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Blade Runner Economics
Will Innovation lead the Economic Recovery?

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ABSTRACT

Schumpeterian economics has for long associated phases of economic expansion to the introduction in the economic and social fabric of successful innovations. On the contrary, economic depressions have often been explained as the inability, or the lack of availability, of innovations. Can the economic crisis started in 2008 be explained as an inability to introduce innovations in the economic system? And, conversely, will a new stream of innovation be lead an economic recovery?

These issues are not new: after the economic crisis of the 1970s, it was repeatedly asked which innovations could lead a new development phase. In the early 1980s, contrasting views where discussed at the Science Policy Research Unit of the Sussex University: Christopher Freeman was leading those who believed that only revolutionary changes in the economic structure could lead to a long-term recovery, while Keith Pavitt stressed the importance of accumulated skills and competences to sustain economic life.

These hypotheses were tested against some of the emerging technologies of the period: nuclear energy, bio-technology and ICTs were scrutinised to assess their potential impact in terms of employment generation. After thirty years, it can be said that nuclear energy and bio-technology have not delivered (yet?) their promises, while ICTs have become much more important than expected. In particular, they have managed, as predicted by Freeman, not only to generate a successful new industry, but also to change the operation of all other industries.

These predictions were the result of an explicit model about when and how new technologies can become the driving force of economic and social development. What can does the model tell about the reality of the XXI century?

The paper presents an attempt to identify what could be the driving technologies of the next economic wave on the ground of: 1) Cost reductions in a wide range of products and services; 2) Improvement of the technical characteristics of products and services; 3) Social and political acceptability; 4) Environmental acceptability; 5) Pervasiveness in the overall economic system; 6) Emergence of new companies, often also with a distinctive managerial organization.

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I was just a boy when the fortunes of life led me to watch *Blade Runner* at the Venice Film Festival in 1982. Ridley Scott and Harrison Ford were there, but I was impressed and fascinated by the fantasy of new technologies much more than by the celebrities in the theatre. The devices and innovations that stricken my imagination comprised:

Electronics. Battery operated electronic tills in street kiosks. Televisions operated by voice commands. Scanners (I do not think that the word already existed in 1982) that could in an instant enlarge photos by several times.

Biotechnology. Artificial animals (snakes, owls). Artificial body parts (human eyes). Living toys (dolls, puppets and tin soldiers). And, of course, the very hero of the film itself, the Replicant, the artificial human that could be detected as such only after a rather complex psychological / oculist test.

Less impressive technologies. Many prospective technologies presented in the film, such as flying vehicles, were less striking since they were already predicted as forthcoming products by previous science fictions novels and cartoons.

There were two distinctive aspects of *Blade Runner* that made it somehow unique in the science fiction landscape. The first was that it did not present a totally new society: many things were almost identical to the civilization of the 1980s. The structure of social classes depicted in *Blade Runner* is rather similar to what existed at the time of the film release, and this is by itself a fulfilled prediction since income inequality has become even greater in the last thirty years. The film provided, however, a different urban stratification of social classes: they are not distributed in different neighbourhoods but rather across floors. A sort of vertical, rather than horizontal, social stratification Lower classes are low also because they occupy the lower floors, while the upper classes are showing their highflying nature also literally, by working and living in the top floors of skyscrapers. The second characteristic is that the dominant technologies are not identified by single innovations only, but by clusters of interrelated innovations.

With retrospective wisdom, we can today identify these technologies as belonging to two main clusters: "Information and Communication Technologies" (ICTs) and "Bio-technology". In the eyes of the early 1980s, both of ICTs and Bio-tech had a potential that was still unexplored and that could lead society in uncharted waters. I insist on this point: at the time, both micro-electronics and bio-technology appeared equally revolutionary and promising.

A while ago, I watched again the film with a very privileged company, that of my children. Re-reading science fiction after many decades always provide significant insights. Novels such as *1984* and *Brave New World*, films like *Metropolis* and *2001. A Space Odyssey* force us to think about the dangers and the opportunities ahead, to meditate on when and how civilization took the right turn and when it took the wrong turn. Watching science fiction with your children is certainly one of the hardest intellectual tests: what is futuristic for you could be already outdated for them.

