# Research Network on Industrial Resilience
# RENIR 1st International Workshop

*19-20 February 2018 - Collegio Carlo Alberto Torino*

Piazza Arbarello 8 - Torino

Organised by BRICK, Collegio Carlo Alberto Torino (Ita) and Munk School of Global Affairs - University of Toronto (Can)

Presentations will be in CLASSROOM 2 at the ground floor

| Feb 19th | Monday | Title |
|---|---|---|
| 10.15 | Welcome coffee | |
| **10.30** | **Welcome address - Aldo Geuna & Dan Breznitz** | |
| **11.00** | **session 1 - Chair: Warrian** | |
| **1.1** | Bottai | What Do We Measure When We Measure Regional Relatedness? |
| **1.2** | Warrian | The Dynamics of Knowledge Transfer with SME Firms in the Automotive Supply Chain |
| **1.3** | Geuna - Miletto - Patrucco, Enrietti and Nava | The evolution of the Italian Aeronautic industry: 1908-2016 |
| **1.4** | Geuna, Patrucco, Enrietti and Nava | The birth and development of Italian automotive industry (1894-2015) and the Turin car cluster: Marshall and Klepper revisited |
| 13.00 | buffet lunch | |
| **14.00** | **session 2 - Chair: Patrucco** | |
| **2.1** | Nuccio, Patrucco and Nava | Industrial structure and regional competitiveness in post-2008 Italian regions |
| **2.2** | Goracinova and Wolfe | Regional Resilience and Ontario's Automotive Cluster: It's Future in the Digital Age |
| **2.3** | Breznitz and Conserva | Innovative Over Time: Reinvention, Rebirth, or Stagnation |
| 16.00 | coffee break | |
| **16.30** | **session 3 - Chair: Neirotti** | |
| **3.1** | Helper, Martins and Seamans | Value Migration and Industry 4.0: Theory, Field Evidence, and Propositions |
| **3.2** | Guerzoni, Geuna, Colombelli, Cappelli | Topic modelling of technological patents: where are the robots? |
| **3.3** | Cappelli, Montobbio and Morrison | The crisis and regional unemployment in Europe: resilience and the role of technological capital |
| 20.30 | social dinner<br>*Restaurant: LA VIA DEL SALE (The Salt Road)*<br>*via S. Francesco da Paola 2 - Torino* | |

| Feb 20th | Tuesday | Title |
|---|---|---|
| **9.15** | **session 4 - Chair: Rutherford** | |
| **4.1** | Musso | Work organization and industrial relations in the history of Fiat |
| **4.2** | Neirotti and Paolucci | Rediscovering lean manufacturing capabilities through their microfoundations: An analysis of the world class manufacturing program at FCA |
| **4.3** | Rutherford and Frangi | Employment relations, regional resilience and high performance work systems in Canadian automotive assembly plants |
| 11.15 | coffee break | |
| **11.30** | **session 5 - Chair: Bottai** | |
| **5.1** | Bottai and Nava | Urban Scaling: A Panel Data Approach |
| **5.2** | Geuna, Guerzoni and Nuccio | Productivity and manufacturing in Piemonte and Northern Italy |
| **5.3** | Neirotti, Paolucci and Pesce | Skill-biased technological change at the rise of a new technological paradigm: an industry-level perspective on the effect of ICT investments in Italy |
| 13.30 | buffet lunch | |
| **15.00** | **Innovation Economics Seminar Series** | |
| | Stefano Breschi (Bocconi University) and discussants | The Effect of Knowledge and Social Interdependencies on Inventor Outward Mobility |
| **17.30** | National Automotive Museum | |

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| | | D. Wolfe | |
| 4 | Employment relations, regional resilience and high performance work systems in Canadian automotive assembly plants | T. Rutherford | trutherf@maxwell.syr.edu |
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| 5 | Innovative Over Time: Reinvention, Rebirth, or Stagnation | D. Breznitz | dan.breznitz@utoronto.ca |
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| 12 | What Do We Measure When We Measure Regional Relatedness? | Bottai C. | carlo.bottai@unito.it |
| 13 | Topic modelling of technological patents: where are the robots? | Guerzoni M. | marco.guerzoni@unito.it |
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| 16 | Urban Scaling: A Panel Data Approach | C. Bottai | carlo.bottai@unito.it |
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**Peter Warrian**
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***The Dynamics of Knowledge Transfer with SME Firms in the Automotive Supply Chain***

