

# Nested Skills in Labor Ecosystems: A Hidden Dimension of Human Capital[5]

## Abstract

Modern economies, characterized by their vast output of goods and services, operate through globally interconnected networks. As economies become more complex, so do these networks, coordinating increasingly diverse portfolios of specialized efforts and knowledge. In this study, we analyze U.S. survey data (2005-2019) to infer an underlying interdependency tree within the fabric of skill portfolios. Hierarchically constructed, this skill tree starts from widely needed, foundational abilities, constituting the root, and extends to highly specialized, niche skills required by select jobs at the extremities. The directionality is defined by the asymmetrical conditional probabilities of the presence of one skill given the existence of another. Examining 70 million job transitions in resumes and national surveys, we observe that individuals tend to delve deeper into these nested specialization paths as they ascend the career ladder to enjoy higher wage premiums. Nevertheless, the role of foundational skills for such ascent remains pivotal; without reinforcing them, the anticipated wage premiums may vanish. Hence, we further differentiate nested skills from others, with the former building on common prerequisites while the latter does not, and analyze disparities in these skill gaps across different geographic locations, genders, and racial/ethnic groups, observing how these variations in absorptive capacity impact wage premiums. Our analysis reveals a growing and concerning fragmentation in the divide between these two skill groups over the past two decades, suggesting further polarization within the job landscape. Our findings highlight the critical role of robust foundational skills as a stepping stone to specialization and the economic advantages it can confer, reinforcing the need for balanced skill development strategies in complex economies

## Summary

The article examines skills from widely needed (general) to highly specialized. They find that skill sets are in a hierarchical structure with some that are heavily nested and others that are not. They look at the skill structures and how they relate to individual trajectories. They see that as time progresses people tend to fit a "path" and it depends on foundational skills. This is more focused on the individual and how there is a widening gap between disadvantage subgroups. The usefulness might be in techniques to relate SKAs.

## Data

1. 70 million job transitions resumes
2. Survey data - conducted by the U.S. Bureau of Labor Statistics (BLS), which record the importance and intensity of each skill, knowledge, or ability required in detailed occupational categories

## Methods

1. classify skills into categories of generality based on their demand profile shapes
2. group skills by their similar distribution shapes by k-mean clustering algorithms with correlation metrics. SKAs are taken from *O\*NET*

3. builds a network of skills (node is skill), weighted directions based on conditional probabilities of a skill given the other skill is present, e.g. math and computer programming.

## Skill relatedness and firm diversification[7]

### Abstract

Because of the importance of human capital, a firm's choice of diversification targets will depend on whether these targets offer opportunities for leveraging existing human resources. We propose to quantify the similarity of different industries' human capital or skill requirements, that is, the industries' skill relatedness, by using information on cross-industry labor flows. Labor flows among industries can be used to identify skill relatedness, because individuals changing jobs will likely remain in industries that value the skills associated with their previous work. Estimates show that firms are far more likely to diversify into industries that have ties to the firms' core activities in terms of our skill-relatedness measure than into industries without such ties or into industries that are linked by value chain linkages or by classification-based relatedness.

### Summary

This paper discusses skill relatedness and how it will link firms across industry, that is, if your current firm has the same skill set as another firm in a different industry, you are more likely to diversify into that industry. They do not look at specific skills, instead they assume that the overall size of labor flow from industry A to industry B represents their skill relatedness. They use  $SR_{ij} = F_{ij}/\hat{F}_{ij}$ , where  $F_{ij}$  is observed labor flow from industry  $i$  to  $j$ .  $\hat{F}_{ij}$  is predicted cross-industry flow. They find: "Our empirical analyses show that a skill-relatedness index based on labor flows has strong predictive power for firm diversification."

"Therefore, we propose a different method for measuring human capital relatedness, or "skill relatedness," by using direct measures of labor sharing across industries. In essence, we submit that the interconnectedness of industries that guides corporate diversification strategies also affects cross-industry labor flows. Or, reversing this logic, we aim to predict corporate diversification by studying the structure of cross-industry labor flows."

"In labor economics, human capital is often treated as if it were readily quantifiable, for instance by numeric values that reflect educational attainment or the number of years of work experience. However, human capital is no homogenous quantity. Rather, human capital consists of sets of heterogeneous skills. It is therefore more appropriate to discuss human capital in terms of which skills an individual possesses rather than in terms of how many skills."

### Data

Data from administrative records that cover roughly 4.5 million individuals who were employed in over 400 different industries in Sweden between 2004 and 2007.

## Methods

Basic statistics and build a network between industries where links are based on  $SR_{ij}$ . They also use logistic regression to predict firm diversification moves.

## Skill Networks and Measures of Complex Human Capital[2]

### Abstract

We propose a network-based method for measuring worker skills. We illustrate the method using data from an online freelance website. Using the tools of network analysis, we divide skills into endogenous categories based on their relationship with other skills in the market. Workers who specialize in these different areas earn dramatically different wages. We then show that, in this market, network-based measures of human capital provide additional insight into wages beyond traditional measures. In particular, we show that workers with diverse skills earn higher wages than those with more specialized skills. Moreover, we can distinguish between two different types of workers benefiting from skill diversity: jacks-of-all-trades, whose skills can be applied independently on a wide range of jobs, and synergistic workers, whose skills are useful in combination and fill a hole in the labor market. On average, workers whose skills are synergistic earn more than jacks-of-all-trades.