My kids also found the film imaginative and adventurous. But with some basic differences. On the one hand, all the innovations in the field of ICTs have become trivial: in less than 30 years, voice controlled appliances, scanners, audio-visuals and photo enlargers have become part of their daily life and with greater accuracy than what was predicted in the film. In the

middle of the adventure, one of the kids wondered: "why does he not send an email with attachment?", and the question was not that silly. *Blade Runner* underestimated the pace of change in ICTs, up to the point that it does not consider what has become the most significant innovation of the last decades, namely the web. On the other hand, none of the innovations in the field bio-technology has to the same extent changed our life. ICTs have created new companies and millions of jobs, and they have transformed the operation of traditional industries such as retailing. Bio-technologies, in spite of the massive investment in Research and Development (R&D) have not (yet?) produced the same effect.

Schumpeterian insights

The idea that certain clusters of innovations are related to phases of economic development was older than *Blade Runner*. Schumpeter and the Schumpeterian economics have for a century tried to identify stages of development as a consequence of application in the society of a combination of different technologies. According to this view, each historical period is dominated by the intensive and extensive use of specific production technologies. These technologies may be fostered or hampered by institutions and social beliefs, and this often explains why they are developed and disseminated in some parts of the world rather than in others.

Crucial to the Schumpeterian insight is that innovations do not have an economic impact in isolation: they become dominant because they are applied in different contexts allowing shaping and transforming original ideas and devices in each occasion. Innovations could occur in different economic areas (e.g. steam engine and textile machinery), but they are mixed and recombined in the economic and social fabric (e.g. the steam engine provides power for textile mills). When the new knowledge associated to a few emerging technologies start to be diffused in the economic life, they will generate a phase of economic expansion. New technological opportunities manage to generate new industries that did not exist before, leading to job creation and structural change. When the opportunities start to dry out, it is likely that there will be a lower rate of economic growth or even an economic crisis.

Regularities are always difficult to be recognized, but Schumpeterian economists have made an attempt to identify five phases of capitalist development, each associated to a cluster of dominant technologies. Chris Freeman and Carlota Perez have called these major phases "techno-economic paradigms" by identifying their key characteristics in terms of: i) core industries, ii) industrial organization, iii) modality to introduce innovations. Table 1 sketches the key characteristic of each of them.[2]

Why do we need these categorizations? The main purpose is to understand the distinctive technological areas of a specific epoch and to trace their evolution. Archaeologists have found it useful to classify ancient societies in Stone, Bronze and Iron Ages since the techniques associated to each of these periods can explain quite a lot about their economic, social and even cultural and political life.[3] These ages do not necessarily occur simultaneously: for example, anthropologists consider that aboriginal communities in

[2] Chris Freeman, *The Economics of Hope. Essays on Technical Change, Economic Growth and the Environment*, London, Pinter Publishers, 1992; Carlota Perez, *Technological Revolutions And Financial Capital The Dynamics of Bubbles and Golden Ages*, Cheltenham Glos, Edward Elgar, 2002.

[3] This periodization was originally suggested by the Danish archaeologist Christian Jürgensen Thomsen in 1840s and since then it has been widely applied.

Australia lived in the Stone Age until the advent of the European colonization.[4] It is sometimes said that "uncontacted tribes" in remote part of Amazonia or Australia even today live in the Stone Age.[5]

The French historian Bernard Gille has further developed these ideas by tracing the core "technical system" of each society.[6] A technical system can be identified on the ground of the core technologies used in a society and, above all, on the interconnections among various devices. This requires the development of human skills to use profitably the available techniques, which in turn generates substantial changes in the distribution of employment across the various sectors of production. Mutual interdependence guarantees the coherence and the success of the overall economic and social system.

One of the core characteristic of development is that only a few previous technologies get totally obsolete. The innovations introduced back in the first industrial revolution continues to be with us and it will be difficult to imagine our life without simple technological artefacts such as the myriad of mechanical devices that came to the fore during the Enlightenment. Of course, several products and services were replaced by superior alternatives: steam power has been substituted by the combustion engine and the combustion engine will soon be substituted by solar power. The rate of change has been even faster in communication: pigeon-post has been substituted by telegrams and telegrams by email. By looking at the techniques used, it is possible to recognize each epoch and to distinguish the areas driving change.

The capitalist system in the last three centuries has made such development faster and geographically comprehensive. Each phase can also be associated to the birth of firms with rather distinctive typologies. These companies are likely to exploit the new technological opportunities and organizational structures and become the distinctive institutions of the new phase (see last column of Table 1). Since *Blade Runner* was released, a few of these companies have become part of our daily life: Microsoft, Apple, Google and Facebook are just the most successful and visible among them. But also established companies have opened business lines to exploit new opportunities, as it has happened with IBM, a company that has been in business for more than a century and that has managed to remain big and leading-edge by progressively abandoning its hardware component to embrace the emerging software industry. This indicates that a new and growing industry can be populated both by brand new companies and by companies that have the resources and the competences to enter into the new field.