FULL PAPER SUBMITTED

The divestment of auto parts production from OEMs was a major structural shift in the automotive industry. The cumulative impact has been to make the supply chain the major site of value added and innovation. In addition, the impact of enhanced environmental and safety regulations has resulted in "lightweighting" becoming the predominant driver in technological innovation in automotive manufacturing. The latter is a qualitative change where the mastery of microstructural manufacturing capability becomes a fault line between expanding margins and a downward spiral of cost-competitive competition. The technical merging of design and manufacturing changes what engineers do in the auto supply chain. (Smitka & Warrian 2016; Helper & Lau 2016).

A mature automotive region like Ontario faces unique challenges. Its supply chain firms, particularly SMEs, tend of be in the lower end of the value chain and weakly represented in leading edge technologies like electronics and material science. The engineering culture of even the leading firms like Magna and Linamar, were built by their founders with an exclusive focus in identifying micro-efficiencies in parts production. This remains the DNA of the technical culture of the firms. It is inherently resistant to disruptive technological change and the macro-efficiency opportunities of the materials science revolution. When looking for positive examples elsewhere, Ontario faces the dilemma that all mature automotive regions confront: tightly integrated innovation systems like Baden Wurttemberg or the Midlands are much more successful but they face 'lock-in' issues that entrenches incrementalism. More de-centralized systems like the North American Automotive Alley, may be more open to radical technological change but are heavily dependent on the disparate capacities of SME firms.

**Elena Goracinova and David A. Wolfe**
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***Regional Resilience and Ontario's Automotive Cluster: It's Future in the Digital Age***

FULL PAPER SUBMITTED

The paper argues that the strength of Ontario's regional innovation system (RIS) and growing OEM R&D investments provide expanding opportunities for the cluster to remain competitive either by: 1) firms upgrading or moving up the value chain by strengthening skills and production capabilities; or 2) modernizing on the basis of connected or electric vehicle technologies or organizational innovations.
The focus of the study are the efforts on the part of OEMs and current federal and provincial policies in the form of technology push initiatives, the goal of which is to intensify regional knowledge linkages, although it is not yet clear whether they will be able to help existing suppliers upgrade their operations, or whether new industrial fields will be positively locked-in and continue to grow. However, the willingness of OEMs to connect with the Canadian start-up scene and the resilience of established automotive suppliers indicate the potential for the emergence of a revitalized and innovative automotive ecosystem.
The paper begins with a discussion of the evolutionary economic geography literature on new path creation and identifies potential trajectories for the automotive cluster given Ontario's regional innovation system. It continues with an investigation of the initiatives targeting both OEMs and the supply chain and ends with a discussion of the possible trajectory for the future development of the region's automotive cluster.

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and
**Lorenzo Frangi**, Département d'organisation et ressources humaines Université du Québec à Montréal, Québec, Canada

***Employment relations, regional resilience and high performance work systems in Canadian automotive assembly plants***

In this paper we will present some initial results of an ongoing research project investigating the adoption of High Performance Work Systems (HPWS) in Canadian automotive assembly plants in Southern Ontario. The paper take its point of theoretical point of departure from the growing attention to human resources or talent in both the resiliency and economic geography literature (see Florida 2012; Crescenzi et al, 2016). We argue that (i) these approaches need to pay greater attention to the role played by more workplace focused incremental and process forms of innovation and (ii) more fully recognize how innovation can also be driven by employees and their representatives such as unions (Roha, 2010). Our study shows that HPWS adoption is both uneven and contradictory. It is uneven because firms prioritize different goals when implementing HPWS and it is contradictory because they seek to both intensify work, yet also engage employees individually and collectively, in order to increase innovation (see also Neirotti, 2016). In some Canadian plants, unions have adopted a critical role in attempting to mitigate such contradictions by (i) holding management 'to account' --that is by making sure firms actually live up to their commitments to employees when adopting HPWS, such as for better ergonomic design, (ii) by pushing back against increasing work intensity which compromises employee engagement in work process innovation and (iii) by fighting against the adoption of two-tier employment systems which increase divisions within workforces and reduces team work cohesion. In some plants this process has also led to alliances between unions and higher managers seeking to implement HPWS systems, against middle managers who view such systems as threat to their role. We conclude by arguing that (i) contrary to those positing a commoditization and convergence of work organization in the auto assembly industry (Mordue and Sweeney, 2017), HPWS adoption is significantly influenced by plant level employment relations and (ii) the latter that can play a significant role not only in innovation, but also in influencing regional resilience.

