

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.*

Keywords: Industry dynamics; Skills; Taxonomy

JEL Code: C38; L0; J24; O33

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 also observe 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 operationalisation 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 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; Shrolec 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 Cohenen, 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 programs (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, 2010; 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.

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 Shrolec and Verspagen (2012).

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 of their importance for performing the occupation. Skills encompass various categories: “basic” (e.g. reading, writing and listening), “processing” abilities (e.g. gathering and organizing information), “social” (e.g. interaction with others) and “technical” (e.g. maintenance and repairing) abilities.³ Each of these items is assigned a score by O*NET survey respondents, and is subsequently matched with other data using the Standard Occupational Classification (SOC) code.

The database used here was built relying on different sources. First, we retrieved from Bureau of Labor Services (BLS) data for employment and the average number of years in

³ For further information about O*NET see National Research Council (2010).

excess of High-School (Standard Vocational Preparation) on a unique combination of 22 two-digit SOC occupations and 290 four-digit NAICS US industrial sectors for the period 2002-2011. This information was subsequently matched with the corresponding occupational information of O*NET, thus generating a vector of skill scores for each of the 22 two-digit SOC occupations. We also gathered information at the four-digit NAICS level on labour productivity (Source: US Bureau of Labor Statistics), on the number of firms per sector (Source: Business Dynamics Statistics, US Census), on Capital Expenditures for Structures and Equipment (Source: US Census).

Following the preamble above, we submit that changes in the repertoire of skills reflect the evolution of industry needs and that the associated change in the knowledge base is likely to engender, or to reinforce, systematic cross-industry heterogeneity. To operationalize these ideas, we aggregate occupation-specific information on skills by industry using relative scores, that is, weighted measures of skill intensity (see Oldenski, 2012). First, we multiply the skill score at the unique 2-digit SOC and 4-digit NAICS by the number of years in excess of High-School. Subsequently we normalize the resulting values to fix a range between 0 and 100 and compute the following skill measure:

$$SkillInt_{s,ind} = \sum_{occ} EmpShare_{occ,ind} * NormSkill_{s,occ,ind}$$

where $EmpShare_{occ,ind}$ is the relative importance in terms of employment of occupation occ in industry ind and $NormSkill_{s,occ,ind}$ is the normalized value of skill s in occupation occ and industry ind . Summing over occupations in each industry yields an input intensity measure of each skill s in each industry ind ($SkillInt_{s,ind}$). After this transformation we are left with 290 industry-specific intensity measures for each of the 35 skill types for each of the ten years under analysis.

3.2 – Constructing the taxonomy: skills and sectors

The original data contains 35 skill variables. Recall that we are not interested in their absolute values but, rather, in the way skills combine within industry-specific occupational structures. Moreover, the raw scores of skill intensity are highly correlated with each other due to high complementarity across skill endowments at industry level. To meet the former goal and to overcome the latter limitation, we reduce the set of skill indicators to a smaller number of

non-overlapping dimensions by means of a factor model (see e.g. Castellacci and Archibugi, 2008). Table 1 presents a compact view of the skill constructs extracted from the 35 indicators of skill intensity for the period 2002-2011.⁴ Note that different methods of factor extraction – principal components, iterated principal factors and maximum likelihood – yield consistent results. Altogether the factors explain a large percentage of the variance.⁵

TABLE ONE ABOUT HERE

Previous literature assists the interpretation of these two constructs on the basis of functional specificities (Autor et al, 2003; Wolff, 2006). First of all, we note that our constructs fit squarely with Herbert Simon's (1969) notion of problem-solving as the combinatorial outcome of different types of knowledge. Indeed, the first factor includes items that involve the use of cognitive abilities in non-routine circumstances, like interpersonal interaction or abstract thinking, and is labelled Interactive & Abstract Skills. The second construct, Technical & Analytical Skills, contains a broad range of cognitive and manual abilities employed for routine tasks such as managing or recombining existing information, or when operating specialized technical equipment. The cognitive and manual abilities within this second construct are normally employed for highly routinized tasks that are more prone to automation like calculation or information processing (see Autor et al, 2003).

Following on the above, sectors are grouped together on the basis of the skill distributions embedded in their occupational structures. In particular we apply clustering techniques to factors scores⁶ by means of regression methods (Thomson, 1951) and use them as inputs in the clustering algorithm.⁷ This exercise yields three clusters (see Appendix B for a full summary). The first, Complex Production and Distribution, includes the majority of Hi- and Medium- Tech Manufacturing, and some knowledge intensive services.⁸ The core of this

⁴ To select the number of factors to be retained we employ a combination of three common rules of thumb suggested in the literature – see Gorsuch (1983): (i) we retain only those factors with an eigenvalue larger than one (also known as Guttman-Kaiser rule); (ii) we keep the factors which, in total, account for about more than 80% of the variance and (iii) we retain all factors before the breaking point in the scree-plot. In all these cases, our results consistently point to two factors to be retained.

⁵ The two factors are robust to alternative estimations for individual years and for various blocks of multiple years. Results are in line with those presented above and are available from the authors upon request.

⁶ Factor scores have been standardized to range between -1 and 1. Thus, a positive (negative) value of a factor score should be interpreted as an above-(below-) average value.

⁷ We use different hierarchical clustering methods (average linkage, centroid linkage and Ward's linkage) based on the Calinski-Harabasz pseudo F-statistic and the Duda-Hart index stopping rules for selecting the optimal number of clusters. Finally we check the robustness of the results with a Partition-clustering method.

⁸ The labels Hi-, Medium- and Low-Tech for Manufacturing, and High- and Low-Knowledge-Intensity Services have been assigned on the basis of the NACE-based Eurostat classification, and subsequently converted to the

cluster, calculated as the 90th percentile by mean skill intensity, includes industries like Satellite Telecommunications (NAICS: 5174); Software Publishers (5112); Computer Systems Design Services (5415); Manufacturing of Computer and Peripheral Equipment (3341); Data Processing and Related Services (5182); Architectural, Engineering, and Related Services (5413); Communications Equipment Manufacturing (3342). In the second cluster, labelled Basic Production and Distribution, are the bulk of Low-Tech Manufacturing industries and Service activities with low knowledge intensity, mostly commercial activities complementary to the former. At its core are Iron and Steel Mills Manufacturing; Commercial Refrigeration Equipment Manufacturing; Tobacco Manufacturing; Utility System Construction; Coal Mining; Vending Machine Operators; Automotive Repair and Maintenance. The last cluster, People Services, contains service activities characterized by direct interaction with customers such as Legal Services; Securities and Commodity Exchanges; Instruction Services; Insurance and Employee Benefit Funds; Central Bank; Internet Publishing and Broadcasting; Investment Pools and Funds.

3.3 – *The taxonomy at work: an illustrative analysis*

Let us explore more in detail the characteristics of the constructs at hand. Figure 1 offers a compact view of the distribution of Industry-Clusters in the know-how space defined by both the Skill-Factors. Each point in the scatterplot is a 4-digit NAICS industry arranged by their relative Skill-Factor intensity and labelled by shapes depending on the cluster they belong to. For analytical purposes, we find it convenient to further distinguish observations that are either manufacturing or to service activities. The diagram clearly shows that industries in *Complex Production and Distribution* (Cluster 1) exhibit a higher than average value of both *Interactive & Abstract Skills* and *Technical & Analytical Skills*. This is not surprising since in this construct are activities like high- and medium- tech manufacturing or KIBS, thus requiring not only a high level of knowledge intensity but also a good degree of complementarity between different types of know-how, therein including analytical skills, creative thinking as well as interactive skills. In the language of Herbert Simon (1969: 87) these are ‘semantically-rich’ domains, that is, activities whose task structures are characterized by strong specificity and require high levels of cognitive responsiveness to construct ad-hoc mental frameworks and performance criteria. Industries in the second cluster, *Basic Production and Distribution*, exhibit a lower than average value of *Interactive*

NAICS system. See http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/High-tech_statistics. For a critical view of this classification see Godin (2004).

& *Abstract Skills*. This resonates with the population items that populate the cluster, mostly production of consumer durables, processing or raw materials or trade and activities that, in general, require more manual and technical abilities than abstract thinking. The defining feature of *Basic Production and Distribution* is that it encompasses ‘non semantically-rich domains’ strongly biased towards standardized tasks. In this type of domains the repertoire of problem-solving options is known ex-ante with a finer degree of precision, and replication of existing routines through non-cognitive skills suffices (Simon, 1969; Autor et al, 2003). Finally, *People Services* mainly comprise Knowledge Intensive Services such as teaching, social and community services but also financial intermediation, and indeed they score rather high in *Interactive & Abstract Skills* but not in *Technical & Analytical Skills*. This exercise also illustrates the ubiquity of service activities as well as their functional specificities depending on whether they exhibit complementarity with manufacturing, as in the case of the first two clusters, or they rather stand in a category of their own like in the People Services construct. This result resonates with recent analyses of sectoral specificities (see Castellacci, 2008; Peneder, 2007; Consoli and Elche, 2010).

FIGURE ONE ABOUT HERE

To gain a clearer characterization of these constructs we check for statistical correspondences between Skill-Factors and Sector-Clusters. This is done by regressing the likelihood of belonging to a particular cluster against the skill constructs and a set of other industry characteristics (see Section 3.1) such as capital expenditure in infrastructures, capital expenditure in office equipment, labour productivity (measured as average hourly wage⁹) and number of firms (in thousands). We also include a set of dichotomous variables taking value 1 when the industry belongs to one of the industrial categories Hi- and Low-Tech Manufacturing, High- and Low-Knowledge Intensive Services (see Footnote 10). We believe that this exercise contributes to provide a characterisation of our clusters across relevant dimensions in a descriptive flavour.

The results (Table 2) corroborate preliminary insights obtained by the inspection of Figure 1 and indicate that the probability of belonging to the *Complex Production and Distribution* cluster is positively and significantly associated with both *Interactive & Abstract Skills* and *Technical & Analytical Skills*. This is to say that occupations within these industries employ a broad set of skills or, put otherwise, that their task content embraces a wide spectrum of

⁹ As for raw measures of skills wage data are available at the unique two digit SOC and four digit NAICS level. We aggregate hourly wage at the industry level by weighting for employment shares.

cognitive and non-cognitive activities. Conversely industries in the *Basic Production and Distribution* cluster have a negative association with *Interactive & Abstract Skills*, meaning that the values of that particular skill type are significantly below average compared to the other clusters. Finally, sectors within the *People Services* cluster have a significant and positive association with *Interactive & Abstract Skills* and a negative one with *Technical & Analytical Skills*.