A new techno-economic paradigm is not made by large firms only. All the companies mentioned, in spite of the invaluable contribution they have provided to the coming of the information society, are not sufficient to shape our economic life: without a myriad of smaller and often unknown firms, we would not be in a society that makes such an intensive use of information. The fact that there is virtually no industry that does not make intensive use of ICTs shows the degree of pervasiveness and integration today reached in the information society.

Creative destruction or technological accumulation?

[4] http://www.aboriginalculture.com.au/introduction.shtml
[5] http://www.uncontactedtribes.org/
[6] Bertrand Gille, *Histoire des techniques*, Paris, Editions Gallimard, 1978.

To move from one techno-economic paradigm to another one is often a traumatic experience, which requires major transformation. Economists have for a long time debated the relative importance of the cumulative development of expertise on the one hand and the disruptive nature of change on the other hand. Karl Marx and Joseph Schumpeter believed major crises were intrinsic to capitalist development. Marx compared capitalism to giant Antaeus, who was able to get new energy every time he was falling down and touching earth (modern wrestlers have made us better understand Antaeus' fighting skills). He underlined that capitalism needs economic crises to reorganize its production, to demobilize capital from the industries with lower profit margins and to reinvest it in the growing industries.

Schumpeter, an economist that was a fierce opponent of Marx but also among his genuine reader,[7] also stressed the importance of disruptive change, noting that they were associated also to technological transformations. "Add successively as many mail coaches as you please, you will never get a railway thereby"[8], he noted, to make it clear that radically new products and processes could not be obtained by incremental changes only. Discontinuities were therefore needed to allow the introduction of new technologies and these were also likely to produce crises in the economic space. Some could be confined to selected firms, industries, cities, regions or nations; others were likely to have broader impact.

Schumpeter also stressed that there was not only a process of reorganization of capital, but that such a process was associated to individual agency. Schumpeter, an admirer of Nietzsche as much as of Marx, understood that changes do occur not only because there is an unanimated capital willing to grow, but because there are entrepreneurs that search and exploit new opportunities. It is out of these animal spirits, as Keynes would have labelled them, that inventions are transformed into innovations and eventually diffused up to the point that they shape economic and social life.

The problem is therefore to understand which players will be able to ripe these opportunities. In some occasions they are associated to new successful entrepreneurs: the automobile industry was shaped by Henry Ford and the electricity business by Thomas Edison. It will be for us difficult to imagine an information-based society without thinking to the rise of companies such as Microsoft, Apple, Google and Facebook and we associate them to entrepreneurs such as Bill Gates, Steve Jobs, Larry Page, Sergey Brin and Mark Zuckerman. These entrepreneurs understood earlier and better than others that the supply of information could become much larger than conceived in the past and that, in spite of the fact that its cost per unit would have dropped by many time (compare the cost of a telegram to the cost of an email), new technological opportunities were so huge that the overall market would have grown.

On other occasion established firms, which have already accumulated organizational resources, labour and capital, are the first to understand that winds are changing and to adjust to a new paradigm. If they do not manage to do that, they are likely to be locked-in their own existing market and to decline with it. If they, on the other hand, manage to use their skills and competences to explore new opportunities, they may jump into a new profitable business. Take the case of Eastman Kodak and Fuji, two companies competing on the same core

[7] Schumpeter called his mentor Eugen von Böhm-Bawerk "the Marx of the bourgeoisie". But, as noted by his pupil Sylos-Labini, he would have been pleased to get such a nick-name for himself.

[8] J.A. Schumpeter, *Theory of Economic Development*, Cambridge, MA, Harvard University Press, 1934, p. 64.

market, cameras' films.[9] The former has not managed to adjust to the digital revolution in photography, the latter has done so and, exploiting its knowledge of consumers and markets has successfully managed to jump into a new technological paradigm becoming a leader in digital technology.

Change is therefore driven not only by disruption but also by continuity. Disruption does not necessarily lead to progress or to more economic efficiency, and if it not properly managed it can lead to societal and company losses. Competences and skills are needed to upgrade production, and they are often accumulated by individuals and organizations in years and years of experiments. The model of creative destruction has be compared to creative accumulation, which assumes that individuals and organizations with the appropriate competences are better located to introduce successful changes.

