. During the past decade, firms from the game industry have been adapting their technologies to increase their market in both age tails and also trying to explicit their educational properties. These firms, particularly in the videogame industry, have also an important share of

[7] - This is not an easy task as these are mainly very large holdings of quite diversified companies.

their patent portfolio related to educational technologies, although in a much less extent than the previous group.

-- INSERT Figure 3 ABOUT HERE --

These large and diversified companies are dominating the education industry – in technological terms – since the late nineties. All of them but one have reached the top50 in terms of educational and teaching technologies by the year 2000, while Pioneer, Aisin, Panasonic, Philips, Sony, Robert Bosch, Hitachi and Xanavi Informatics are stable in the top10 since 1998. The stability of the main players in the education industry is depicted in Figure 3 (a) by testing the rank correlation of each with respect to the 2004 standings. This also goes along with the idea of a Schumpeter Mark II phase of *creative accumulation*.

But this growth is not only explained by these large international companies, as we can see also the formation of a population of small firms which are specialized in the development of technological solutions to educational problems and issues. This is apparent by the entrance of new firms (Figure 2 b), but also in the declining (technological) concentration evidenced by different indicators. On Figure 3 (b) we can observe that the concentration – expressed by both technological shares held by the top 4 and by the top 10 firms – has been steeply declining over the past two decades. The inverse Herfindahl-Hirschman Index (HHI) furnishes a similar picture, showing that the technological concentration has been reduced from around thirty to sixty "ideal" firms. Furthermore, all three indicators suggest that this evidenced deconcentration might be slowing down or, if we consider the HHI, even regressing. If this trend is confirmed, we have again another symptom of the end of 'widening' phase of the educational industry and the beginning of the 'deepening' phase.

In any case, these preliminary results point without a doubt to the appearance and consolidation of a educational and teaching related industry with strong roots on new technologies. This industry seems to receive its main actors from the 'traditional' ICT players, but also from other industries like the Automobile and the Entertainment ones.

An open question mark rests on the production of technologies by the educational actors themselves. Even if still with a little impact on the absolute numbers, universities and public institutions seem not to be completely inactive on this domain.

Little less than fifty universities have at least one (triadic) patent on an educational related technology, Among them there are the universities of Saga, Johns Hopkins, MIT, California, Florida, Goeteborg and East Carolina. Many of them are producing their technologies from (and for) their Medical schools or health departments, mainly in the form of surgical simulators. There are also initiatives from public institutions, notably in Japan, where the National Institute of Information Communication Technology, the Nagoya Industrial Science Research Institute and the National Institute of Advanced Industrial Technology are actively patenting on the educational domain.

The development of methods of pedagogy in the wake of a great GPT

In fact, the characteristics of a GPT are horizontal propagation throughout the economy and complementarity between invention and application development. Expressed in the economist's jargon, the invention of a GPT extends the frontier of invention possibilities for the whole economy, while application development changes the production function of one particular sector. The basic inventions generate new opportunities for developing applications in particular sectors. Reciprocally, application co-invention increases the size of the general technology market and improves the economic return on invention activities related to it. There are therefore dynamic feedback loops in accordance with which inventions give rise to the co-invention of applications, which in their turn increase the return on subsequent inventions. When things evolve favorably, a long term dynamic develops, consisting of large scale investments in R&D whose social and private marginal rates of return attain high levels. It is clear that the sort of renaissance of innovation in practices and methods of pedagogy and instructions is strongly associated with the dynamics of ICTs. It is however premature to claim that the education sector has reached the position today of a central user sector having the potential to significantly boost the dynamics of ICTs. Our discussion in the final section about the nature and some operational features of the market for new methods of pedagogy will provide a quite pessimistic view about the education sector as able to play an active role in these dynamic feedback loops between inventions and co-inventions of applications.