**Dan Breznitz** and **Nicolas Conserva**
Munk School of Global Affairs

***Innovative Over Time? The Reinvention, Rebirth, or Stagnation of Regions***

This paper aims to explain how highly innovative locales can stay innovative over time. Broadly speaking, there are two modes by which this can be achieved. First, regions can continuously innovate within the same sectors, such as automobiles or ICT. We define this mode of long-term innovation rebirth, since the regions' success is based in its ability to birth new life into the same sectors. A second way for a locale to stay innovative is to move to new industries. Here a region specialized in a specific industry, say mining, that faces decline, re-invents itself by becoming a hotbed for nanotechnology. Overtime, a failure to do either will result in regional stagnation and decline.

Scholars of regional economies have studied how locales gain and lose their innovative edge, but it is generally unclear how socio-political-economic structures (SPEs) support processes of rebirth and re-invention, or lead to stagnation. In particular, it is unclear why similar regions that have managed to become globally innovative across a variety of industries take diverging paths. The fact that those regions have become highly innovative across multiple industries should already endow them with the same SPEs that are supposedly needed to sustain continuous innovation. Yet, not every region that is innovative at one point in time manages to remain equally innovative in the long run.

Therefore, we utilize a critical (extreme) case research design to compare three regions that were globally innovative in the beginning of the 20th century, but have since followed diverse trajectories: Turin in Italy, and Boston and Cleveland in the United States. We adopt a long-term perspective that starts from the 1850s until 2015. Notwithstanding significant crises faced throughout this period, Boston is an almost ideal-type of a locale utilizing the reinvention route from textile, to steel, plastic, ICT, and biotech. Turin is currently experiencing rebirth. However, Cleveland, arguably the most innovative region of the three in the beginning of the 20th century with the most sophisticated formal and informal SPEs, started down a path of stagnation that has been continuous for the last sixty years.

Our working theory affirms that remaining innovative over time depends on how SPEs distribute resources across different industries, as well as on how SPEs regulate the shift of resources from a declining sector to a growing one. The question is, therefore, what allows these SPEs to stay effective in some cases, while destroying them in others. Our current, tentative hypothesis is that the emergence of an over-dominant group of actors may alter the SPE structure in a way that prevents the shift of resources from a declining sector, thus causing stagnation.

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***Value Migration and Industry 4.0: Theory, Field Evidence, and Propositions***

FULL PAPER SUBMITTED

Our paper offers several predictions about how Industry 4.0—the coordinated use of robots, sensors, AI, and other digitally-enabled technologies in manufacturing—will affect which firms and occupations capture value in manufacturing. We develop our insights using in-depth interviews with manufacturers that are part of the automotive value chain, including parts suppliers and automakers, and with integrators who provide robotics and other advanced automation to manufacturers. Among other findings, we highlight that value migration within firms likely affects whether and how value migration occurs across firms.

**Cappelli Riccardo**
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**Montobbio Fabio**
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*The crisis and regional unemployment in Europe: resilience and the role of technological capital*

It is well recognized that technological capital has a pivotal role in explaining economic growth of regions (Fagerberg, 1994). However, relatively scarce are research papers addressing the role of technological capital on economic fluctuations like the recent economic crisis. We try to fill this gap in the literature through descriptive and econometric analysis for 248 regions of 26 countries (i.e. the EU27 countries excluding Slovenia).
Unemployment data are used to measure the degree of regional resilience to economic crisis, i.e. the depth of reaction of a region's economy to a shock (Martin and Sunley, 2015). On the other side, we use EPO patent data to measure the magnitude and qualitative characteristics of the technological capital of a region. The results of our analyses show that the most performing regions (i.e. regions with the lowest increase in the unemployment rates) are located mainly in Germany and Poland, while the most severely hit regions are located mainly in Greece, Ireland, Italy, Spain and Baltic states. Besides this strong country effect, it emerges that the performance of regions during the crisis is affected by the initial level of unemployment. There are regions with a highest (lowest) initial level of unemployment and a highest (lowest) performance during the crisis period. More interestingly, it emerges that is not the technological capital per se to matter but its characteristic to be resistance at technological crises.