Table 2 compares the characteristics of the models of creative accumulation and creative destruction. Both the models allow companies to prosper. In the creative accumulation model, large firms exploit systematically new technological opportunities as a method to maintain their market shares and to keep outsiders out of business. In the creative destruction model, major innovations are introduced by small companies that become big precisely because they have won the bet on the potential of their new products and processes. It is not difficult to find examples of innovations and innovators that belong to both the groups. Are these models equally suited to lead an economic recovery?

Who is investing in innovation after the 2008 economic crisis?

Much has been written about the origin of the economic crisis and there is not yet consensus neither on its causes nor on its consequences. According to many commentators, the crisis is generated by the fact that speculative finance went out of control. The attempt to link financial crises to over-expectations on emerging industries has not provided conclusive results.[10] In a decade, we have witnessed a financial bubble in 2001 mostly associated to the difficulty of ICTs to keep up with expectations, and an economic crisis in 2008 originated in a traditional sector such as housing.

Some commentators tend to associate it to the drying out of technological opportunities and, therefore, to the difficulty to sustain the expectations of a high and steady growth rate. On the ground of this hypothesis, there is a pessimistic view that argues that it is difficult to foresee technological opportunities comparable to those that the world economy experienced in the 1950 and 1960s, and that the rate of economic growth of these decades (the so-called golden age) is likely to be unique in history.[11] More optimistic views argue that technological opportunities are still there, and they can guarantee new jobs and new prospects, provided the economic and social systems allow their introduction and diffusion.[12]

[9] "The last Kodak moment?", *The Economist*, Jan 14th 2012.

[10] At least, according to the fascinating account of Charles Kindleberger, *Manias, Panics, and Crashes. A History of Financial Crisis*, New York, Basic Books, 1978.

[11] Robert Gordon, *Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds*, NBER Working Paper No. 18315, Cambridge, MA, August 2012. For Angus Maddison, *Dynamic Forces in Capitalist Development. A Long-Run Comparative View*, Oxford, Oxford University Press, 1991, the golden age spans from 1950 to 1973.

[12] Carlota Perez, "Unleashing a golden age after the financial collapse: Drawing lessons from history", *Environmental Innovation and Societal Transitions*, 6 (2013) 9–23.

After several years from the beginning of the economic crisis, and after a few signs of economic recovery are emerging, the core question is: if we are not prepared to expect a long steady-state economy, what will allow the world economy to grow again? And who will take the lead? These are the core issues discussed by policy makers, business leaders and the public opinion. Perhaps, economists can provide some insights.

The first way to explore this is to check the behaviour in terms of innovation of economic players. Investment in innovation is a bet on the future. Firms, governments, universities and other institutions do invest in R&D and innovation when they expect that they will be able to repay the costs through new and improved products and processes. We already know that innovation, more than other forms of investment, is an uncertain activity. Some projects may manage to introduce successful innovations that will repay several times the initial costs, while others may not succeed in generating commercially successful innovations at all. In spite of this, businessmen's willingness to invest in innovation indicates a propensity not only to bear risks, but also to playing the game. And, without playing, there will never be winners.

The research that Andrea Filippetti, Marion Frenz and I have carried out has indicated that there has been a general reduction in the willingness to invest in innovation across European enterprises as a direct consequence of the 2008 financial crisis.[13] This is hardly a surprising factor: in the middle of the credit crunch and with gloomy business opportunities, most companies try to reduce all costs, including investment. So, it is not surprising that the number of enterprises that have reduced their investment in innovation is greater than of enterprises that have increased it. Figure 1 shows that a substantial amount of enterprises have not changed their level of investment as a consequence of the economic crisis. The fact that so many companies do not change their innovative plans in an economic slump already suggests that knowledge accumulation is vital for enterprises' survival.

But, as expected, a very significant number of enterprises adapted their innovation investment to economic cycle and therefore reduced their investment. The behaviour of these enterprises may lead to the deepening of the recession: Keynesian economics has shown that a reduction of investment depresses aggregate demand, and Schumpeterian economics has indicated that a reduction of investment of innovation makes more difficult to develop new opportunities. A very small number of enterprises, however, have followed a different behaviour and have been "swimming against the stream" increasing, rather than decreasing, their effort to innovate. These enterprises are not many: less than 7 per cent of the sample. But here lies a fundamental difference between investment in general and investment for innovation in particular. While investment in general is a steady proportion of aggregate demand, investment in innovation has unpredictable and random economic effects. A few successful innovative projects may have a band-wagon effect; and generate jobs, profits and structural change that can potentially revitalize the whole economy.