For what concerns the other dimensions, *Complex Production and Distribution* exhibit a positive and significant association with capital expenditure in office machinery. This is expected, and in line with the literature that emphasises the complementarity between ICTs and cognitive skills (Autor et al, 2003; Levy and Murnane, 2004). On the other hand the negative sign of the coefficient for capital expenditure in infrastructures is somewhat expected too, considering that it signals that this type of resource commitment has relatively lower importance in this kind of knowledge intensive activities. At the same time we use dummies to check whether the probability of belonging to the clusters varies across industry ecologies. In the case of Cluster 1 we observe some degree of diversity since the coefficients are positive and significant for all types, relatively more for Hi-Tech Manufacturing. This configuration stands in contrast with that of the *Basic Production and Distribution* cluster whereby the coefficients for capital expenditure suggest that investments in infrastructure play a stronger role. The coefficient for number of firms is negative and non-significant in this construct and, also, no industry type exhibits positive and/or significant probability to fall in this group. The composition of *People Services* on the other hand is rather clear due to the prominent role of interactive and abstract skills (as seen in Figure 1) which resonates with the positive and significant coefficient of H-KIS. Lastly, the test equality of coefficients indicates that the difference between the coefficients of *Interactive & Abstract Skills* in both *Complex Production and Distribution* and in *People Services* is not significantly different from zero. This suggests that the skill factor is similarly important in both constructs. Conversely, the two clusters differ for what concerns the effect of *Technical & Analytical Skills* which are significantly different from *Interactive & Abstract Skills* in *Complex Production and Distribution* cluster.¹⁰

¹⁰ The Breusch–Pagan test, significant at 1% level, indicates that the residuals of the three clusters are not independent and justifies the use of multivariate regression. It is worth stressing that in this method, different from multiple regression, dependent variables are jointly regressed on the same independent variables. The joint estimators of multivariate regression are built on the between-equation co-variances, and allow testing for relevant factors across equations. This way we can learn about their relative importance in each cluster.

TABLE TWO ABOUT HERE

The analysis so far has been concerned with uncovering structural aspects of the cognitive content of industries. As anticipated in the conceptual framework outlined of Section 2, the salient mark of industry evolution is the emergence of significant and persistent cross-industry differences. It seems therefore relevant to analyse the dynamic behaviour of both skill-factors and of industry clusters change over time. To this end we first check whether skill-factor intensity is homogeneous across sectors. The kernel density distributions in Figure 2 offer two clear hints.¹¹ First, the right-skewed shapes suggest high concentration, or uneven distribution across sectors, more so for of *Interactive & Abstract Skills* (Factor 1) compared to *Technical & Handling Skills* (Factor 2). As for the longitudinal behaviour, the kernel curves for years 2002, 2006 and 2011 indicate significantly different patterns of change. The upward-left shift between 2002 and 2006 of the distribution of Factor 1 indicates that the majority of industries gather around low and medium-high levels of skill-factor intensity. In the second part of the decade the trend is reversed and skill concentration in 2011 is close to the levels of 2002, but still highly skewed. The case of Factor 2 is quite different in that the initial kernel density curve is bi-modal, and then it progressively becomes bell-shaped, though not normally distributed.¹²

FIGURE TWO ABOUT HERE

These patterns resonate with the view that the distribution of ‘soft’ skills, such within Factor 1, is uneven across sectors because they are heavily context-dependent and, thus, harder to standardize (Bartel and Lichtenberg, 1987; Autor et al, 2003; Vona and Consoli, 2015). The broad message that emerges from this graphical analysis is that there is high variation in the distribution of skill intensity across industries, and that path-dependence in the organization of labour routines tends to reinforce the bias (David, 2000; Amable, 2003).

4. Discussion

The empirical analysis of the preceding section has provided several insights concerning the organization of industry through the lenses of the skills embedded in the workforce. To recap, we synthesised the distributions of relative skill intensity in two constructs that capture salient characteristics of the knowledge content of occupations: *Interactive & Abstract Skills*,

¹¹ Here we select the industries whose skill intensity lies below the 90h percentile to control for outliers at the far extremes of the distributions.

¹² The coefficients of the Kolgorov-Smirnov test confirm the non-normal distributions: for Factor 1, 2002: 0.19***; 2006: 0.16***; 2011: 0.16***. For Factor 2: 2002: 0.17***; 2006: 0.09***; 2011: 0.1***

normally associated to non-routine tasks, and *Technical & Analytical skills* that are mostly involved in carrying out routine activities. We subsequently fed back these results in the grid of 290 industrial sectors and obtained three clusters that capture distinctive patterns of knowledge organization across industrial sectors. Let us now reflect on these results and offer a broader view of the contribution of the present study.

To do so we propose a heuristic comparison between our industry taxonomy and other similar empirical exercises in the literature. Taxonomies are often elaborated with the intent of offering a compact view of multi-dimensional constructs, like industry, while not losing sight of the underlying richness. The effort of undertaking yet another taxonomic classification is partly motivated by the curiosity of testing the generalizability of existing constructs when new information, such as the skill content of occupations, becomes available. Could have we used existing taxonomies for the analysis of industry knowledge bases? To what extent our constructs add to previous work? We tackle these questions by checking how much previous taxonomies capture the skill content of industries.¹³

The selection of candidate studies for such a task is not easy considering the sheer breadth of options available (see Peneder, 2003 for a review). After a thorough revision of the literature we picked two key antecedents for the sake of comparison. Our first choice is Pavitt's renowned taxonomy, a point of reference for virtually all industry classifications. This was built through a detailed assessment of about 2000 inventions and firms in the UK between 1945 and 1979 using size, innovation patterns and sources of innovation as organizing criteria. The resulting constructs are Scale-Intensive (SI), Supplier-Dominated (SD), Science-Based (SB) and Specialised Supplier (SS). A well-known criticism is the scarce consideration to service activities in this taxonomy, especially in view of their fast growth in both size and importance across most advanced economies. To accommodate this insight we use Miozzo and Soete's (2001) revision of the Pavitt taxonomy and include two categories of service activities, namely Personal Services (PS), which includes KIBS as well as intermediation activities, and Non-Personal Services (NPS), which encompasses all other service activities (Castaldi, 2009). Our second choice is the taxonomy by Castellacci (2008) built using Community Innovation Survey (CIS) data with the goal of offering an integrated classification of manufacturing and service sectors. The sorting criteria are two: the function that each industry plays in the broader eco-system through the supply or the demand of goods

¹³ We are indebted to an anonymous referee for drawing our attention to this issue and for suggesting this comparative exercise.

and services, and the level of technological capabilities of innovative firms within a particular group of industries. This taxonomy contains four meta-categories: (i) Advanced Knowledge Providers (AKP) which include KIBS but also specialized manufacturing such as machinery and equipment, medical and optical instruments; (ii) Mass production Goods (MPG) featuring science-based manufacturing (i.e. chemicals, computers), electrical machinery but also scale-intensive manufacturing (i.e. rubber and plastic products; basic metals; motor vehicles); (iii) Supporting Infrastructure Services (SIS) encompassing network infrastructure services (i.e. Post and telecommunications), financial intermediation as well as wholesale trade and transport activities; and (iv) Personal Goods and Services (PGS) which includes supplier-dominated goods (i.e. food and beverages; textiles; leather) together with supplier-dominated services such as Sales, maintenance and repair of motor vehicles; retail trade and repair of personal and household goods; hotels and restaurants.¹⁴

For the purpose of a comparative analysis we assigned each of the 290 4-digit NAICS industries to a unique class within the other taxonomies. In all cases the industrial classification of reference is NACE rev. 2. Accordingly we built a crosswalk between our 290 4-digit NAICS and 2-digit NACE rev.2 sectors to the effect of matching industries in the two sets.¹⁵ After this step we are left with 285 4-digit NAICS.¹⁶ Appendix B provides the result from the crosswalk where each 4-digit NAICS industry has been assigned to a 2-digit NACE rev. 2 code and then, following the relevant contribution (Pavitt 1984; Miozzo and Soete, 2001; Castellacci, 2008) to the respective industrial class. As a result, the 285 industries in our dataset can be classified according to the taxonomies of Pavitt-Miozzo-Soete (PMS) and Castellacci (FC). Subsequently we proceeded in three steps.

First, we cross-tabulated industry co-occurrences between our taxonomy and the others to detect overlaps with a cut-off value of 40%.¹⁷ The logic is as follows. A high overlap suggests that the distribution of industries in our Cluster constructs coincides with that of other taxonomies. Arguably a systematic overlap indicates that our taxonomy may be redundant because it does not add much to previous work. When a high overlap between

¹⁴ Heuristic comparisons have been tried with other taxonomies in the literature but for the sake of parsimony we restrained to the two above. Further trials are available by the authors upon request.

¹⁵ Our starting point was the concordance table provided by CENSUS and available at: <http://www.census.gov/eos/www/naics/concordances/concordances.html>.

¹⁶ We were unable to allocate five 4-digit NAICS to 2-digit NACE rev.2. These are: 4821 (Rail Transportation), 5251 (Insurance and Employee Benefit Funds), 9991 (Federal Executive Branch and United States Postal Service), 9992 (State Government) and 9993 (Local Government).

¹⁷ We set the cut-off value at 40% for ease of exposition. Results hold in terms of the robustness and differentiation irrespective of the cut-off value. Results are available from the authors upon request.

clusters of different taxonomies was detected, we moved to the next step, the actual comparison of the identified groups by means of multivariate regression similar to the previous section. The goal is to assess the relationship between different types of skill intensities and the probability of being part of a group in a different taxonomy compared to our classification conditional on the set of industry characteristics. Clearly, one of our clusters and a cluster from a different taxonomy can share a number of industries but can also contain industries extremely different in the remaining group. By regressing the likelihood of belonging to a particular group against a number of characteristics we can appreciate the extent of the similarity. The last step of our procedure consists in comparing the skill coefficients across models and testing statistically the contribution of the skill factors to the cluster. Specifically, for each skill factor construct we compute one parameter vector and simultaneous (co)variance matrix of the sandwich/robust type and then we test whether their difference is significantly different from zero. Doing so allows us to check whether other classifications capture the relative importance of skill repertoires across industries. We now present these comparisons and comment them in the last subsection.

4.1 – Comparison with Pavitt-Miozzo-Soete taxonomy

Table 3a reports the cross-tabulation between our clusters and those of Pavitt-Miozzo-Soete (PMS): industry co-occurrences are expressed by percentages. The Pearson χ^2 test of independence (statistically different from zero) suggests the existence of an association between the two groups. As shown in the Table our Cluster 1, *Complex Production and Distribution*, is spread across most PMS groups with no two constructs from either classifications showing strong overlap (highest overlap 29% with Scale Intensive, SI). This suggests that the two taxonomies capture different things. At the same time we detect significant overlaps between two sets of groups: *Basic Production and Distribution* (cluster 2) and *Non-People Services* in NPS (48% co-occurrences); and *People Services* and *Personal Services* 46%. Coherent with the prelude to this analysis, we concentrate on the comparison of these two subsets of industries.