Keywords: regional resilience; economic crisis; unemployment; patents

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**Stefano Musso**
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*Work organization and industrial relations in the history of Fiat*

Fiat represented a special case of a big private company in a country whose historical industrial structure was – and still is - characterized by the widespread presence of small and medium-size firms. Nonetheless, as a national champion Fiat had a large influence both on the history of industrial relation and social conflict in Italy, and on the introduction of Taylorism, Fordism and Lean production. The proposed contribution will explore such issues from an historical point of view.

During WW1 Taylor's writings were translated into Italian, but Taylor methods were already known by Fiat managers because of the strike at Renault in 1913. Industrial mobilization in 1915-18 triggered off a huge increase in dimension of plants and equipment. In 1916 started the building of the Fiat Lingotto. The rapid and enormous increase in employment (from 4.000 to almost 40.000 people) hindered any rationalization process. Skilled workers were in charge of organizing and supervising the newly hired workers, many of whom were female workers and young people. In the aftermath of the war the strike wave of the so called "biennio rosso" stopped any attempt to introduce Taylor's methods.

In 1927, Fiat created the "Società Italiana Bedaux" (Italian Bedaux Company), with the founder of Fiat, Giovanni Agnelli, as President. The Italian Bedaux Company acted as a consulting body of engineers who were expert in the rationalization of production processes. About 200 Italian companies adopted the Bedaux system. Thus, Fiat played a major role in the introduction of Taylorism in Italy.

In the post-WW2 period, Fiat started the mass production of small-size cars leading the rush to the Italian economic miracle. Fiat fully implemented Ford methods after the defeat of the communist and socialist trade unions. A hierarchical and centralized organization imposed a severe discipline to workers. The number of unskilled workers grew dramatically, as well as Turin's population. They were mainly migrants from the South of the country, suffering from the lack of social housing and services. By the end of the 1960s a new wave of worker unrest started in Italy and lasted until the end of the 1970s. In 1980, Fiat succeed in defeating the unions in a very sharp and long conflict that marked the end of the worker mobilization throughout the country. In the 1990s, Fiat led one more time the renewal of production methods in Italy adopting and diffusing lean production methods through the supply chain and the Employers' association. The same happened after 2005 with the adoption of WCM, even if by that time Fiat ceased to be a national champion, being transformed into a global player based in UK and Holland.

**Neirotti P., Paolucci E. e D. Pesce**
Politecnico di Torino

***Skill-biased technological change at the rise of a new technological paradigm: an industry-level perspective on the effect of ICT investments in Italy***

After many years of research on the business value produced by Information Systems, the creation of various forms of values produced by these technologies remains quite a "grey box" and there is consequently limited knowledge on how industry-level productivity is affected by the capability of sectors to absorb IS knowledge. This knowledge gap is critical in the current era where IS are acknowledged to unleash growing economic divides between countries, sectors with different capabilities to absorb IS-related innovation, and – within industries – between firms and even among workers with different skill educational levels. In this study, we contribute to disentangle the multifaceted "IS business value" construct by analysing at the industry level the effects that IT spending have on labour productivity and on its components, output growth and input use efficiency, referred to employment and its related cost. The empirical settings of our analysis are 255 three-digit industries in Italy between 2007 and 2014. We found that IT spending significantly affects a growth in labour productivity that is caused by a growth in output and a reduction in employment and it is accompanied by a reduction in wages and in the remuneration of labour over the value added. We found that these effects are more visible in sectors with high information intensity. However, in sectors producing information goods (e.g. software, R&D, consulting) IT spending is associated with a growth in wages and with a lack of a negative impact over employment. Our results confirm that industry is a relevant variable in IS research on business value due to the competitive and institutional forces at play in an industry that shape the diffusion of management capabilities on IS. In this vein, our results suggest that skill-biased technological change, standardization and geographical disaggregation of business process are more likely in sectors with a high information intensity of the operations, but not in sectors producing information goods.