Of course, these changes are not uniform across the economic space, first of all across countries. In some European countries the companies that have maintained or even increased innovative investment is greater than the companies that have reduced it. It is quite interesting to look at these countries: we find in this club those that have the higher

[13] Daniele Archibugi and Andrea Filippetti, *Innovation in Times of Crisis. Lessons and prospects from the economic downturn*, London, Routledge, 2011; Daniele Archibugi, Andrea Filippetti and Marion Frenz, "The Impact of the Economic Crisis on Innovation: Evidence from Europe", "Technological Forecasting and Social Change", 80, 7 (2013), 1247-1260; Daniele Archibugi, Andrea Filippetti and Marion Frenz, "Economic Crisis and Innovation: Is Destruction Prevailing over Accumulation?", *Research Policy*, 42, 3 (2013) 303– 314.

innovative rate and that cannot reduce it even in bad times: Sweden, Switzerland, Finland, Germany (See Figure 2). These countries cannot avoid continuing investing since they are highly specialized in areas where you innovate or perish. If they stop innovating, they may be forced to move out of business.

It would be important to compare Europe with other continents. I expect that a large national innovative system such as the USA has experienced a similar trend, with knowledge-intensive states such as California and Massachusetts maintaining their innovative investment while other weaker states reducing it. In emerging economies, including China and India, the growth of innovation-related activities has been so phenomenal that they have hardly noticed that there was an economic crisis. One of the consequences of an economic crisis is also to accelerate change across areas, and we are prepared to find out that, at the end of the economic crisis, the OECD member countries will meet more assertive and more capable emerging areas.

The survey can also provide information about the typology of innovators. Who is likely to generate new ideas and introduce innovations? In other words, who is "swim against the stream"? First of all, the enterprises that are increasing their innovative investment are not necessarily the large ones: on the contrary, it seems that size is overall reducing the likelihood that enterprises are expanding it. Second, there is a propensity of young enterprises to invest more. Third, these enterprises are mostly exploring new market opportunities. Finally, they are not competing on costs but rather on new products. Our data are not particularly robust since we have an indication of the trend but not real data on how much they are spending on innovation. But it seems that we have to expect that the recovery will be led by creative destruction more than by creative accumulation. In a period of crisis, radically new opportunities are less likely to be exploited by the incumbents, while newcomers may find the energy and the willingness to challenge not only incumbent firms but, above all, the current steady state.

We have therefore an identikit of the innovators: but where they will innovate?

Emerging business opportunities

I am not alone to wonder where the new wave will come from: business analysts invest a lot of money in exploring market and technological opportunities. Even if they often get it wrong, and sometimes very wrong, the resources they use make it difficult for scholars to compete in forecasting. There must be a reason why academics are poorer and poorer even when they get it right and business analysts are richer and richer even when they get it wrong.

One of the most detailed attempts to identify and explore new technological opportunities was released last year by the McKinsey Global Institute.[14] They have tried to identify the core technologies that have are expected to have a major impact by 2025, a bit more than a decade. The methodology chosen by McKinsey follows very closely what was already

[14] McKinsey Global Institute, *Disruptive technologies: Advances that will transform life, business and the global economy*, May 2013, at http://www.mckinsey.com/insights/business_technology/disruptive_technologies

identified by the Schumpeterian tradition and in particular by the identification of techno-economic paradigms by Freeman, Perez and Dosi.[15] The four criteria they used are:

1. Technology is rapidly advancing or experiencing breakthroughs
2. The potential scope of impact is broad
3. Significant economic value could be affected
4. Economic impact is potentially disruptive

If we look at the top six areas where there are expectations of substantial growth, we discover that they are all in the ICT area. *Mobile Internet*, *Automation of knowledge work*, *Internet of Things* and *Cloud technology* all belongs directly to the ICT cluster. Also the next two areas identified, *Advanced robotics* and *Autonomous vehicles*, formally belong to, respectively, Machinery and Transport industries, but the core innovative component is, also in this case, associated to software. The next six emerging technologies are predicted to have a lower economic impact, for example in terms of job creation, but are also associated to a larger variety of knowledge base. We find, for example, *Next-generation genomics*, the fundamental component to implement the Replicant, *Advanced materials* and issues associated to energy production and distribution such as *Energy storage*, *Renewable energy* and *Advanced oil and gas exploration*. *3D printing*, on the other hand, so heavily based on software seems to be another important extension of the information society.