Let us check whether these associations are merely quantitative or whether they are due to the actual composition of the constructs. The multivariate regression in Table 3b indicates that the overlap between our *People Services* and PMS' *Personal Services* reflects some similarity. Indeed, the Breusch-Pagan test is highly significant, thus suggesting that the

residuals of the two models are dependent.¹⁸ A closer look at the coefficients of the first two models in Table 3b supports the intuition that the similarity between the two constructs is driven by industry ecology, and therefore by the industry types (i.e. H-KIS, H-TECH, et cetera), more than anything else. The coefficient of the skill factors in both groups share the same sign but not the same level of significance. On the other hand, *Basic Production and Distribution* shows no significant association with PMS' *Non-Personal Services*. The Breusch-Pagan test does not reject independence of the residuals, and a comparison of the coefficients does not suggest any similarity. Last but not least, the tests of equality between coefficients at the bottom of Table 3b offer further insight on the extent to which the constructs are qualitatively similar. For what concerns *Interactive and Abstract Skills* we find that the coefficients are significantly different in both comparisons. Conversely, the coefficients for *Technical and Analytical Skills* are significantly different only in the first comparison, *People Services* vs NPS.

TABLES 3a and 3b ABOUT HERE

4.2 – Comparison with Castellacci's taxonomy

Table 4a shows the cross-tabulation of our clusters with the categories Castellacci (2008). Again the rejection of the Pearson χ^2 test of independence suggests the possibility of some quantitative association between the groups in the two taxonomies. Indeed we observe high co-occurrences between *Basic Production and Distribution* and Personal Goods and Services (PGS) (55%), and between *People Services* and again PGS (56%). Like before, we use multivariate regression to compare the two groups (Table 4b).

The first two columns show that the coefficients of our cluster 1, *Basic Production and Distribution*, and of Castellacci's PGS are mostly at variance for what concerns both significance levels and the signs. This is confirmed by the non-significant value of the Breusch-Pagan test. On the whole this resonates with a closer look at the nature of the two constructs: our cluster is populated mostly by low-tech manufacturing and trade activities while Castellacci's includes KIBS and other such services. Thus, the similarity between the two is only apparent. Moving to the other comparison, we detect a somewhat stronger correspondence between *People Services* and PGS, especially for what concerns the

¹⁸ Although Breusch-Pagan test was originally developed to test for heteroschedasticity in a linear regression model, it seemingly applies to test independence among equations in multivariate regression models. In our case, we calculate the F-test in a regression containing all the estimated squared residuals from the different regressions of the multivariate model. If this test confirms that all residuals are jointly significant then the null hypothesis of independence among equations in the multivariate model can be rejected.

coefficient and the significance levels of the associated skill factors. But again, the Breusch-Pagan test indicates that the residuals are independent. This is further corroborated by the tests reported at the bottom of Table 4b showing that when comparing *Basic Production Distribution* and Castellacci's PGS, the coefficients for *Interactive and Abstract Skills* and *Technical and Analytical Skills* are significantly different between the two taxonomies. On the other hand the Breusch-Pagan test reveals significant similarity in *Technical and Analytical Skills* between *People Service* and Castellacci's PGS indicates. Put otherwise, the PGS group properly captures the skill content of this group of industries.

TABLES 4a and 4b ABOUT HERE

4.3 – *Summing up*

The key message stemming from this analysis is that industries differ in the variety of capabilities they employ. These differences do not depend solely on which skills are used but also on how skills combine with each other. This is why we argue that labour is a useful empirical dimension: employment structures are akin to coordinating devices for ensuring coherence between what is required from the workforce and the pool of capabilities that are available. The heuristic comparison between our taxonomy and other comparable classificatory exercises indicates that the skill-based analysis captures an aspect of industry organization that previous works do not. Indeed when the direct comparison between candidate groups suggests broad similarities, there is a systematic variance in the relative intensity of industry-specific skills. In formal terms, this means that the industry-cluster construct is due to a 'within industry' effect, viz. intensity of use of a particular skill, and a 'between industry' effect reflecting the comparative cognitive specialization of some industries compared to others.

The first comparison suggests that our taxonomy captures patterns of combinations of know-how that fall outside of the remit of Pavitt, Miozzo and Soete. We ascribe this to the absence in our constructs of the manufacturing-services dualism that was rather common to early taxonomic exercises. Such a division is partly grounded in historical reasons given that the interpenetration between increasingly complex products and ever-more refined services has gained consensus among scholars only over the last fifteen years (see e.g. Miles, 2005). The confirmation of this is that KIBS, once considered a monolithic block of high-level services, emerge from our analysis as a very diverse group encompassing professional activities that rely on specialist technical know-how, for example Engineering or Computer System Design,

but also highly interpersonal or even creative services, such as legal assistance and advertisement. And, indeed, different types of KIBS belong to different cluster constructs in our taxonomy.¹⁹ This lends support to the idea that cross-sectoral differences are not so much due to some activities belonging to ‘high-’ or ‘low-’ categories – regardless of whether the prefix applies to technology or knowledge – but rather on how work activities are organized and on the particular type of know-how they use.

Turning to the other comparison, the similarity between Castellacci’s *Personal Goods and Services* group and our *People Services* cluster is not surprising. A closer look at these constructs reveals that, beyond mere industry matching, the know-how content is similar, prominently interpersonal and communication skills as well as cognitive ability to think creatively. What is most striking however, and this applies to the comparison with PMS’ taxonomy, is the lack of a match with our *Complex Production and Distribution* cluster. It is worth reminding that this is a distinctive group of industries exhibiting a strong and positive association with both *Interactive and Abstract Skills* and *Technical and Analytical Skills* factors. We interpret this cluster as a reflection of significant transformations occurred in the US economy over the last fifteen years due to the maturing of the technological base and the concurrent expansion of international trade. For what concerns the former, the literature has shown convincingly that the first wave of computer diffusion exerted a positive selection effect on high-skill professionals – mostly jobs entailing intensive use of abstract skills – and a negative effect on routine-intensive occupations – mostly jobs whose core tasks (i.e. processing information or assembling) were displaced by computer capital (Autor et al, 2003). As this technology reached maturity, at least in the early domains of application such as office and industrial machinery, the attendant specialist know-how has been codified and widely diffused and this has progressively reduced the initial comparative advantage of high-skill workers (Vona and Consoli, 2015). At the same time the pressure of unprecedented growth in international trade on the US and other advanced economies has accelerated the fragmentation of supply chains and the switch to high-quality products relying intensively on a broad range of Non-Routine skills (Baldwin, 2011; Consoli et al, 2014). These developments have not undermined the importance of technical know-how but, rather, changed the way in which this is strategically used, notably in conjunction with interpersonal skills. Put another way, the emergence of a highly specialized cluster that brings together Hi-

¹⁹ Though this would have not surprised an economist of past generations like Solomon Fabricant who made a compelling case about the heterogeneity of services in a rather old manuscript (Fabricant, 1972).

and Medium- Tech Manufacturing and knowledge intensive services is a consequence of the evolution of the selection forces at work in the US economy (see Autor et al, 2013).

Before concluding, a caveat is in order. The low correspondence between the taxonomies reviewed here is not necessarily a sign of weakness on either side. True, the arrangement of sectors today is not what it was, say, at the time of Pavitt's analysis. But we argue that this reaffirms the dynamic validity of taxonomic constructs. If we consider the 'logic' of arranging sectors by functional similarities, the sets of results reviewed here are arguably not ontologically dissimilar. Put otherwise, the enduring legacy of Pavitt's (1984) contribution is the intuition of classifying sectors through snapshots of knowledge organization, however imperfect they may be. Underpinning this heuristic model is the axiom that knowledge structures have transient nature: repeat the same exercise thirty years on and different configurations will be observed due to further evolution of the knowledge configurations.

5. Concluding remarks

Innovation scholars have often adopted industry classifications to grasp the characteristics of technological change and, more implicitly, of the underpinning organization of knowledge. This paper takes workforce skills as unit of analysis to detect commonalities and differences in the knowledge base of industry. Let us sum up the main results and reflect about future avenues of research that may stem from the present work.

First, we draw attention to the relation between labour, knowledge and the organization of industry, arguably an underdeveloped topic in innovation studies. In particular, we surmise that the skills content of the workforce is a reliable indicator of the knowledge that is relevant to an industry at any time. Accordingly, as industry needs evolve over time the occupational structures and the relevant skills are, so to speak, engaged in an open-ended chase along the trajectory of knowledge growth which, as argued elsewhere, calls upon institutional responses to fill emergent skill gaps (Rosenberg, 1998; Vona and Consoli, 2015). In this view evolving skill structures are both the cause and the effect of shifting industrial regimes based on the generation, adaptation and diffusion of useful knowledge.

The paper proposes a novel taxonomy of industrial sectors based on the analysis of the skill content of occupations across 290 sectors in the US. This empirical exercise yields two skill factors and three industry clusters. The former capture parsimoniously the co-existence of different types of knowledge distinguished functionally depending on whether skills are employed for non-routine cognitive tasks or for manual activities. In the latter, the industry

clusters, service activities are present everywhere and exhibit strong complementarity with manufacturing production (Clusters 1 and 2) or stand alone in the construct with the stronger interactive nature (Cluster 3). This result resonates with recent research suggesting that the traditional dualism with manufacturing is perhaps obsolete (Castellacci, 2008; Peneder, 2007) and casts a shadow on the persistent view of services as a homogeneous block of activities (Consoli and Elche, 2010; 2013).

To conclude, there is no doubt that this work is but a preliminary step in an arguably promising trajectory. Greater understanding of industry-specific skill content opens important windows on policy issues concerning skill mismatches, knowledge gaps and on the role of education policy in responding to emergent industry needs. Growing availability of micro-longitudinal data such as those used here bodes well for future endeavors in this area of study. The most enticing prospect, and our next goal, is to retrieve other industry dimensions, both economic (i.e. productivity, value added) and technological (i.e. patenting), to explore statistical regularities with the skill configurations. Attractive as these endeavours may appear, any future empirical exercise will need a prior effort of systematization of concepts and methods that, we hope, this paper contributes to outline.