**Bottai Carlo and Nava R. Consuelo**
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***Urban Scaling: A Panel Data Approach***

In recent years, the popularity of the urban scaling theory has grown, encouraged by an increasing interest among scholars as well as policy makers in the determinants of the urbanization dynamic and metropolitan cities expansion.
In particular, several authors described the formation and persistence of cities as the emerging property of the dynamic evolution of a Complex Adaptive Systems [Bettencourt and West, 2010]. Specifically, it has been observed that Power-law distributions describe the relationship among the size of many cities or metropolitan areas around the world and many other key macroscopic variables. This suggests that scale-free laws govern the agglomeration dynamics [Bettencourt, 2013; Bettencourt and Lobo, 2016].
In the paper, we investigate the development of the biggest OECD Functional Urban Areas [OECD, 2012] and we estimate their nonlinear agglomeration and scaling effects. To do so, we compare their dimension – measured by the population size– with other relevant variables: mainly their urbanized area size; number of patents granted; GDP and total employment levels.
Given the small size of most of the national samples analysed, the consistency of the scaling parameters across nations and over time is assessed using a panel data approach, which ensures more accurate estimates. Unobserved time, city and nation-dependent features are captured with a random effect approach, while the temporal dimension is, for the first time, appropriately exploited in an explicit manner.
In conclusion, the paper, facing most of the theoretical issues linked to the empirical investigation of the urban scaling effects, wants to be a step forward in the knowledge about the development and the transformation of urban spaces: a geographical entity not only shown as key for the economic development and transformation of nations, but that is nowadays at the core of many policy actions and programs.

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**Geuna, A. Guerzoni M. and Nuccio M.**
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***Productivity and manufacturing in Piemonte and Northern Italy***

An issue of paramount importance for the future of the Italian economy is the long-term resilience of manufacturing – in particular in the regions of the North-West (the primary locus of the country's early industrialization) and North-East (the primary locus of industrialization in the 1980s and 1990s). These areas comprise Piedmont, Lombardy, Emilia Romagna and "Triveneto" – i.e. the three regions of Veneto, Friuli Venezia Giulia and Trentino-Alto Adige. Overall, this geographical macro-area accounts for about 27 million people, equivalent to the population of BeNeLux. The journey from Milano by train takes 45 minutes to reach Torino, 60 minutes to reach Bologna and 200 minutes to reach Venezia. Milano and Torino can be considered an urban agglomeration (e.g., the Metropolitan Statistical Area of greater Boston is about 110 km in diameter involves a mean work commute travel time of 45 minutes).

Our analysis is based on a set of indicators aimed at capturing industrial resilience since the mid-1990s, when Italian productivity began to lag behind that of Germany, the other main European exporter. And we focus specifically on how digital technologies (big data, computational power, algorithms and the related fast developments in artificial intelligence) are shaping the development of a new generation of cyber-physical systems based on the convergence among robots, sensors and 3D printing. As is well known, digital technologies are reshaping the division of labour within and between firms, with a reallocation of capital and labour towards new activities. Against this background of opportunities and challenges, regions and countries have a major interest in re-shoring those industrial activities with higher potential for generating value for their territories.

In general terms, we have identified a shortage of competences in Computing Technology and Artificial Intelligence – key competitive areas for Northern Italy. Although the machinery and robotics industrial base is quite robust, there may be bottlenecks in the evolution towards advanced digital manufacturing which would negatively affect competitiveness. Indeed, the synergies between all these sectors are essential and require targeted investments and coordination among the key actors.

To address these challenges, policies aimed at developing human capital should be pursued at multiple levels: secondary, tertiary and post-graduate education. And formal education should complement on-the-job training and apprentice contracts. At the same time, it is necessary to attract foreign professionals, based on career opportunities, financial incentives and local quality of life.

Production processes require not only graduates but also specialized technicians. Piedmont, in particular, is already reaping the rewards of the Istituti Tecnici Superiori (ITS – Higher Technical Institutes) introduced in 2011, although the number of students is still very small. ITS in the region are organized in seven schools and cover areas such as innovation, mobility, tourism, culture and fashion, energy and biotechnology. The activities include co-design of profiles and skills, support and advice on job placement, rapid adaption of profiles to business needs, transfer of innovations, focus on work objectives and practice, high-level apprenticeships and internships. The two year ITS higher education programme could be complemented by a system of online training that would allow workers to continue to update their skills. Such an online system, premised on the ITS courses, would benefit from the alumni network and support infrastructure. To facilitate knowledge sharing at the local level, the physical infrastructure of the ITS could become the locus for the creation of an online repository of software, best practices, data, etc., accessible to all accredited ITS students.