If the prediction of McKinsey will prove to be accurate, it seems that the next decade will continue to be dominated by the ICT techno-economic paradigm. In other words, we could expect a consolidation and a deepening of the current paradigm rather than its integration with other core areas. But one of the key characteristics of very disruptive technologies is that they hardly knock at the door, they just enter the social and economic life changing most expectations.

Bio-technology as an emerging industry has been anticipated for many years, and not only by Ridley Scott. Already in the late 1980s, students of innovation have pointed out the potential of the industry.[16] So far, we can only say that it has not kept to its expectation, but things may change, and faster than expected. If ICTs will eventually manage to be closer integrated with bio-technology it is likely that a new and substantially different techno-economic paradigm will emerge.

My bet is that in the next decades, perhaps not in the next decade, but in twenty years' time, there will be a new fusion, similar to the integration achieved at the end of the XIX century between the electrical and chemical industry. The new fusion will therefore lead us to a much greater use of bio-technology in combination with nano-technology, often controlled by software and other ICT devices. I expect to see that quality of human life will change substantially and that the next major advances will not be associated to our ability to connect everywhere and with everybody, but to understand better how our bodies work and what are the implications for well-being.

[15] Freeman, *The Economics of Hope*, cit., Perez, *Technological Revolutions and Financial Capital*, cit., Giovanni Dosi, "Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change", *Research Policy*, 11(3) 1982: 147–162.

[16] Luigi Orsenigo, *The Emergence of Biotechnology. Institutions and Markets in Industrial Innovation*, London, Pitner Publishers, 1989.

I envisage a society in which our next portable devices will not be able to let us know instantaneously how much it will rain in our street this afternoon, how to avoid the cold that we would otherwise catch, and fix diseases. These devices may also be able to provide advice on how to avoid depression and what is the food and beverages we will need.

My forecast is therefore that, when I will watch again *Blade Runner* with my grand-children, they will be totally unimpressed by the innovations in both ICTs and Bio-technologies. And, perhaps, they will note with wiseacre attitude that the film underestimated progress by all accounts and, of course, will pet me as the think and dumb grand-father. I should be ready to have something else to impress them: today I could show the recent film *Transcendence*, by Wally Pfister, a story that has already predicted the full integration of ICTs and Bio-tech. If this will not work, I will teach them an evergreen lesson: economists, futurologists and business analysts often get it wrong. But artists, real artists, are always right.

Figure 1 - Phases of Capitalist Development and Pavitt's Categories of Firms

Period	Successive Techno-Economic Paradigms	Industrial organisation	Typical industries	Rise of Pavitt's category of firms
1770-1830	Early Mechanisation	Growing importance of small manufacturing firms	Textiles, Potteries, Machinery	Supplier dominated
1840-1880	Steam power and railway	Separation been producers of capital and consumption goods	Mechanical engineering, Steel and Coal	Specialized suppliers
1890-1930	Opportunities associated to scientific discoveries	Emergence of large firms	Chemicals, Electrical machinery, Engineering	Science based
1940-1980	Fordist and Taylorist revolutions	Oligopolistic competition for mass consumption	Automobiles, Synthetic products, Consumer durables	Scale intensive
1980-2010	Information and communicaiton	Networks of firms, strong user-produces interactions	Microelectronics, Telecoms, Software	Information intensive