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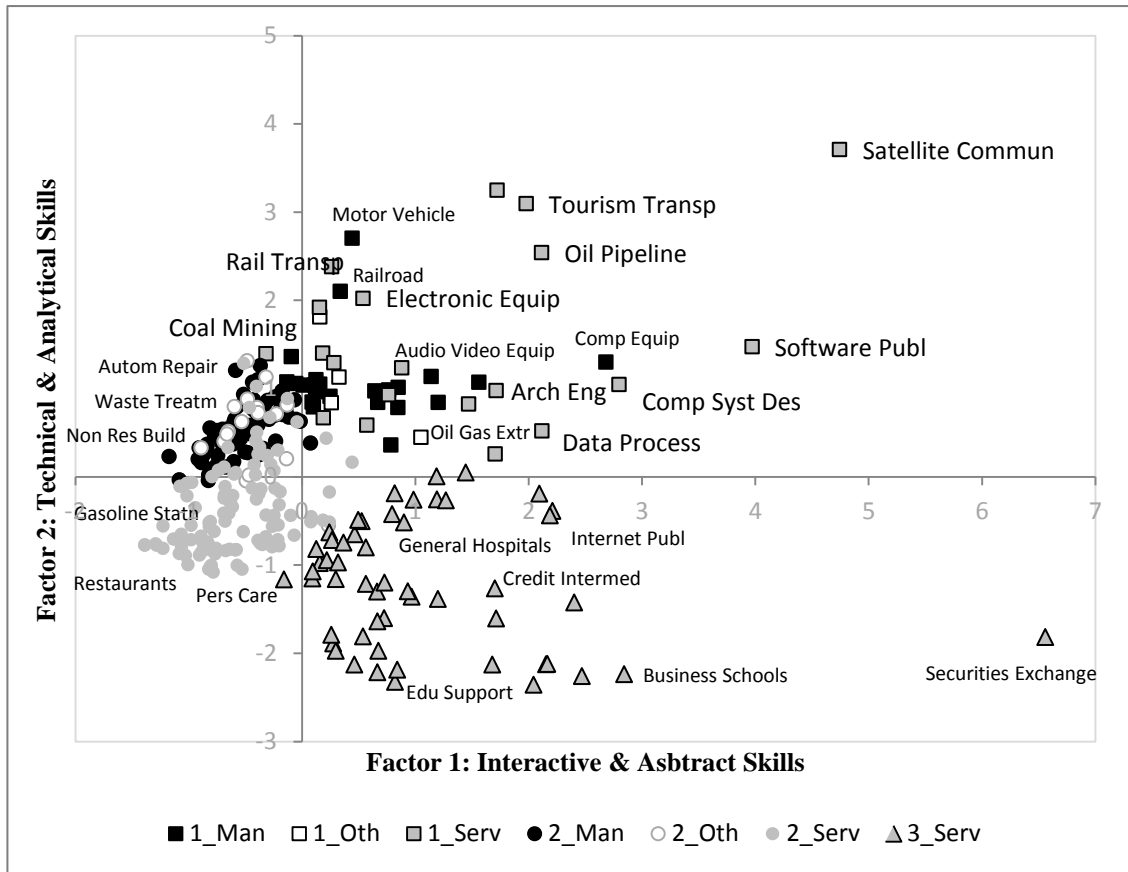
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Note: industries are labeled according to two dimensions: cluster (shape) and type (color).

Legend: Square=Complex Production (Cluster 1); Circle=Basic Production and Distribution (Cluster 2); Triangle=People Services (Cluster 3); Black=Manufacturing; Gray=Services; White=Other (Agriculture, Mining, Utilities).

Figure 1: Industry Clusters by Skill Factors

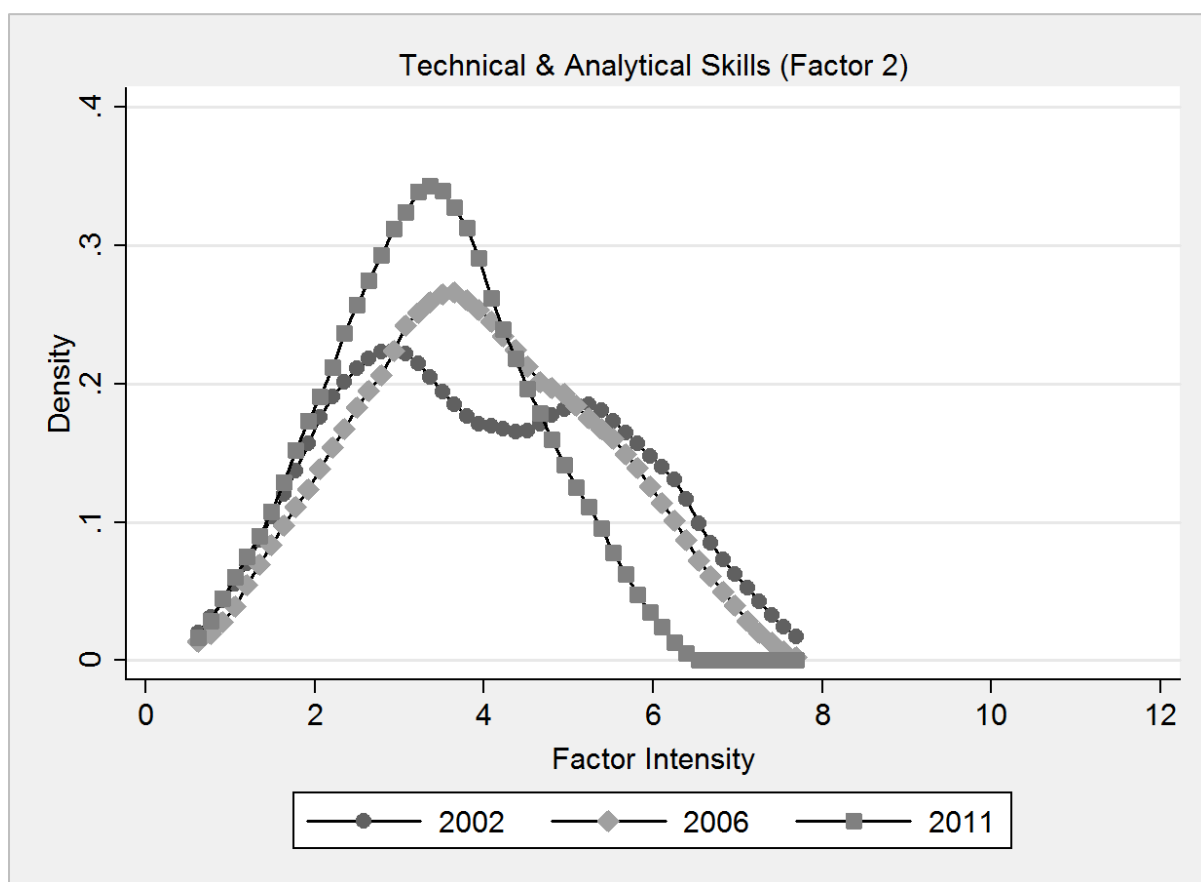
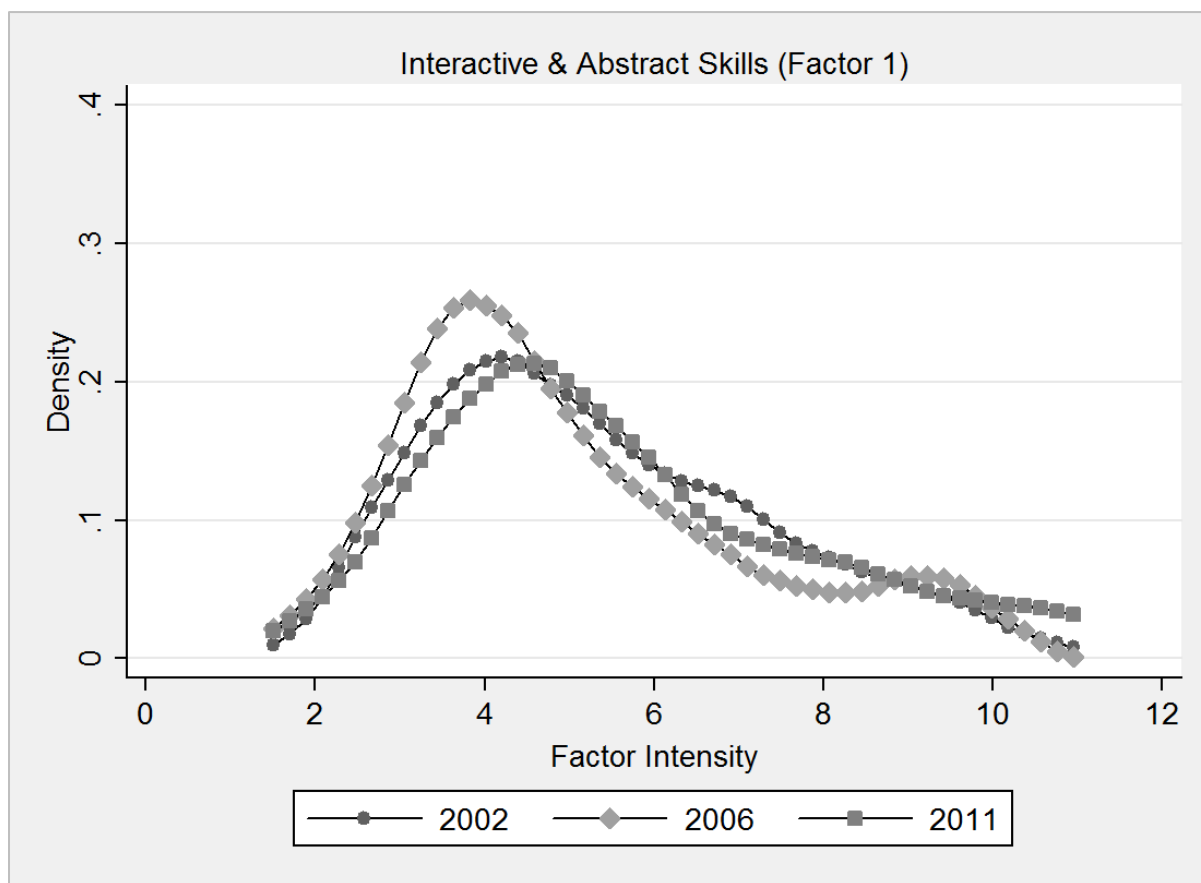


Figure 2: Kernel density distributions of Skill-Factors intensity across industries

		Principal Component		Iterated Principal Factors		Maximum Likelihood	
		<i>Factor1</i>	<i>Factor2</i>	<i>Factor1</i>	<i>Factor2</i>	<i>Factor1</i>	<i>Factor2</i>
Factor 1 Interactive & Abstract	Active Learning	0.9427	0.322	0.9428	0.3241	0.9244	0.3742
	Active Listening	0.9736	0.1897	0.974	0.1909	0.9722	0.2203
	Complex Problem Solving	0.9101	0.4001	0.9095	0.4028	0.8808	0.4654
	Coordination	0.927	0.3382	0.9262	0.3404	0.9179	0.3584
	Critical Thinking	0.9464	0.3105	0.9466	0.3124	0.9302	0.3614
	Instructing	0.9216	0.156	0.9155	0.1611	0.9339	0.1509
	Judgment & Decision Making	0.9264	0.3553	0.926	0.3577	0.9046	0.4101
	Learning Strategies	0.943	0.1881	0.9398	0.1913	0.9466	0.2002
	Mathematics	0.7929	0.5464	0.7901	0.548	0.7452	0.627
	Manag of Financial Resources	0.8822	0.3144	0.877	0.3176	0.8456	0.3902
	Manag of Material Resources	0.8277	0.5265	0.8258	0.5293	0.7964	0.5637
	Manag of Personnel	0.9216	0.3269	0.92	0.3294	0.9031	0.363
	Monitoring	0.9523	0.2731	0.9522	0.2749	0.9457	0.2986
	Negotiation	0.9578	0.2	0.9564	0.2024	0.9428	0.25
	Operations Analysis	0.7981	0.5255	0.7949	0.5269	0.7376	0.6316
	Persuasion	0.9753	0.1703	0.9754	0.1718	0.9608	0.2258
	Programming	0.6437	0.4904	0.6371	0.4819	0.5586	0.6517
	Reading Comprehension	0.9503	0.2899	0.9504	0.2918	0.9401	0.3314
	Science	0.6526	0.5262	0.6475	0.5174	0.6338	0.5471
	Social Perceptiveness	0.9633	0.0154	0.9603	0.0192	0.9786	0.0187
	Speaking	0.9825	0.1438	0.9833	0.1446	0.9826	0.1749
	Service Orientation	0.9608	0.0245	0.9574	0.0286	0.9723	0.0328
	Systems Analysis	0.8132	0.5307	0.8108	0.533	0.7631	0.6153
	Systems Evaluation	0.8417	0.5021	0.8398	0.5049	0.797	0.5785
	Time Management	0.9566	0.2656	0.9567	0.2673	0.9491	0.2959
	Writing	0.9716	0.2132	0.9722	0.2145	0.9627	0.2602
Factor 2 Technical & Analytical	Equipment Maintenance	-0.0035	0.941	0.0006	0.9277	0.0078	0.8072
	Equipment Selection	0.5784	0.7847	0.5761	0.7866	0.5526	0.7789
	Installation	0.2513	0.9222	0.251	0.9176	0.2118	0.9106
	Operation and Control	0.2197	0.8961	0.2233	0.8808	0.2259	0.7946
	Operation Monitoring	0.1511	0.9346	0.1529	0.9253	0.1457	0.8504
	Quality Control Analysis	0.5373	0.8184	0.5348	0.8213	0.4934	0.8476
	Repairing	-0.0656	0.9425	-0.0618	0.9302	-0.0675	0.8328
	Technology Design	0.6143	0.7112	0.6121	0.7081	0.5541	0.7895
	Troubleshooting	0.4013	0.9022	0.398	0.9075	0.3626	0.9023
<i>% of variance explained</i>		0.5824	0.2488	0.5446	0.3058	0.5768	0.256
<i>Cumulative % of var expl</i>		0.5824	0.8312	0.5446	0.8504	0.5768	0.8328