V – Discussions and directions for further research

A quite intensive innovation activity regarding the development of new methods of pedagogy and instruction technologies is observable. However the locus of this activity is not really inside the sector but on the supply side. Given our observation and discussion of the innovation deficit in "the core" of the system (the classroom), explaining partly the non progressive nature of the education sector, it is good news that a population of entrepreneurs enter and grow on the market for new pedagogical methods. However there is a need to qualify this trend. First, while an industry structure made of a population of small and specialized firms has many virtues from a dynamic efficiency point of view, it brings also some concerns. These concerns are mainly related to the increasing activity of patenting which is needed for small specialized firms to enter and compete but is likely to adversely affect static efficiency through the pricing of ideas and knowledge which were used to be freely accessible in the former period. Second, it is not clear whether the largest market for new methods of pedagogy – which is the public sector of education - will match well the business model of these hordes of entrepreneurs seeking for high economic returns on intensive R&D and frenetic innovations.

Towards a new (vertically specialized) structure: opportunities and problems

We observe the development of an industry structure populated by firms that specialize in one well specified set of activity. While innovation in methods of pedagogy continue to be dominated by large integrated firms, a population of small specialized firms is emerging and expanding. Of course in this new structure patenting and licensing play a greater role both as a cause and a consequence of the new vertically disintegrated structure. There are some reasons to believe that the new structure is likely to be more efficient than a structure where only large integrated firms would serve the markets for methods of pedagogy (Cockburn, 2003). Efficiency gains from specialization, market driven resource allocation and intensified competition are the factors which are discussed in the literature as generating efficiency gains through vertical specialization. But there are also problems.

One of these problems involves the fact that the entry and growth of an increasing number of small specialized firms seeking for high economic returns market for methods of pedagogy imply that potential users must pay now for access to methods and knowledge of the kind that used to be obtained for free but is now explicitly priced in the form of licensing agreements. In educational communities, some of the new patents are likely to generate great anxiety as practitioners realize that they are infringing patents and violating the law just by applying methods and practices that they used to apply freely since the beginning of their professional life. We know that researchers in biomedical sciences are quite good in simply "ignoring" (in the sense of failing to obey) the patents on research tools (Walsh et al., 2002). And the firms which have been granted these patents either anticipate bad appropriability of their knowledge by granting licenses on a large scale or simply tolerate infractions, especially by academic researchers. This set of norms and practices on both sides result in minimizing in a quite effective way the social inefficiencies which are potentially generated by the so-called anti-commons problem in biomedical research. It is not clear whether schools managers and teachers are in the position to have similar behaviors and what would be the strategic responses of the small specialized firms holding the patents.

For example, the US patents of Blackboard "for technology used for Internet-based education support system and method", are covering 44 different features that make up a learning management system. F.Lowney, Director of the IT management system at the Georgia College and State University Library wrote : "*Much of what Blackboard claims to have invented really came from and was freely given by the education community. Now the community is being punished through a gross lessening of competition in this market*" (Networkworld, 2008). For an Associate Professor of Medical Education, the real question is: "*What are they going to do next, try to patent word processing and charge you royalties if you are using it in a classroom? If obvious uses of technology to facilitate teaching based on standard software applications are allowed to be patented just because they are used to support education we are in real trouble*" (Inside Higher Ed, 2006). The problem with Blackboard patents and we suspect hundred of patents for educational technologies involves clearly the now usual conflict between open source communities (which are proliferating in the educational world) and for-profit business attempting to enforce their claims on some (software) patents. But a new problem arises here which is about patenting in an area where traditionally the norms of public good and free access were strongly dominant.

Another problem with the vertically disintegrated structure is about the ability of the small specialized companies to capture the benefits of their innovation. Transaction and bargaining costs on these markets for methods of pedagogy are likely to be very high; and patents as a means to capture the value of the innovation might be not so effective (depending partly about how the first problem is going to be solved). The problems of the firms considered here are rather similar as what has been described by Cockburn (2003) with regard to the tools companies in the biotechnology sector.

Is education a fine market for Schumpeterian innovators?

This is the big question. As it stands now the public sector of education is certainly not a market which would match the business models of small entrepreneurial firms seeking economic rents from an intensive activity of innovation. Beyond all the problems identified and discussed in section 2 (involving the weak incentives of managers and practitioners to solve problems and increase efficiency through an improvement of methods and practices), this market is centralized and regulated (for instance in most countries any new software-based products to learn reading or mathematics need to be evaluated by public authorities before a wide adoption within the public sector). This is also a special market in the sense that "the consumers" want not necessarily to buy every year a better product that a restless innovative activity can offer. For this new industry to be developed, the issue is, therefore, of creating a "demand side" of the technology equation. As put it clearly by Tearle (2003) who is reporting on case studies about ICT-based innovations in British schools, "*It is important to consider whether there is an inherent problem in expecting such radical change when those "in the system" are deeply embedded in an existing traditional framework of assessment and statutory requirements. This framework which has not yet been adapted or reconstructed to recognize the current of future role of ICT*".

