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A taxonomy of multi-industry labour force skills

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ABSTRACT

This paper proposes an empirical study of the skill repertoires of 290 sectors in the United States over the period 2002–2011. We use information on employment structures and job content of occupations to flesh out structural characteristics of industry-specific know-how. The exercise of mapping the skills structures embedded in the workforce yields a taxonomy that discloses novel nuances on the organization of industry. In so doing we also take an initial step towards the integration of labour and employment in the area of innovation studies.

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1. Introduction

This paper proposes an empirical analysis of the skill repertoires of the workforce in 290 industrial sectors of the United States (US) over the period 2002–2011. In so doing it addresses two questions:

- (1) What are the skill configurations that characterize industries and sectors?
- (2) Do particular skill configurations associate to specific industry types?

This study contributes various streams of scholarly research. First, it captures the correspondence between skill endowment and the organization of industry, an arguably underdeveloped theme in the area of innovation studies. In particular we identify specific categories of practical know-how that resonate with recent works on skills (Giuri et al., 2010; Neffke and Henning, 2013) and, also, explore empirical associations between these and industry characteristics. Another contribution of the paper is the articulation of important nuances on cross-industry differences that goes beyond

macro-level evidence (e.g. Howell and Wolff, 1992; Autor et al., 2003). Last but not least, the classification of industry groups on the basis of the skill content allows us to propose a new taxonomy that adds to previous literature, in particular Pavitt (1984) and Castellacci (2008). In the last part of the paper we propose that the distinctively dynamic character of employment and skills, and the complicated role of technology in them, bode well for greater engagement on these themes on the part innovation scholars.

The paper is structured as follows. Section 2 prepares the ground by outlining the theoretical backdrop and our proposed operationalization of the main concepts at stake. The empirical analysis of Section 3 illustrates important nuances of skill structures, and explores basic empirical regularities within industry types. Section 4 explores commonalities and differences with other taxonomic exercises in the innovation literature. The last section concludes and summarizes.

2. Background

The area of innovation studies is the field of research that has arguably explored in greater detail the relation between knowledge, industry evolution and competitiveness. A full review is beyond the scope of this paper but suffice it to say that the debate is often couched in terms of the ontology of technological knowledge, or the articulation of processes by which knowledge is organized

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and diffused, or the assessment of the contexts in which different kinds of knowledge are put to use (see Rosenberg, 1976; Cowan et al., 2000; Metcalfe, 2001; Foray, 2004; Antonelli, 2006). A wealth of empirical evidence indicates that heterogeneity is the trademark of knowledge-driven transformation at various levels of aggregation including firms (Bottazzi et al., 2002; Srholec and Verspagen, 2012), industries and sectors (Pavitt, 1984; Mowery and Nelson, 1999; Malerba, 2002), clusters (Jensen et al., 2007) as well as regional (Cooke et al., 1997; Asheim and Coenen, 2005) and national systems of innovation (Nelson, 1993; Carlsson et al., 2002). The causes of this diversity cannot be reduced to a single factor but, rather, are ascribed to complementary transformations in the knowledge base, the networks of actors and institutional infrastructures (Amable, 2003; Nelson, 1994; Malerba, 2005). Central to this view is the notion that beneath industry dynamics are the cyclical decline of obsolete activities and the emergence of new ones that disrupt the extant order and induce a transformation in the “way of doing things”. These adjustments are necessary to either restore or create ex novo appropriate conditions for productive specialization (Nelson, 1994; Metcalfe and Ramlogan, 2005).

The present paper seeks to contribute to the area of innovation studies by focussing on employment, a crucial driver of industry evolution. To be sure, the role of the labour input in the organization of industry is a common, if understated, thread across various areas of scholarly research. The management literature focuses on strategic aspects related to the coordination of know-how and attitudes across employers (Cohen and Levinthal, 1989; Kogut and Zander, 1992). Scholars in business economics ascribe differences in firm performance to differential abilities within the workforce in creating and using knowledge (Geroski et al., 1993; Henderson and Cockburn, 1996; Johnson et al., 1996). More recent empirical work puts emphasis on the mutual influence between employees' skills and forms of innovation (see e.g. Leiponen, 2005; Freel, 2005; Lavoie and Therrien, 2005). Last but not least, empirical studies in economics explore the impact of Information and Communication Technologies on the content, the structure and the dynamics of employment with special emphasis on the sources of wage inequality (Galor and Moav, 2000; Autor et al., 2003; Goldin and Katz, 2008).