Rotation method: Varimax with Kaiser normalization.

Table 1: Factor Analysis

	Complex Production and Distribution (CL1)	Basic Production and Distribution (CL2)	People Services (CL3)
Interactive & Abstract Skills	0.1161*** [0.0243]	-0.2481*** [0.0298]	0.1320*** [0.0211]
Technical & Analytical Skills	0.2212*** [0.0202]	-0.0293 [0.0247]	-0.1919*** [0.0175]
Labour productivity	0.0049 [0.0056]	-0.0052 [0.0069]	0.0003 [0.0049]
Cap. Exp. OCM	0.0043*** [0.0015]	-0.0045** [0.0018]	0.0002 [0.0013]
Cap. Exp. Infrastructures	-0.0024*** [0.0008]	0.0019** [0.0009]	0.0005 [0.0007]
N. of firms	0.0005 [0.0005]	-0.0009 [0.0006]	0.0004 [0.0004]
(Ref. Other)			
H-KIS	0.1303* [0.0767]	-0.3838*** [0.0941]	0.2535*** [0.0666]
H-TECH	0.6445*** [0.1138]	-0.5002*** [0.1396]	-0.1442 [0.0988]
L-KIS	0.1509** [0.0653]	-0.0684 [0.0801]	-0.0825 [0.0567]
L-TECH	0.2063** [0.0922]	-0.1932* [0.1131]	-0.0131 [0.0800]
Constant	-0.0935 [0.1563]	0.9757*** [0.1918]	0.1178 [0.1357]
N. of observations	285	285	285
R ²	0.5613	0.596	0.6941
Breusch-Pagan	$\chi^2(3)=250.493^{***}$		
<i>Tests of equality of coefficients</i>			
[Cluster 1] Factor 1 vs [Cluster 3] Factor 1	$\chi^2(1) = 0.17$		
[Cluster 1] Factor 1 vs [Cluster 1] Factor 2	$\chi^2(1) = 8.5^{***}$		

* p<0.10, ** p<0.05, *** p<0.01. Degrees of freedom and robust standard errors are in parentheses.

Capital Expenditures in Office and Computing Machinery (OCM) and in infrastructures both measured in million \$. Other=Agriculture, Mining, Utilities. H-KIS: High Knowledge Intensive Services; H-TECH=Hi-Tech Manufacturing; L-KIS=Low Knowledge Intensive Services; L-TECH: Low-Tech Manufacturing.

Table 2: Multivariate Regression

	Complex Production and Distribution	Basic Production and Distribution	People Services
NPS	23%	48%	22%
PS	19%	8%	76%
SB	13%	0%	0%
SD	2%	19%	2%
SI	29%	22%	0%
SS	15%	4%	0%
Total	48	185	54
Pearson χ^2	166.48(10)***		

*** p<0.01. Degrees of freedom are in parentheses. Personal Services (PS); Non-Personal Services (NPS); Scale-Intensive (SI); Supplier-Dominated (SD); Science-Based (SB); Specialised Supplier (SS)

Table 3a: Pavitt-Miozzo-Soete taxonomy: cross-tabulation

	People Services	PS	Basic Production and Distribution	NPS
Interactive & Abstract Skills	0.1320*** [0.0379]	0.0063 [0.0403]	-0.2481*** [0.0560]	-0.0095 [0.0406]
Technical & Analytical Skills	-0.1919*** [0.0251]	-0.0319 [0.0268]	-0.0293 [0.0403]	-0.0014 [0.0335]
Labour productivity	0.0003 [0.0047]	0.0156** [0.0069]	-0.0052 [0.0079]	-0.0125 [0.0087]
Cap. Exp. OCM	0.0002 [0.0015]	0.0012 [0.0016]	-0.0045** [0.0019]	-0.0009 [0.0018]
Cap. Exp. Infrastructures	0.0005 [0.0006]	0.0017*** [0.0006]	0.0019 [0.0012]	-0.0012* [0.0006]
N. of firms	0.0004 [0.0005]	0.0016** [0.0007]	-0.0009** [0.0004]	-0.0017** [0.0007]
H-KIS	0.2535*** [0.0900]	0.6839*** [0.0934]	-0.3838*** [0.1150]	0.0956 [0.1234]
H-TECH	-0.1442* [0.0776]	-0.1977*** [0.0693]	-0.5002*** [0.1567]	-0.0063 [0.1161]
L-KIS	-0.0825** [0.0386]	0.1656*** [0.0516]	-0.0684 [0.0676]	0.6262*** [0.0961]
L-TECH	-0.0131 [0.0597]	-0.1053* [0.0618]	-0.1932 [0.1209]	-0.0898 [0.1079]
Constant	0.1178 [0.1291]	-0.4826** [0.1913]	0.9757*** [0.1859]	0.5525** [0.2237]
N. of observations	285	285	285	285
R ²	0.6941	0.547	0.596	0.5832
Breusch-Pagan	$\chi^2(1)=9.443***$		$\chi^2(1)=1.698$	
<i>Tests of equality of coefficients</i>				
[SK] Factor 1 vs [PMS] Factor 1	$\chi^2(1)=6.89***$		$\chi^2(1)=14.02***$	
[SK] Factor 2 vs [PMS] Factor 2	$\chi^2(1)=21.28***$		$\chi^2(1)=0.34$	

* p<0.10, ** p<0.05, *** p<0.01. Degrees of freedom and robust standard errors are in parentheses. SK=Skill taxonomy, PMS= Pavitt Miozzo and Soete taxonomy. Personal Services (PS), Non-Personal Services (NPS).

Table 3b: Pavitt-Miozzo-Soete taxonomy: multivariate regression

	Complex Production and Distribution	Basic Production and Distribution	People Services
AKP	33%	5%	15%
MPG	25%	21%	0%
PGS	13%	55%	56%
SIS	29%	19%	30%
Total	48	185	54
Pearson χ^2	58.03(6)***		

*** p<0.01. Degrees of freedom are in parentheses. Advanced Knowledge Providers (AKP), Mass production Goods (MPG), Supporting Infrastructure Services (SIS) Personal Goods and Services (PGS).

Table 4a: Castellacci taxonomy: cross-tabulation

	Basic Production and Distribution	PGS	People Services	PGS
Interactive & Abstract Skills	-0.2481*** [0.0560]	0.0513* [0.0278]	0.1320*** [0.0379]	0.0513* [0.0278]
Technical & Analytical Skills	-0.0293 [0.0403]	-0.1705*** [0.0279]	-0.1919*** [0.0251]	-0.1705*** [0.0279]
Labour productivity	-0.0052 [0.0079]	-0.0358*** [0.0088]	0.0003 [0.0047]	-0.0358*** [0.0088]
Cap. Exp. OCM	-0.0045** [0.0019]	0.0032 [0.0027]	0.0002 [0.0015]	0.0032 [0.0027]
Cap. Exp. Infrastructures	0.0019 [0.0012]	-0.0060*** [0.0012]	0.0005 [0.0006]	-0.0060*** [0.0012]
N. of firms	-0.0009** [0.0004]	0.0008 [0.0008]	0.0004 [0.0005]	0.0008 [0.0008]
H-KIS	-0.3838*** [0.1150]	-0.2433* [0.1384]	0.2535*** [0.0900]	-0.2433* [0.1384]
H-TECH	-0.5002*** [0.1567]	0.2369 [0.1690]	-0.1442* [0.0776]	0.2369 [0.1690]
L-KIS	-0.0684 [0.0676]	-0.0741 [0.1359]	-0.0825** [0.0386]	-0.0741 [0.1359]
L-TECH	-0.1932 [0.1209]	0.4268** [0.1742]	-0.0131 [0.0597]	0.4268** [0.1742]
Constant	0.9757*** [0.1859]	1.5006*** [0.2839]	0.1178 [0.1291]	1.5006*** [0.2839]
N. of observations	285	285	285	285
R ²	0.596	0.372	0.6941	0.372
Breusch-Pagan	$\chi^2(1)=1.17$		$\chi^2(1)=1.08$	
Tests of equality of coefficients				
[SK] Factor 1 vs [CASTEL] Factor 1	$\chi^2(1)=27.44***$		$\chi^2(1)=2.71*$	
[SK] Factor 2 vs [CASTEL] Factor 2	$\chi^2(1)=9.86***$		$\chi^2(1)=0.34$	

* p<0.10, ** p<0.05, *** p<0.01. Degrees of freedom and robust standard errors are in parentheses. SK=Skill taxonomy, CASTEL=Castellacci taxonomy. Personal Goods and Services (PGS).

Table 4b: Castellacci taxonomy: multivariate regression

Appendix A

O*NET, the Occupational Information Network, is a database of worker attributes and job characteristics maintained by the U.S. Department of Labor (DOL) and the National Center for O*NET Development, through its contractor Research Triangle Institute. It is the replacement for the Dictionary of Occupational Titles (DOT) and the primary source of occupational information for the US labour market. Data Collection is carried out in two steps: (1) identification of a random sample of businesses expected to employ workers in the targeted occupations, and (2) selection of a random sample of workers in those occupations within those businesses. New data are collected by means of a survey circulated among job incumbents (National Research Council, 2010). Occupations in O*NET are defined according to the criteria of the Standard Occupational Classification (SOC) system. Data Collection provides descriptive ratings based on the questionnaire covering various aspects of the occupation: Worker Characteristics, Worker Requirements, Experience Requirements, Occupation Requirements, Occupational Characteristics, and Occupation-Specific Information. In addition to the questionnaires completed by workers and occupation experts, additional ratings are provided by occupation analysts. Responses from all three sources – workers, occupation experts, and occupation analysts – are used to provide complete information for each occupation. The standardized skill set on which the questionnaire is built contains the categories reported in the table below.