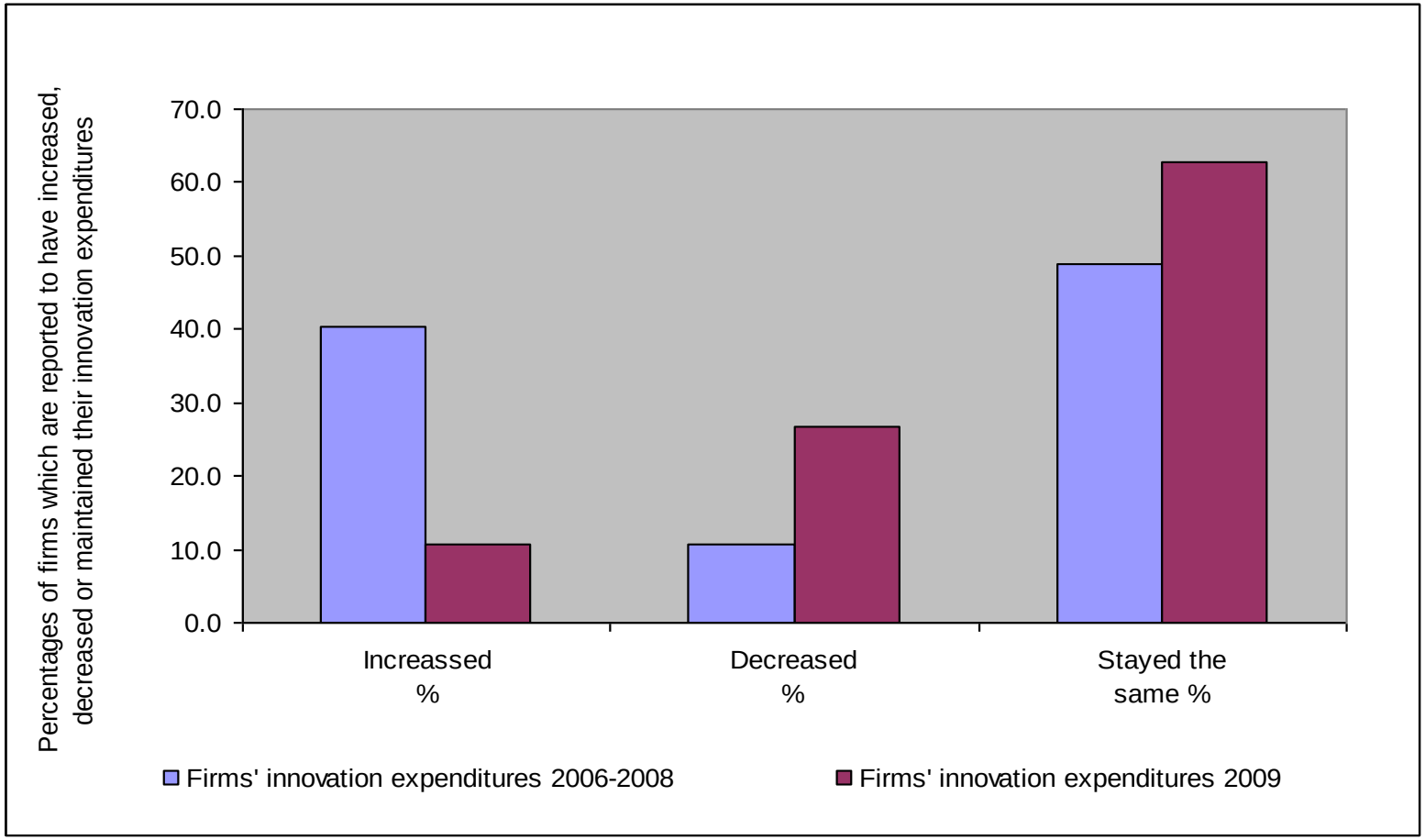
Source: Author's Elaborations on Freeman (1987), Table 15. Last column derived from Pavitt (1984).

Table 2 Innovative firms characteristics under the creative accumulation and creative destruction models

Categories	*Creative accumulation*	*Creative destruction*
Characteristics of the innovating firms	Innovations are driven by large, incumbent firms that seek new solutions through formal research exploiting their pre-existing capability.	Small firms, new entrants are the key drivers in the innovation process. They use innovation and economic turbulence to acquire market share from incumbent firms.
Type of knowledge sources	High relevance of past innovations and accumulated knowledge. Importance of formal R&D, in-house but also jointly performed or externally acquired.	Higher relevance of collaborative arrangements leaning towards the applied knowledge base (other firms). Exploration of new markets and technological opportunities.
Type of innovations	The innovation process is dominated by a large number of incremental innovations. Organizational routines dominate the generation of innovations.	The emphasis is on path-breaking innovations often able to create new industries. New organizational forms contribute to generate innovations.
Characteristics of the market	Barriers to entry are high due to relative importance of appropriation and cumulativeness of knowledge and high costs of innovation. Dominance of oligopolistic markets. Technological advancement based on path dependent and cumulative technological trajectories.	Low barriers to entry into the new industries. A high rate of entry and exit leads to low levels of concentration and high competition. Discontinuous technologies are available that generate growing markets and new opportunities.