There are current national experiments (US, Chile, UK, New Zealand) on the development of quasi-markets in education in order to foster educational innovations (Lubjenski, 2009). These experiments will be important to study and assess to see whether any greater demand for innovation is associated to such institutional changes. Will the new industry specialized in the development of new methods of pedagogy find more dynamic markets – as more countries will engage in leveraging quasi-market mechanism of choice and competition in education?

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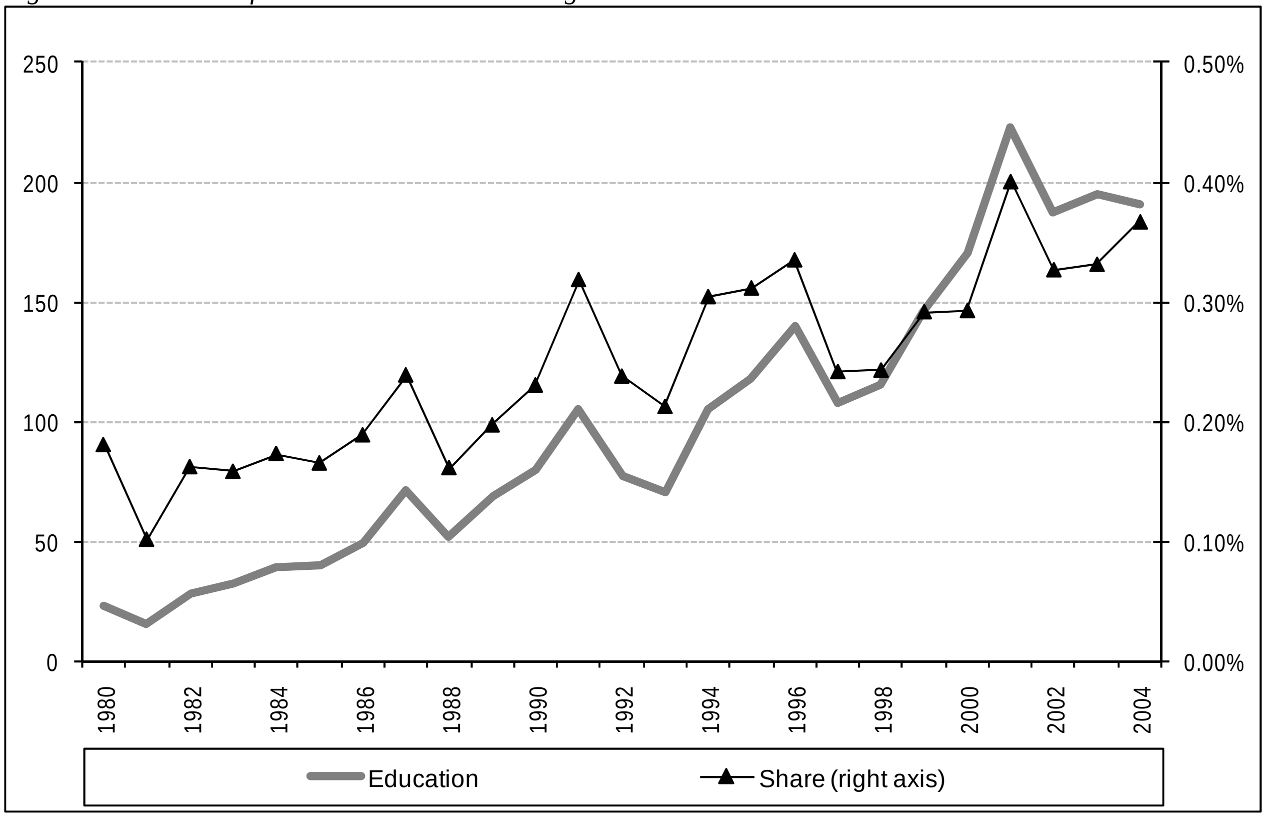
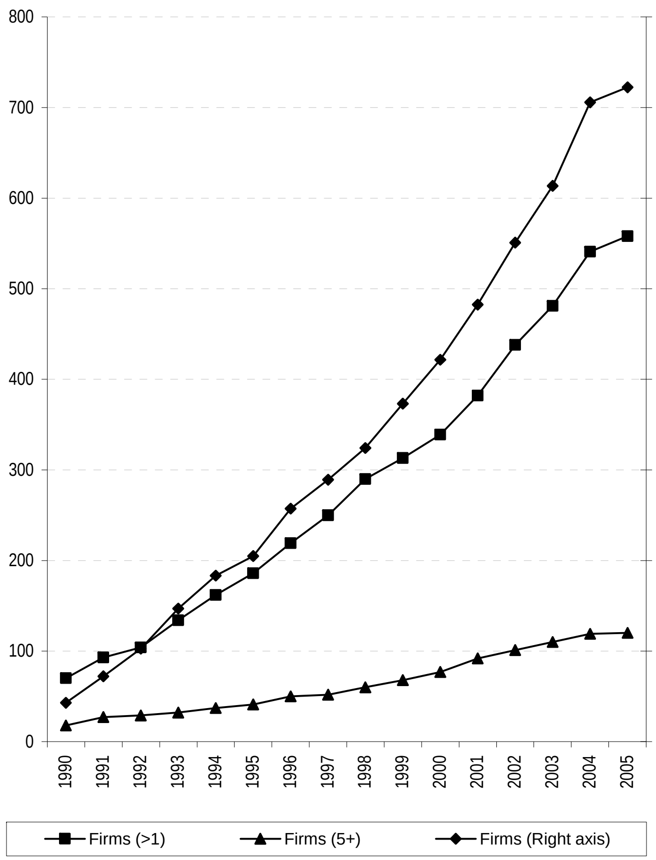
Figures