I. Basic Skills	IV. Social Skills
Active Learning	Coordination
Active Listening	Instructing
Critical Thinking	Negotiation
Learning Strategies	Persuasion
Mathematics	Service Orientation
Monitoring	Social Perceptiveness
Reading Comprehension	V. Systems Skills
Science	Judgment and Decision Making
Speaking	Systems Analysis
Writing	Systems Evaluation
II. Complex Problem Solving Skills	VI. Technical Skills
Complex Problem Solving	Equipment Maintenance
III. Resource Management Skills	Equipment Selection
Management of Financial Resources	Installation
Management of Material Resources	Operation and Control
Management of Personnel Resources	Operation Monitoring
Time Management	Operations Analysis
	Programming
	Quality Control Analysis
	Repairing
	Troubleshooting
	Technology Design

Appendix B

(Legenda: SK= Skill taxonomy; FC=Fulvio Castellacci; PMS=Pavitt, Miozzo and Soete; F1= Interactive & Abstract Skills, F2= Technical & Analytical Skills)

NAICS	Description	F1	F2	Type	SK	FC	PMS
3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	4.92	5.53	L-TECH	Basic Production	AKP	SS
3339	Other General Purpose Machinery Manufacturing	5.54	5.25	H-TECH	Basic Production	AKP	SS
5612	Facilities Support Services	4.94	3.53	L-KIS	Basic Production	AKP	PS
3331	Agriculture, Construction, and Mining Machinery Manufacturing	5.00	5.24	L-TECH	Basic Production	AKP	SS
5615	Travel Arrangement and Reservation Services	4.73	2.03	L-KIS	Basic Production	AKP	NPS
3391	Medical Equipment and Supplies Manufacturing	4.73	4.30	H-TECH	Basic Production	AKP	SS
5613	Employment Services	3.07	2.37	H-KIS	Basic Production	AKP	PS
5614	Business Support Services	4.58	2.27	L-KIS	Basic Production	AKP	PS
5419	Other Professional, Scientific, and Technical Services	6.08	3.62	H-KIS	Basic Production	AKP	PS
3328	Coating, Engraving, Heat Treating, and Allied Activities	3.83	4.24	L-TECH	Basic Production	MPG	SI
3312	Steel Product Manufacturing from Purchased Steel	4.57	5.16	L-TECH	Basic Production	MPG	SI
3362	Motor Vehicle Body and Trailer Manufacturing	4.30	4.81	L-TECH	Basic Production	MPG	SI
3351	Electric Lighting Equipment Manufacturing	5.31	5.21	L-TECH	Basic Production	MPG	SS
3272	Glass and Glass Product Manufacturing	3.69	4.40	L-TECH	Basic Production	MPG	SI
3372	Office Furniture (including Fixtures) Manufacturing	4.72	4.89	L-TECH	Basic Production	MPG	SD
3211	Sawmills and Wood Preservation	3.02	3.86	L-TECH	Basic Production	MPG	SD
3273	Cement and Concrete Product Manufacturing	3.47	3.78	L-TECH	Basic Production	MPG	SI
3371	Household and Institutional Furniture and Kitchen Cabinet Manufacturing	3.15	3.87	L-TECH	Basic Production	MPG	SD
3259	Other Chemical Product and Preparation Manufacturing	5.71	5.23	L-TECH	Basic Production	MPG	SI
3359	Other Electrical Equipment and Component Manufacturing	5.10	5.15	L-TECH	Basic Production	MPG	SD
3399	Other Miscellaneous Manufacturing	4.19	4.01	L-TECH	Basic Production	MPG	SD
3315	Foundries	3.79	4.94	L-TECH	Basic Production	MPG	SI
3329	Other Fabricated Metal Product Manufacturing	4.88	5.02	L-TECH	Basic Production	MPG	SS
3323	Architectural and Structural Metals Manufacturing	4.63	4.93	L-TECH	Basic Production	MPG	SI

3322	Cutlery and Handtool Manufacturing	5.16	5.32	L-TECH	Basic Production	MPG	SI
3352	Household Appliance Manufacturing	4.49	5.05	L-TECH	Basic Production	MPG	SS
3262	Rubber Product Manufacturing	3.66	4.63	L-TECH	Basic Production	MPG	SI
3313	Alumina and Aluminium Production and Processing	4.16	5.36	L-TECH	Basic Production	MPG	SI
3311	Iron and Steel Mills and Ferroalloy Manufacturing	4.14	5.62	L-TECH	Basic Production	MPG	SI
3314	Nonferrous Metal (except Aluminium) Production and Processing	4.78	5.30	L-TECH	Basic Production	MPG	SI
3326	Spring and Wire Product Manufacturing	5.14	5.39	L-TECH	Basic Production	MPG	SI
2123	Non-metallic Mineral Mining and Quarrying	3.64	4.52	Other	Basic Production	MPG	SI
3111	Animal Food Manufacturing	3.74	3.41	L-TECH	Basic Production	MPG	SI
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	4.18	4.85	L-TECH	Basic Production	MPG	SI
3379	Other Furniture Related Product Manufacturing	4.26	4.40	L-TECH	Basic Production	MPG	SD
3113	Sugar and Confectionery Product Manufacturing	2.96	3.31	L-TECH	Basic Production	MPG	SI
3116	Animal Slaughtering and Processing	1.93	2.81	L-TECH	Basic Production	MPG	SI
3261	Plastics Product Manufacturing	3.68	4.34	L-TECH	Basic Production	MPG	SI
3363	Motor Vehicle Parts Manufacturing	4.12	4.97	L-TECH	Basic Production	MPG	SI
3279	Other Non-metallic Mineral Product Manufacturing	4.18	4.44	L-TECH	Basic Production	MPG	SI
3271	Clay Product and Refractory Manufacturing	4.18	4.50	L-TECH	Basic Production	MPG	SI
3112	Grain and Oilseed Milling	4.19	4.81	L-TECH	Basic Production	MPG	SI
1152	Support Activities for Animal Production	4.48	3.44	Other	Basic Production	MPG	SI
2121	Coal Mining	3.75	5.42	Other	Basic Production	MPG	SI
1151	Support Activities for Crop Production	2.89	3.32	Other	Basic Production	MPG	SI
3321	Forging and Stamping	4.94	5.55	L-TECH	Basic Production	MPG	SI
2131	Support Activities for Mining	4.35	4.80	Other	Basic Production	MPG	SI
1133	Logging	3.59	3.99	Other	Basic Production	MPG	SD
4529	Other General Merchandise Stores	2.90	1.56	L-KIS	Basic Production	PGS	NPS
3255	Paint, Coating, and Adhesive Manufacturing	6.18	5.01	L-TECH	Basic Production	PGS	SI
4239	Miscellaneous Durable Goods Merchant Wholesalers	3.97	2.68	L-KIS	Basic Production	PGS	NPS
7224	Drinking Places (Alcoholic Beverages)	2.07	1.19	L-KIS	Basic Production	PGS	NPS
3122	Tobacco Manufacturing	5.42	5.53	L-TECH	Basic Production	PGS	SI
4442	Lawn and Garden Equipment and Supplies Stores	4.09	3.01	L-KIS	Basic Production	PGS	NPS
4411	Automobile Dealers	4.91	3.39	L-KIS	Basic Production	PGS	NPS

7121	Museums, Historical Sites, and Similar Institutions	5.70	2.89	H-KIS	Basic Production	PGS	NPS
4532	Office Supplies, Stationery, and Gift Stores	4.26	2.16	L-KIS	Basic Production	PGS	NPS
8121	Personal Care Services	3.90	1.82	L-KIS	Basic Production	PGS	NPS
4244	Grocery and Related Product Wholesalers	3.05	2.00	L-KIS	Basic Production	PGS	NPS
7211	Traveler Accommodation	2.19	1.57	L-KIS	Basic Production	PGS	NPS
4421	Furniture Stores	3.80	1.92	L-KIS	Basic Production	PGS	NPS
3117	Seafood Product Preparation and Packaging	2.96	3.16	L-TECH	Basic Production	PGS	SI
4441	Building Material and Supplies Dealers	3.95	2.05	L-KIS	Basic Production	PGS	NPS
4531	Florists	4.35	2.23	L-KIS	Basic Production	PGS	NPS
3159	Apparel Accessories and Other Apparel Manufacturing	4.30	4.04	L-TECH	Basic Production	PGS	SD
3161	Leather and Hide Tanning and Finishing	4.45	4.64	L-TECH	Basic Production	PGS	SD
8134	Civic and Social Organizations	4.05	1.63	L-KIS	Basic Production	PGS	NPS
2389	Other Specialty Trade Contractors	3.57	3.98	Other	Basic Production	PGS	SD
3212	Veneer, Plywood, and Engineered Wood Product Manufacturing	3.22	3.93	L-TECH	Basic Production	PGS	SD
7213	Rooming and Boarding Houses	3.61	2.40	L-KIS	Basic Production	PGS	NPS
7212	RV (Recreational Vehicle) Parks and Recreational Camps	4.08	2.56	L-KIS	Basic Production	PGS	NPS
3121	Beverage Manufacturing	3.30	2.96	L-TECH	Basic Production	PGS	SI
2383	Building Finishing Contractors	3.50	3.85	Other	Basic Production	PGS	SD
6233	Community Care Facilities for the Elderly	3.98	2.01	H-KIS	Basic Production	PGS	PS
4511	Sporting Goods, Hobby, and Musical Instrument Stores	3.49	1.70	L-KIS	Basic Production	PGS	NPS
4235	Metal and Mineral (except Petroleum) Merchant Wholesalers	5.37	3.84	L-KIS	Basic Production	PGS	NPS
4543	Direct Selling Establishments	4.06	3.44	L-KIS	Basic Production	PGS	NPS
4248	Beer, Wine, and Distilled Alcoholic Beverage Merchant Wholesalers	5.30	2.72	L-KIS	Basic Production	PGS	NPS
7222	Limited-Service Eating Places	1.74	1.00	L-KIS	Basic Production	PGS	NPS
3151	Apparel Knitting Mills	3.38	4.05	L-TECH	Basic Production	PGS	SD
3119	Other Food Manufacturing	3.27	3.06	L-TECH	Basic Production	PGS	SI
4234	Professional and Commercial Equipment and Supplies Merchant Wholesalers	7.53	5.19	L-KIS	Basic Production	PGS	NPS
2372	Land Subdivision	7.29	3.83	Other	Basic Production	PGS	SD
4246	Chemical and Allied Products Merchant Wholesalers	5.61	3.58	L-KIS	Basic Production	PGS	NPS
7132	Gambling Industries	2.91	1.65	L-KIS	Basic Production	PGS	NPS