A second set of policies needs to focus on coordination and diffusion mechanisms involving universities and research institutions that are already focusing on computing and robotics. There are indeed successful cases that could inspire similar and broader efforts, but in a highly dynamic and competitive global setting, today's windows of opportunity could close quickly.

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***Topic modelling of technological patents: where are the robots?***

The project aims at mapping the evolution of the knowledge base of two advanced technologies. The emergence of Industry 4.0 as the rising organizational standard in manufacturing requires industrial robots to interact much more intensively with the environment. We assume that this new generation of smart robots require a technological base which combine the advancement in robotics with those in computing technology such as artificial intelligence. We try to elicit this pattern of technological evolution with two methods. A supervised approach relies on experts' opinions to identify key words defining the two technologies. Co-occurrence analysis is applied at a second stage to test the hypothesis of convergence. Conversely, in the unsupervised method we run a topic modeling exercise on a broad range of technological classes and we identify ex-post whether there exist clusters of co-occurring words referring to the two technologies. Also here at a second stage it is possible to observe the trajectory over time of these topics. Eventually, we conclude with a comparison of the two techniques.

**Neirotti P. and Paolucci E.**
Politecnico di Torino

***Rediscovering lean manufacturing capabilities through their microfoundations: An analysis of the world class manufacturing program at FCA***

Only few companies succeed in adopting good lean practices. To understand why this happens, we studied how Fiat Chrysler Automobiles implemented its lean program. Our analysis on 22 plants in Italy decomposed part of the social complexity of lean programs highlighting the role assumed by changes in the behavior, the structures and the processes that regulate the evolutionary adaptation of such programs. To do so, we explored the links between plant's progress in lean implementation and the micro-level context of workers' involvement in continuous improvement. Our results adds new light on the strategic valence of lean production.

**Nuccio, M. Patrucco PP. and Nava C.**
Università di Torino

***Industrial structure and regional competitiveness in post-2008 Italian regions***

Although spread in different disciplines -psychology, environmental management, engineering and architecture, organizational studies, etc. we can find two major definitions of resilience in economic geography (Boshma, 2015; Martin and Sunley, 2015): the ability of a region to accommodate shocks and the ability of regions to reconfigure their socio-economic and institutional structures to develop new growth paths.
In the former definitions the re-discovery of time into economic analysis emerges both in terms of relevance of history (path dependence) and long-term economic cycles.
The aim of our paper is to describe and evaluate the reaction of Italian productive capacity to the two last major recessions in 1992-95 and 2009-13. From a methodological perspective we adopt and adapt the framework by Martin et al. (2016) splitting the measure of resilience into two shift-share components: industrial structure and regional competitiveness.
Although results are preliminary and somehow limited by the availability of data, two aspects are immediately evident. First, Italy shows an extraordinary low rate of employment of the active population: only 58,4% in November 2017, accounting for slightly more than 23 mln working people, which is more or less the employment in UK in 1977. Second, micro- and macro-regional behaviours are very differentiated and divergent.
We show three different output. First, for each regional unit we evaluate the combination of resistance and recoverability for the two above mentioned cycles according to the following matrix (Fig 1).

Fig. 1. Res-Rec Matrix (Martin et al. 2016)

| Resistance | | Recoverability | |
|---|---|---|---|
| | >0.0 | Good resistance but weak recoverability | Good resistance and good recoverability |
| | 0.0 | Weak resistance and weak recoverability | Weak resistance but good recoverability |
| | <0.0 | <0.0 | 0.0 |

In the first cycle (1993-2008), which was characterised by a long-boom, we found a positive relationship between resistance and recoverability across regions, i.e. those regions most resistant to recession have also recovered better. This is something we cannot over the last cycle (2008-2017).
In the second output we show the percentage change in regional employment combining the industrial mix effect and the regional shift factors (as annual average rate).
Finally, we calculate the Krugman structural dissimilarities indices and we compare different industrial performance over specific regions.

**Bottai Carlo**
University of Turin

***What Do We Measure When We Measure Regional Relatedness?***
***A Critical Revision of the Measure Used by the Resilience Literature***

Economists and Geographers have been debating for long whether regional growth were better influenced by specialisation (MAR agglomeration externalities) or diversification (Jacobian agglomeration externalities). Specifically, it has been suggested that economic diversity enhances economic performance, both by promoting higher levels of economic well-being and by improving the ability of regions to cushion the adverse effects of economic cycles.