Figure 1 - Evolution of Education related technologies

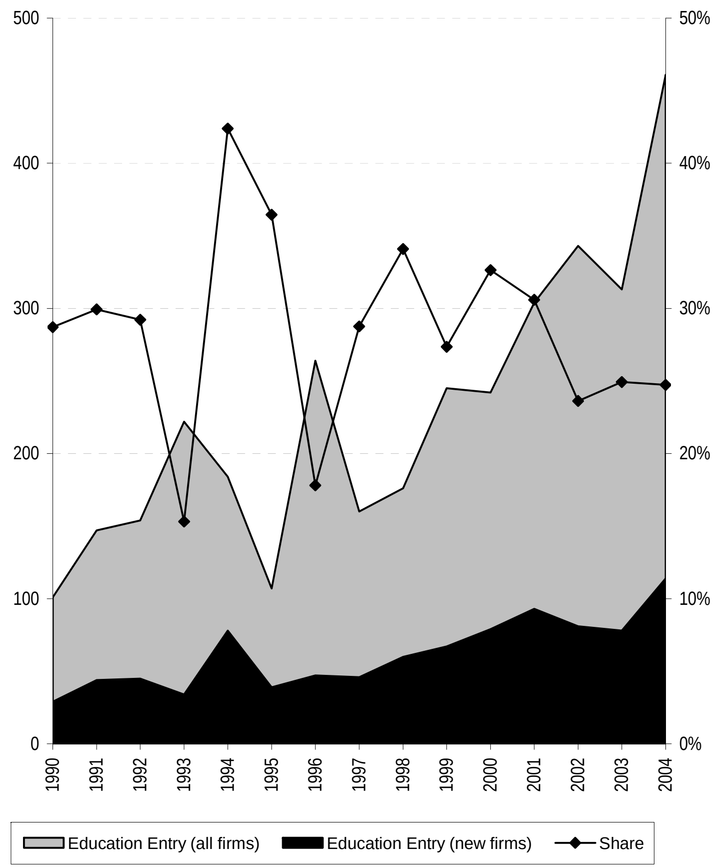


Source: PATSTAT (September 2008). Figures express Triadic patent families declaring a G09B IPC subclass.