3131	Fiber, Yarn, and Thread Mills	3.42	5.20	L-TECH	Basic Production	PGS	SD
4481	Clothing Stores	3.20	1.36	L-KIS	Basic Production	PGS	NPS
7223	Special Food Services	2.11	1.16	L-KIS	Basic Production	PGS	NPS
5616	Investigation and Security Services	3.60	2.37	H-KIS	Basic Production	PGS	PS
4243	Apparel, Piece Goods, and Notions Merchant Wholesalers	5.88	2.97	L-KIS	Basic Production	PGS	NPS
3118	Bakeries and Tortilla Manufacturing	2.39	2.58	L-TECH	Basic Production	PGS	SI
4542	Vending Machine Operators	5.27	5.41	L-KIS	Basic Production	PGS	NPS
4539	Other Miscellaneous Store Retailers	3.60	1.98	L-KIS	Basic Production	PGS	NPS
4232	Furniture and Home Furnishing Merchant Wholesalers	5.54	3.19	L-KIS	Basic Production	PGS	NPS
3169	Other Leather and Allied Product Manufacturing	4.67	4.16	L-TECH	Basic Production	PGS	SD
2373	Highway, Street, and Bridge Construction	4.40	4.76	Other	Basic Production	PGS	SD
7139	Other Amusement and Recreation Industries	2.60	1.57	L-KIS	Basic Production	PGS	NPS
4412	Other Motor Vehicle Dealers	4.93	4.24	L-KIS	Basic Production	PGS	SI
3222	Converted Paper Product Manufacturing	3.64	4.12	L-TECH	Basic Production	PGS	SD
4238	Machinery, Equipment, and Supplies Merchant Wholesalers	5.10	4.15	L-KIS	Basic Production	PGS	NPS
6231	Nursing Care Facilities	5.39	2.88	H-KIS	Basic Production	PGS	PS
3221	Pulp, Paper, and Paperboard Mills	4.02	5.22	L-TECH	Basic Production	PGS	SD
3256	Soap, Cleaning Compound, and Toilet Preparation Manufacturing	5.11	4.55	L-TECH	Basic Production	PGS	SI
3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing	2.80	3.37	L-TECH	Basic Production	PGS	SI
3149	Other Textile Product Mills	3.79	3.98	L-TECH	Basic Production	PGS	SD
3141	Textile Furnishings Mills	3.02	3.54	L-TECH	Basic Production	PGS	SD
4413	Automotive Parts, Accessories, and Tire Stores	4.51	4.36	L-KIS	Basic Production	PGS	NPS
2381	Foundation, Structure, and Building Exterior Contractors	3.92	4.42	Other	Basic Production	PGS	SD
4233	Lumber and Other Construction Materials Merchant Wholesalers	4.19	2.91	L-KIS	Basic Production	PGS	NPS
4521	Department Stores	3.09	1.47	L-KIS	Basic Production	PGS	NPS
4512	Book, Periodical, and Music Stores	3.88	1.57	L-KIS	Basic Production	PGS	NPS
2362	Nonresidential Building Construction	5.54	4.39	Other	Basic Production	PGS	SD
2361	Residential Building Construction	4.50	3.62	Other	Basic Production	PGS	SD
3219	Other Wood Product Manufacturing	3.00	3.58	L-TECH	Basic Production	PGS	SD
2371	Utility System Construction	4.41	5.46	Other	Basic Production	PGS	SD
3132	Fabric Mills	3.54	4.09	L-TECH	Basic Production	PGS	SD

8123	Drycleaning and Laundry Services	3.37	3.13	L-KIS	Basic Production	PGS	NPS
2379	Other Heavy and Civil Engineering Construction	5.24	5.28	Other	Basic Production	PGS	SD
4236	Electrical and Electronic Goods Merchant Wholesalers	7.05	4.51	L-KIS	Basic Production	PGS	NPS
7131	Amusement Parks and Arcades	3.43	2.01	L-KIS	Basic Production	PGS	NPS
2382	Building Equipment Contractors	3.97	4.86	Other	Basic Production	PGS	SD
4422	Home Furnishings Stores	3.67	2.00	L-KIS	Basic Production	PGS	NPS
4533	Used Merchandise Stores	2.87	1.39	L-KIS	Basic Production	PGS	NPS
4461	Health and Personal Care Stores	7.07	4.18	L-KIS	Basic Production	PGS	NPS
4231	Motor Vehicle and Motor Vehicle Parts and Supplies Merchant Wholesalers	4.14	3.10	L-KIS	Basic Production	PGS	NPS
3115	Dairy Product Manufacturing	2.84	3.17	L-TECH	Basic Production	PGS	SI
4471	Gasoline Stations	3.52	1.92	L-KIS	Basic Production	PGS	NPS
7221	Full-Service Restaurants	1.74	1.01	L-KIS	Basic Production	PGS	NPS
4451	Grocery Stores	2.34	1.24	L-KIS	Basic Production	PGS	NPS
4453	Beer, Wine, and Liquor Stores	3.92	1.66	L-KIS	Basic Production	PGS	NPS
4452	Specialty Food Stores	3.14	1.79	L-KIS	Basic Production	PGS	NPS
4245	Farm Product Raw Material Merchant Wholesalers	4.14	2.88	L-KIS	Basic Production	PGS	NPS
3162	Footwear Manufacturing	3.40	3.55	L-TECH	Basic Production	PGS	SD
4431	Electronics and Appliance Stores	5.52	3.88	L-KIS	Basic Production	PGS	NPS
7113	Promoters of Performing Arts, Sports, and Similar Events	5.22	2.80	H-KIS	Basic Production	PGS	NPS
4249	Miscellaneous Nondurable Goods Merchant Wholesalers	3.62	2.23	L-KIS	Basic Production	PGS	NPS
4541	Electronic Shopping and Mail-Order Houses	5.42	2.86	L-KIS	Basic Production	PGS	NPS
3133	Textile and Fabric Finishing and Fabric Coating Mills	4.01	4.16	L-TECH	Basic Production	PGS	SD
4251	Wholesale Electronic Markets and Agents and Brokers	4.67	2.65	L-KIS	Basic Production	PGS	NPS
4247	Petroleum and Petroleum Products Merchant Wholesalers	4.98	3.57	L-KIS	Basic Production	PGS	NPS
4237	Hardware, and Plumbing and Heating Equipment and Supplies Merchant Wholesalers	5.51	3.39	L-KIS	Basic Production	PGS	NPS
7112	Spectator Sports	3.81	2.29	H-KIS	Basic Production	PGS	NPS
3152	Cut and Sew Apparel Manufacturing	3.38	3.34	L-TECH	Basic Production	PGS	SD
4483	Jewelry, Luggage, and Leather Goods Stores	3.78	1.89	L-KIS	Basic Production	PGS	NPS
4241	Paper and Paper Product Merchant Wholesalers	5.72	3.29	L-KIS	Basic Production	PGS	NPS
4242	Drugs and Druggists' Sundries Merchant Wholesalers	5.82	2.98	L-KIS	Basic Production	PGS	NPS

8111	Automotive Repair and Maintenance	3.66	5.41	L-KIS	Basic Production	PGS	NPS
4482	Shoe Stores	4.91	2.07	L-KIS	Basic Production	PGS	NPS
3231	Printing and Related Support Activities	3.92	3.71	L-TECH	Basic Production	PGS	SD
8129	Other Personal Services	2.80	1.75	L-KIS	Basic Production	PGS	PS
4884	Support Activities for Road Transportation	3.74	3.44	L-KIS	Basic Production	SIS	NPS
5321	Automotive Equipment Rental and Leasing	4.70	3.50	L-KIS	Basic Production	SIS	NPS
4889	Other Support Activities for Transportation	4.64	3.90	L-KIS	Basic Production	SIS	NPS
5121	Motion Picture and Video Industries	7.26	4.19	H-KIS	Basic Production	SIS	NPS
4811	Scheduled Air Transportation	4.13	3.52	H-KIS	Basic Production	SIS	NPS
5324	Commercial and Industrial Machinery and Equipment Rental and Leasing	5.26	4.46	L-KIS	Basic Production	SIS	NPS
4854	School and Employee Bus Transportation	3.72	3.87	L-KIS	Basic Production	SIS	NPS
4921	Couriers	4.71	4.09	L-KIS	Basic Production	SIS	PS
4831	Deep Sea, Coastal, and Great Lakes Water Transportation	6.72	5.24	L-KIS	Basic Production	SIS	NPS
5322	Consumer Goods Rental	3.53	1.75	L-KIS	Basic Production	SIS	NPS
4841	General Freight Trucking	2.66	2.62	L-KIS	Basic Production	SIS	NPS
5313	Activities Related to Real Estate	5.31	3.17	L-KIS	Basic Production	SIS	PS
5323	General Rental Centers	5.27	4.09	L-KIS	Basic Production	SIS	NPS
4853	Taxi and Limousine Service	3.88	3.17	L-KIS	Basic Production	SIS	NPS
4883	Support Activities for Water Transportation	4.23	5.18	L-KIS	Basic Production	SIS	NPS
4842	Specialized Freight Trucking	2.82	2.70	L-KIS	Basic Production	SIS	NPS
4871	Scenic and Sightseeing Transportation, Land	4.74	3.80	H-KIS	Basic Production	SIS	NPS
5629	Remediation and Other Waste Management Services	5.65	5.14	L-KIS	Basic Production	SIS	SD
4931	Warehousing and Storage	2.74	2.41	L-KIS	Basic Production	SIS	NPS
5622	Waste Treatment and Disposal	4.96	4.15	L-KIS	Basic Production	SIS	SI
5619	Other Support Services	4.14	2.73	L-KIS	Basic Production	SIS	PS
4872	Scenic and Sightseeing Transportation, Water	4.76	4.19	L-KIS	Basic Production	SIS	NPS
5621	Waste Collection	3.57	3.26	L-KIS	Basic Production	SIS	NPS
5312	Offices of Real Estate Agents and Brokers	4.61	2.24	L-KIS	Basic Production	SIS	PS
4859	Other Transit and Ground Passenger Transportation	3.92	3.01	L-KIS	Basic Production	SIS	NPS
4885	Freight Transportation Arrangement	6.32	3.28	L-KIS	Basic Production	SIS	NPS
4922	Local Messengers and Local Delivery	6.77	3.75	L-KIS	Basic Production	SIS	PS