Stimulated by the differentials among European regions in terms of their reaction capacity against exogenous shocks, this last topic is back in fashion after the Great Recession of 2008–2010 [ESPON, 2014; Aujean et al., 2015]. In particular, several scholars of Evolutionary Economic Geography and Economics of Innovation have stated that a compromise between specialisation and diversification is a fundamental feature in explaining the different levels of adaptive resilience [Martin, 2012] and economic performance of regions and countries [Frenken et al., 2007; Quatraro, 2010; Sedita et al., 2016; Antonelli et al., 2017; Rocchetta and Mina, 2017]. On the one hand, it has been stated that it is not diversity per se, but a coherent diversification of both the regional industrial structure and its knowledge base that pushes employment growth upwards in the short term, by cutting down recombinant innovation costs. On the other hand, to have different groups of specialisations is expected to improve the capacity of a region to cushion sectoral exogenous shocks since they will be balanced out by the performance of other sectors, like through a portfolio diversification strategy [Attaran, 1984; Boschma, 2015].

In this paper, firstly the different measures proposed in the literature will be reviewed. This purpose will be reached by framing the two measures mainly used by the literature, Variety [Frenken et al., 2007] and Coherence [Teece et al., 1994; Nesta and Saviotti, 2005; 2006; Nesta, 2008], in a regional setting; and by introducing two new measures, the Economic Complexity [Hidalgo et al., 2007; Hidalgo and Hausmann, 2009] and the Fitness [Tacchella et al., 2012; Cristelli et al., 2013]. These measures capture different aspects of regional diversification: Variety is able to split diversity in two components, a within-groups and a between-groups; Coherence measures the level of complementarity among the different elements of a set, given its level of diversity; and the last two indexes consider not only the diversity of the set, but also the rarity of its elements.

Secondly, it will be explored the sensibility of the measures to different levels of disaggregation, both with respect to the choice about the technological classes and the geographical units of analysis. Lastly, using European data disaggregated at the NUTS II level (Eurostat Regio and OECD RegPat databases), it will be test the effect of the different aspects of a coherent diversification of the regional capabilities captured by patents on employment rate growth, also differentiation the pre-crisis, crisis and recovery periods. The results show that the choice of the technological classes disaggregation level significantly affect the results, but also that some measures are less affected than others by that choice.

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***The evolution of the Italian Aeronautic industry: 1908-2016***

Through a detailed original archival research, we build the first comprehensive dataset of the Italian aeronautic producers since the beginning of the XX century until 2016. We collected information about the entry and exit of firms, the type of production (full vehicles, engines, components), the location and the eventual joint production in the automotive industry, which has been developing almost in parallel. We aim to: 1) identify the formation of possible clusters of aeronautic producers in Italy; 2) test the relation between entry-exit dynamics and the evolution of the industry, in particular to 3) test the relevance of Marshallian economies vs. spin-offs dynamics; 4) map the co-evolution of automotive and aeronautic industries.

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***The birth and development of Italian automotive industry (1894-2015) and the Turin car cluster: Marshall and Klepper revisited***

Within the well-known Marshallian tradition, the concentration and development of economic activities in space has been explained in terms of agglomeration economies driven by technical externalities and knowledge spillovers. Industries and new firms agglomerate in well-defined geographical areas because of the co-location of a pool of specialised workers together with specialized suppliers that make possible for proximate firms to access productive resources at lower costs. Moreover, within this perspective, agglomeration favours knowledge spillovers: firms can circulate their knowledge through an array of means such as labour mobility, user-producer interactions, informal communication and the bridging role of local institutions. Co-located firms can therefore easily access external knowledge and exploit the advantages of collective learning.

This traditional approach has been challenged by the seminal work of Steve Klepper, who argued that the spin-off process is the main driver of the formation and development of clusters and the local concentration of industries. Within this perspective, the process of spin-off is seen as a means of knowledge transmission between the parent company and the spin-offs. New entrepreneurs (i.e. the founders of the spin-offs) derive their knowledge and skills through their previous experience working in the parent company, in the same or similar sector. Moreover, more successful parent firms are able to generate a larger number of spin-offs, which are in turn more successful than other spin-offs. The development and growth of the cluster therefore depend of the ability of early firms to generate a larger number of new firms, transmitting technical skills, rather than on the mere co-location in the same geographical area.