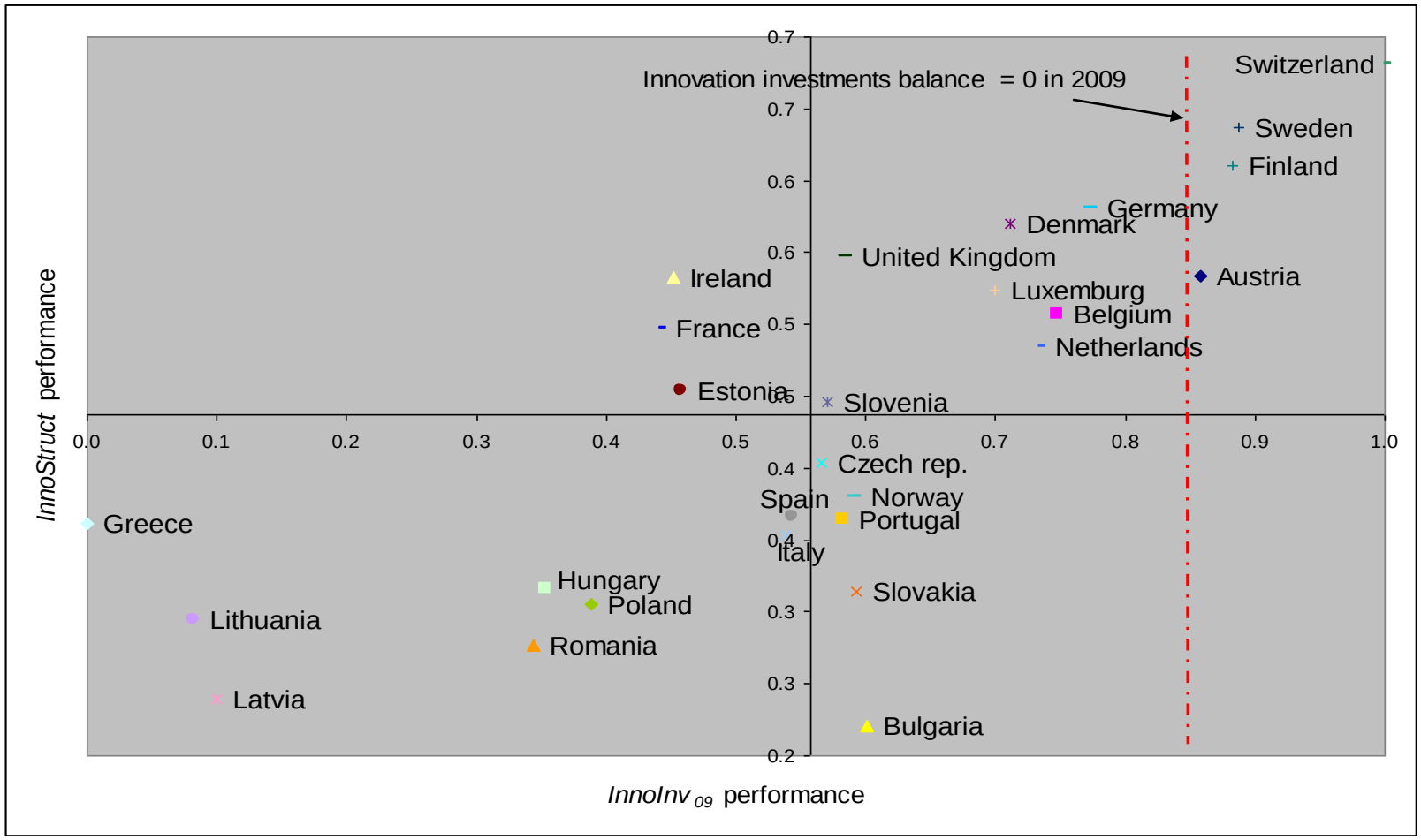
Source: Archibugi and Filippetti (2012).

Figure 1 - Firms' innovation expenditures: comparison between the three years period 2006-2008 and the first six months of 2009



Legend: Data refers to responses by a statistically significant sample of European enterprises carried out by
Source: Archibugi and Filippetti (2012).

Fig. 2 - Short-term firms' innovation performance (*InnoInv$_{09}$*), and national innovation system strength (*InnoStruct*)



Legend: Horizontal axe: Companies that are increasing innovative investment – companies that are decreasing it.
Vertical axe: European Innovation Scoreboard
Source: Archibugi and Filippetti (2012)