2213	Water, Sewage and Other Systems	4.97	4.99	Other	Basic Production	SIS	NPS
5111	Newspaper, Periodical, Book, and Directory Publishers	6.68	3.97	H-KIS	Basic Production	SIS	SD
5311	Lessors of Real Estate	3.91	2.88	L-KIS	Basic Production	SIS	PS
4881	Support Activities for Air Transportation	4.13	4.74	L-KIS	Basic Production	SIS	NPS
4855	Charter Bus Industry	4.83	4.96	L-KIS	Basic Production	SIS	NPS
5617	Services to Buildings and Dwellings	2.46	2.45	L-KIS	Basic Production	SIS	PS
4851	Urban Transit Systems	4.52	4.47	L-KIS	Basic Production	SIS	NPS
5112	Software Publishers	18.94	12.30	H-KIS	Complex Production	AKP	PS
3254	Pharmaceutical and Medicine Manufacturing	8.66	5.98	H-TECH	Complex Production	AKP	SB
3332	Industrial Machinery Manufacturing	7.74	6.84	H-TECH	Complex Production	AKP	SS
5182	Data Processing, Hosting, and Related Services	13.12	8.19	L-KIS	Complex Production	AKP	PS
3333	Commercial and Service Industry Machinery Manufacturing	7.89	6.68	H-TECH	Complex Production	AKP	SS
3346	Manufacturing and Reproducing Magnetic and Optical Media	8.55	6.89	L-TECH	Complex Production	AKP	SD
3335	Metalworking Machinery Manufacturing	5.52	5.97	L-TECH	Complex Production	AKP	SS
3336	Engine, Turbine, and Power Transmission Equipment Manufacturing	5.88	6.21	L-TECH	Complex Production	AKP	SS
3341	Computer and Peripheral Equipment Manufacturing	14.57	10.25	H-TECH	Complex Production	AKP	SB
3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	9.75	7.41	H-TECH	Complex Production	AKP	SB
3343	Audio and Video Equipment Manufacturing	9.37	7.89	H-TECH	Complex Production	AKP	SB
3369	Other Transportation Equipment Manufacturing	6.03	6.20	L-TECH	Complex Production	AKP	SI
3342	Communications Equipment Manufacturing	10.85	8.33	H-TECH	Complex Production	AKP	SB
5415	Computer Systems Design and Related Services	15.17	9.90	H-KIS	Complex Production	AKP	PS
5413	Architectural, Engineering, and Related Services	11.45	8.37	H-KIS	Complex Production	AKP	PS

3344	Semiconductor and Other Electronic Component Manufacturing	8.15	6.96	H-TECH	Complex Production	AKP	SB
3353	Electrical Equipment Manufacturing	5.94	6.01	L-TECH	Complex Production	MPG	SS
3364	Aerospace Product and Parts Manufacturing	8.45	7.13	H-TECH	Complex Production	MPG	SI
3241	Petroleum and Coal Products Manufacturing	5.97	5.68	L-TECH	Complex Production	MPG	SI
3361	Motor Vehicle Manufacturing	6.10	9.16	L-TECH	Complex Production	MPG	SI
2111	Oil and Gas Extraction	9.56	6.55	Other	Complex Production	MPG	SI
3274	Lime and Gypsum Product Manufacturing	5.03	6.22	L-TECH	Complex Production	MPG	SI
2122	Metal Ore Mining	5.69	7.16	Other	Complex Production	MPG	SI
3365	Railroad Rolling Stock Manufacturing	6.09	8.07	L-TECH	Complex Production	MPG	SI
3324	Boiler, Tank, and Shipping Container Manufacturing	5.32	5.87	L-TECH	Complex Production	MPG	SI
3325	Hardware Manufacturing	5.88	6.11	L-TECH	Complex Production	MPG	SI
3251	Basic Chemical Manufacturing	6.47	6.01	H-TECH	Complex Production	MPG	SI
3366	Ship and Boat Building	5.02	5.76	L-TECH	Complex Production	MPG	SI
6212	Offices of Dentists	12.00	8.02	H-KIS	Complex Production	PGS	PS
3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	6.02	5.93	L-TECH	Complex Production	PGS	SI
8112	Electronic and Precision Equipment Repair and Maintenance	6.84	8.16	L-KIS	Complex Production	PGS	NPS
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	6.05	5.63	L-TECH	Complex Production	PGS	SI
8113	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	5.61	7.40	L-KIS	Complex Production	PGS	SS
8114	Personal and Household Goods Repair and Maintenance	4.27	5.93	L-KIS	Complex Production	PGS	SS

4879	Scenic and Sightseeing Transportation, Other	11.65	12.00	H-KIS	Complex Production	SIS	NPS
5174	Satellite Telecommunications	20.38	17.38	H-KIS	Complex Production	SIS	PS
2212	Natural Gas Distribution	6.60	5.94	Other	Complex Production	SIS	NPS
5152	Cable and Other Subscription Programming	7.80	6.25	H-KIS	Complex Production	SIS	PS
4832	Inland Water Transportation	6.12	6.59	L-KIS	Complex Production	SIS	NPS
4812	Nonscheduled Air Transportation	6.52	5.59	H-KIS	Complex Production	SIS	NPS
4861	Pipeline Transportation of Crude Oil	12.14	11.26	L-KIS	Complex Production	SIS	NPS
4852	Interurban and Rural Bus Transportation	6.46	6.77	L-KIS	Complex Production	SIS	NPS
5179	Other Telecommunications	10.73	7.82	H-KIS	Complex Production	SIS	PS
4862	Pipeline Transportation of Natural Gas	8.53	7.47	L-KIS	Complex Production	SIS	NPS
4869	Other Pipeline Transportation	10.28	11.78	L-KIS	Complex Production	SIS	NPS
4882	Support Activities for Rail Transportation	5.80	8.25	L-KIS	Complex Production	SIS	NPS
2211	Electric Power Generation, Transmission and Distribution	6.65	6.47	Other	Complex Production	SIS	NPS
5171	Wired Telecommunications Carriers	8.24	6.79	H-KIS	Complex Production	SIS	PS
5412	Accounting, Tax Preparation, Bookkeeping, and Payroll Services	7.93	3.11	H-KIS	People Services	AKP	PS
5416	Management, Scientific, and Technical Consulting Services	8.18	4.03	H-KIS	People Services	AKP	PS
5411	Legal Services	9.23	2.30	H-KIS	People Services	AKP	PS
5417	Scientific Research and Development Services	11.19	6.49	H-KIS	People Services	AKP	PS
5418	Advertising and Related Services	7.33	3.96	H-KIS	People Services	AKP	PS
5511	Management of Companies and Enterprises	7.48	3.66	H-KIS	People Services	AKP	PS
5414	Specialized Design Services	10.35	6.17	H-KIS	People Services	AKP	PS
5611	Office Administrative Services	7.08	3.35	L-KIS	People Services	AKP	PS

7111	Performing Arts Companies	7.83	4.16	H-KIS	People Services	PGS	NPS
6216	Home Health Care Services	7.48	3.64	H-KIS	People Services	PGS	PS
6239	Other Residential Care Facilities	9.81	2.62	H-KIS	People Services	PGS	PS
6214	Outpatient Care Centers	11.21	4.66	H-KIS	People Services	PGS	PS
8139	Business, Professional, Labor, Political, and Similar Organizations	7.15	2.92	L-KIS	People Services	PGS	NPS
8133	Social Advocacy Organizations	9.14	2.79	L-KIS	People Services	PGS	NPS
6244	Child Day Care Services	10.37	3.07	H-KIS	People Services	PGS	PS
6241	Individual and Family Services	8.38	2.31	H-KIS	People Services	PGS	PS
6111	Elementary and Secondary Schools	9.62	3.68	H-KIS	People Services	PGS	NPS
6232	Residential Mental Retardation, Mental Health and Substance Abuse Facilities	8.25	2.44	H-KIS	People Services	PGS	PS
6115	Technical and Trade Schools	15.02	5.18	H-KIS	People Services	PGS	NPS
8132	Grantmaking and Giving Services	9.48	3.17	L-KIS	People Services	PGS	NPS
6213	Offices of Other Health Practitioners	8.62	4.43	H-KIS	People Services	PGS	PS
6243	Vocational Rehabilitation Services	8.15	2.47	H-KIS	People Services	PGS	PS
6117	Educational Support Services	13.31	4.39	H-KIS	People Services	PGS	PS
6113	Colleges, Universities, and Professional Schools	13.19	4.97	H-KIS	People Services	PGS	NPS
8131	Religious Organizations	9.72	2.95	H-KIS	People Services	PGS	NPS
6219	Other Ambulatory Health Care Services	10.81	6.30	H-KIS	People Services	PGS	PS
8122	Death Care Services	7.83	3.46	L-KIS	People Services	PGS	NPS
6116	Other Schools and Instruction	14.75	4.83	H-KIS	People Services	PGS	NPS
6222	Psychiatric and Substance Abuse Hospitals	10.25	4.31	H-KIS	People Services	PGS	PS
6215	Medical and Diagnostic Laboratories	9.17	5.60	H-KIS	People Services	PGS	PS
7114	Agents and Managers for Artists, Athletes, Entertainers, and Other Public Figures	15.01	4.78	H-KIS	People Services	PGS	PS
6223	Specialty (except Psychiatric and Substance Abuse) Hospitals	9.64	5.32	H-KIS	People Services	PGS	PS
6242	Community Food and Housing, and Emergency and Other Relief Services	10.44	2.63	H-KIS	People Services	PGS	PS
6211	Offices of Physicians	8.31	4.74	H-KIS	People Services	PGS	PS
6221	General Medical and Surgical Hospitals	9.21	5.29	H-KIS	People Services	PGS	PS
7115	Independent Artists, Writers, and Performers	8.15	4.76	H-KIS	People Services	PGS	PS
6112	Junior Colleges	16.27	5.38	H-KIS	People Services	PGS	NPS
6114	Business Schools and Computer and Management Training	17.48	6.06	H-KIS	People Services	PGS	NPS

5331	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	12.85	5.27	L-KIS	People Services	SIS	PS
5221	Depository Credit Intermediation	7.20	2.81	H-KIS	People Services	SIS	PS
5172	Wireless Telecommunications Carriers (except Satellite)	10.22	6.22	H-KIS	People Services	SIS	PS
5151	Radio and Television Broadcasting	9.71	5.90	H-KIS	People Services	SIS	PS
5259	Other Investment Pools and Funds	15.52	5.79	H-KIS	People Services	SIS	PS
5191	Internet Publishing and Broadcasting	13.50	7.37	H-KIS	People Services	SIS	PS
5222	Nondepository Credit Intermediation	8.88	3.46	H-KIS	People Services	SIS	PS
5242	Agencies, Brokerages, and Other Insurance Related Activities	6.29	2.45	H-KIS	People Services	SIS	PS
5241	Insurance Carriers	7.30	3.13	H-KIS	People Services	SIS	PS
5232	Securities and Commodity Exchanges	30.29	11.83	H-KIS	People Services	SIS	PS
5231	Securities and Commodity Contracts Intermediation and Brokerage	10.36	3.93	H-KIS	People Services	SIS	PS
5223	Activities Related to Credit Intermediation	9.31	3.51	H-KIS	People Services	SIS	PS
5239	Other Financial Investment Activities	9.46	3.70	H-KIS	People Services	SIS	PS
5122	Sound Recording Industries	14.10	7.64	H-KIS	People Services	SIS	SD
5211	Monetary Authorities - Central Bank	14.09	6.95	H-KIS	People Services	SIS	PS