By discussing the relations and the missing links between the traditional Marshallian approach and Klepper's view on the role of spin-offs, this paper aims to understand the early genesis and later evolution of the Italian automotive industry through the formation of a car cluster in Turin from the late nineteenth century to WWII.

More clearly, the specific contribution of the paper is on the knowledge economies at the base of the cluster development and it is three-folded.

First, we aim to capture the effect of institutional factors and precisely of education and literacy as early preconditions that support further accumulation of technical know-how in the cluster. Since the late nineteenth century Torino's area exhibit higher levels of education and literacy when compared to other Italian regions where car production were developing. We argue that these are initial preconditions that allow better acquisition of more specialized know-how in mechanics and car production and the formation of a cohort of technicians trained in technical schools. The role of such institutional factors is largely neglected in Klepper's accounting, also according to the recent reappraisal of his work by Ron Boschma (2015).

Second, the paper looks at Jacob's knowledge externalities (Jacobs, 1969) between automotive industry and the aviation sector (which was developing almost in parallel) as a factor supporting the clustering of car production in Torino. While this idea is not new in cluster studies and for instance Boschma and Wenting (2007) considered the role of related industries in the spatial development of British car industry, to our knowledge, all previous studies used aggregate measures of industrial concentration (e.g., employment, patents) to account for the presence of related industries. On the contrary, we are able to look at a microeconomic level by considering the diversification choices of each firm included in our dataset to see whether and how many car producers were also diversifying in the rising aeronautics sector and to see whether inter-industrial technical externalities are at play.

Third, we aim to specify which kind of knowledge, and by which means is transmitted through the spinoff process. Klepper's spin-offs theory is based on the ability to manage technology and strategic issues, or not.

"Disagreements arise because incumbent management has a limited ability to recognize employees with superior ideas and/or abilities. When the disagreements are severe enough, employees leave to found spinoffs" (Klepper, 2007, p. 616). Also, he argued that "spinoffs are expected to be better able than inexperienced firms to manage the process of technological change by dint of their prior experience" (p. 624). He put managerial competences at the core of his model. On the contrary, we want to test the role played by the inheritance of technical, rather than managerial skill and to do so we introduce the analysis of the role of pilots as founders of car producers. In other words, we test whether carmakers founded by entrepreneurs who were previously pilots at other carmakers are more likely, because of the technical and highly tacit skills acquired by their founders as pilots, to survive compared to other firms and to support the development of the cluster. In this sense, pilots are presented as selected or special "breeders", according to the notion by Buenstorf and Klepper (2009 and 2010).

To do so, historical analysis and econometric models will be integrated to identify key factors that have enabled the creation and the success of the automotive industry in Turin. More precisely, the paper will develop a model for the analysis of industrial resilience with which understand the current situation, its possible developments and the policy actions required to support the transition to new systems of production and business organization in the Turin metropolitan area. Localization and persistence of the car industry in the Turin metropolitan area is framed within the current theoretical literature, comparing the traditional Marshallian approach with the analysis of the role of spin-offs pioneered by Klepper. Klepper's hypothesis about spinoffs as driver of industry clustering is tested, and integrated by new elements. In this perspective, the paper is an attempt to build an appreciative theory (Nelson, 1994; Malerba et al., 1999) about long-term cluster formation and development. The different factors (e.g., institutional and technical) interacting in the development of the cluster are complex by definition, not fully captured by formal models and may often be expressed only in qualitative terms. The very nature of appreciative theorising is indeed that of being able to capture such systematic interdependences relaying on a detailed empirical evidence. (Nelson, 1994). This was also possible through the construction of an original dataset AUTOITA of 404 Italian carmakers since 1894 that merges and compares different archival sources and that represents the first and unique database on Italian car producers comparable at the international level.

The article is organized as follow. After a brief history of the Italian Automobile industry (in Section 2), Section 3 illustrates the background and Section 4 describe the Klepper's challenge to Marshallian economies. In Section 5 we define the main alternative research hypotheses that represent the specific contribution of our paper to understand the birth, development and clustering of industries. The hypotheses are tested on an original and rich database (see Section 6). The methodology and the results are presented in Section 7, with a concluding discussion.