A point in common across all these works is the scarce consideration towards the sheer diversity across forms of knowledge, and of the consequences on the organization of industry. This paper brings these ideas within the remit of innovation studies by looking at the skills that are required to perform job tasks. In the view proposed here sectors are bundles of tasks whose execution entails the generation and/or application of specific knowledge (Richardson, 1972; Nelson and Winter, 1982).¹ In turn occupations are industry-specific pathways for matching skills with institutionally agreed tasks and skills are the individual abilities that determine the proficiency in carrying out these job activities (Autor et al., 2003; Levy and Murnane, 2004). In aggregate, the composition of the workforce at industry level reflects the knowledge mix that is relevant at any particular point in time.

Following an established tradition within innovation studies we operationalize the analysis of industry evolution by means of a classificatory exercise of the knowledge base. The first effort in this direction was Pavitt's (1984) renowned study of the technological

characteristics of UK firms which became the basis for a sectoral taxonomy. This has been and continues to be a point of reference for scholars, policy makers as well as for statistical offices designing large-scale data collection programmes (Archibugi, 2001; Peneder, 2003). On a conceptual level the use of taxonomic exercises has inspired a great deal of research on various industry characteristics such as technological opportunities, knowledge cumulativeness, knowledge bases, appropriability conditions, R&D intensity and skills (see e.g. Los and Verspagen, 2004; Breschi et al., 2000; Van Dijk, 2000; Malerba and Montobbio, 2003; Reichstein and Salter, 2006; Krafft et al., 2011).² At the same time greater availability of sector-specific data (such as, for example, the European Community Innovation Survey) has expanded the intellectual scope and the policy remit of classification exercises. This is especially true in the area of studies on service sectors (e.g. Evangelista et al., 1997; Miozzo and Soete, 2001; Leiponen and Drejer, 2007; Castellacci, 2007) where greater understanding of the dynamics of technological paradigms has stimulated both the toning down of the arguably blunt separation between manufacturing and services and, at the same time, a stronger appreciation of the growing diversity that exists across these sectors (Castellacci, 2008; Peneder, 2010; Consoli and Elche-Hortelano, 2010; Consoli and Elche, 2013).

The remainder of the paper puts these concepts to use and proposes a taxonomic exercise based on a hitherto overlooked dimension of analysis, namely the knowledge base of occupations within industrial sectors.

3. Data and analysis

This section presents an empirical analysis of 290 industrial sectors in the United States over the period 2002–2011 with a view to uncover structural and dynamic aspects of industry evolution. Building on the conceptual background laid out above, we propose a taxonomy of industry based on the intuition that the knowledge base of a sector is a portfolio of skill combinations, whereby the co-occurrence of two particular skills in one profession is interpreted as a measure of the joint utilization of those types of know-how. Clearly mastering diverse skills determines workers' ability to meet successfully job requirements, but successful adaptation to new job tasks requires also collaboration across occupations and some degree of teamwork. This is why we prefer to focus on the industry level, since the fate of any individual occupation may conceal broader alterations in the structure of production due to modifications in the job content, in the creation of new occupations, or both (Autor et al., 2003), that would otherwise be unnoticed. Being channelled through the instituted process of employment all these changes are easily detectable by looking at the composition of the labour force. The remainder of this section presents the dataset and the empirical analysis.

3.1. Data description

The key objective of this study is the construction of an industry taxonomy based on the analysis of skill repertoires. The main source is the Occupational Information Network (O*NET) electronic database of the U.S. Department of Labour (DOL) containing specific information on the characteristics of more than 1000 occupations. For the purpose of the present paper we use information concerning the physical and cognitive abilities that are required from workers. This is generated by means of a survey in which occupational analysts, job incumbents and occupational experts are asked to assign a score to 35 types of skills (see Appendix A) on the basis

¹ This is not to say that the issue has been completely neglected: Freeman et al. (1982), Vivarelli (1995), Edquist et al. (2001), and Petit and Soete (2002) are important contributions on the appreciation of the mutual influence of technology, especially Information Technology, and labour. Our claim is, rather, that there have been no attempts to build on that empirical evidence to the effect of integrating the dynamics of employment in a broad theoretical framework such as those of Nelson and Winter (1982) or Metcalfe et al. (2006).

² For critical views on the use and misuses of sectoral taxonomies see Archibugi (2001) and Srholec and Verspagen (2012).

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