Figure 2 – Firms producing Education related technologies (total and entry)



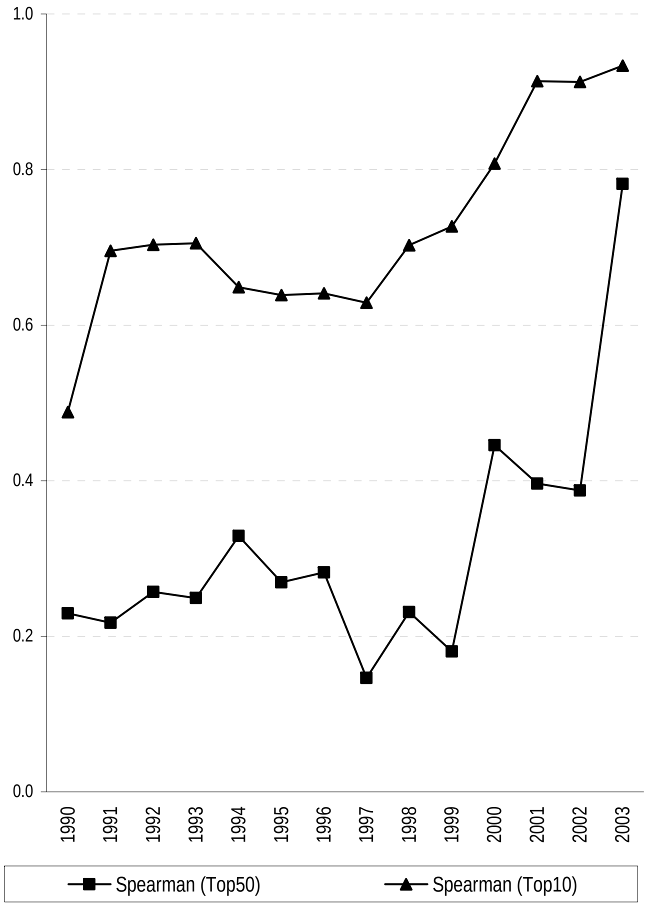
(a) Total firms



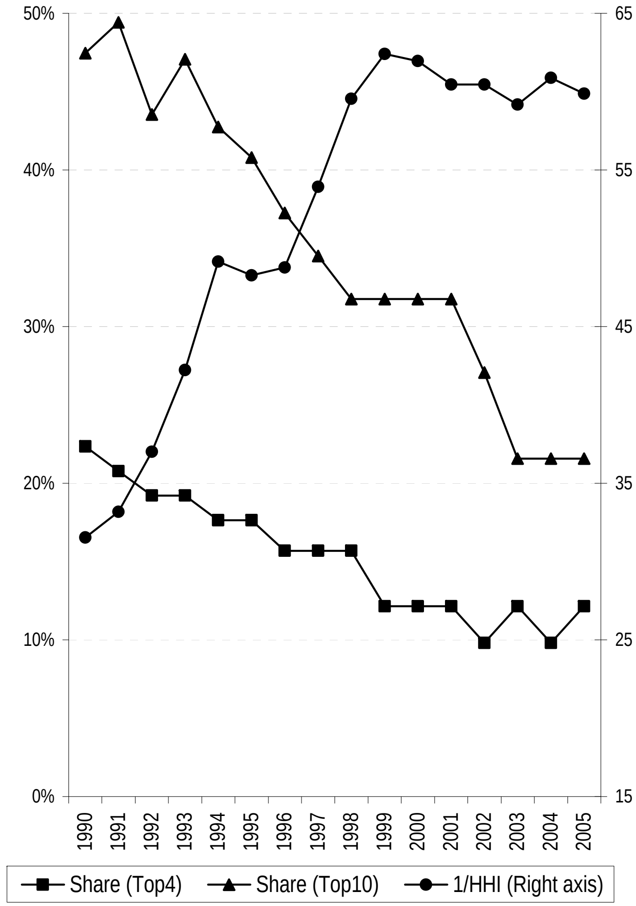
(b) Firms Entry

Source: PATSTAT (September 2008). Firm figures have been retrieved from their Triadic patent families.

Figure 3 - Firms producing Education related technologies (Rank correlation and Technological concentration)



(a) Correlation with 2004 Rank



(b) Technological concentration

Source: PATSTAT (September 2008). Figures are built from the firms' Triadic patent families portfolios.