### Summary

### Data

The data used in this paper was collected from UpWork over a period of three months, between November 2013 and January 2014.<sup>1</sup> We collected a total of 33,592 worker profiles and 365,561 job listings at random from the public part of the website.

### Methods

1. For determining skill similarity: Creates a network where nodes in the two human capital networks are skills and a connection is made whenever two skills are both listed by a worker or job. Links are weighted with  $w_{ij}^{sim} = P(s_j|s_i) = n_{ij}/n_j$ . Where  $n_i$  is the number of workers that have skill  $i$ . They define the skill categories by hand.

## The value of complementary co-workers[8]

### Abstract

As individuals specialize in specific knowledge areas, a society's know-how becomes distributed across different workers. To use this distributed know-how, workers must be coordinated into teams that, collectively, can cover a wide range of expertise. This paper studies the interdependencies among co-workers that result from this process in a population wide dataset covering educational specializations of millions of workers and their co-workers in Sweden over a 10-year period. The analysis shows that the value of what a person knows depends on whom that person works with. Whereas having co-workers with qualifications similar to one's own is costly, having co-workers with complementary qualifications is beneficial. This co-worker complementarity increases over a worker's career and offers a unifying framework to explain seemingly disparate observations, answering questions such as "Why

do returns to education differ so widely?” “Why do workers earn higher wages in large establishments?” “Why are wages so high in large cities?”

## Summary

This paper mainly focuses on education and a workers history. It does look at the education within a plant (or organization), arguing that their education will balance with a plant. They observe a worker’s own skills but also the full set of skills he or she can mobilize through his or her co-workers.

## Data

Detailed information on the education and work histories for the entire Swedish population. These data record an individual’s gender, age, wage, main establishment of work, and current occupation, as well as his or her highest absolved education. There are 491 educational tracks, such as “344z: Accounting and taxation—college degree” or “214a: Fashion design—upper second- ary degree.”

## Methods

Constructs two separate networks. In the first, maps what pairs of **educational tracks** suggest strong synergy by frequently co-appearing in the same establishments. In the second, maps which **educational tracks** are substitutes, by observing which educational tracks allow a worker to do the same jobs. They determine the education synergy.

It uses regression analysis to predict wage using co-worker synergy and substitutability. It also controls for some of the demographic variables in as separate model.

Network 1, uses education track as the node and links are the synergy between them and substitutability.

## Investment in human capital: A theoretical analysis[3]

### Abstract

### Summary

This article spends time talking about how firms should invest in human capital. It does discuss "knowledge" but really means education and on-the-job training. Mainly focused on firm income and employee wages as functions of knowledge sharing.

Becker defines human capital as the knowledge, skills, education, and other attributes that individuals acquire through investment, which can increase their productivity and earning potential.

### Data

Article does not present extensive empirical data,

### Methods

This is more of a theory paper

# On the mechanics of economic development[6]

## Abstract

This paper considers the prospects for constructing a neoclassical theory of growth and international trade that is consistent with some of the main features of economic development. Three models are considered and compared to evidence: a model emphasizing physical capital accumulation and technological change, a model emphasizing human capital accumulation through schooling, and a model emphasizing specialized human capital accumulation through learning-by-doing.

## Summary

Might not be really applicable, but defines 'human capital' simply his general skill level  
Lucas argues that human capital, which includes education and skills, is a crucial driver of economic development. He suggests that investments in education and training lead to increased productivity and long-term economic growth. Lucas's model focuses on endogenous, or internally generated, growth. Unlike earlier growth theories that relied on exogenous factors, such as capital accumulation or technological progress from outside the system, Lucas's model suggests that growth is an outcome of decisions made by individuals and firms within an economy.

## Data

## Methods

Creates time series models to forecast human-capital growth.

## The returns to skill

## Abstract

Since 1975, increases in the return to skill (measured by years of education), in the percentage of the labor force that is skilled, and in the variance of wage income within skill categories have characterized the U.S. labor market. The first two facts point towards an increase in the demand for skilled labor; the third fact establishes that this increase in demand has not been uniform for all members of a particular skill category. Hence, the three stylized facts point toward unobserved skill heterogeneity within education classes. In this paper, we argue that education per se does not measure skill adequately, and we suggest an alternative measure based on the observed skill characteristics of the job. We analyze the return to various dimensions of skill, including formal education. After accounting for other elements of skill, we find that the return to years of education has been constant since 1970. Moreover, variations in direct measures of skill, such as mathematical ability or eye-hand coordination, account for a substantial fraction of the increased dispersion in income among the college educated, and some of the increase in wage dispersion among those who have not earned a college degree.

## Summary

## Data

## Methods

# How general is human capital? a task-based approach[4]

## Abstract

This article studies how portable skills accumulated in the labor market are. Using rich data on tasks performed in occupations, we propose the concept of task-specific human capital to measure empirically the transferability of skills across occupations. Our results on occupational mobility and wages show that labor market skills are more portable than previously considered. We find that individuals move to occupations with similar task requirements and that the distance of moves declines with experience. We also show that task-specific human capital is an important source of individual wage growth, accounting for up to 52% of overall wage growth.

## Summary

They find that human capital is more portable across occupations than previously considered. Specifically, we show that individuals move to occupations having skill requirements similar to those of their previous occupation.

They also show, using a control function approach, that our empirical measure of task-specific human capital is an important determinant of individual wage growth

They show specific human capital is not fully lost if an individual leaves an occupation

## Data

1. The data on job histories and wages are derived from a 2% sample of all social security records in Germany, and they provide a complete picture of job mobility and wages for more than 100,000 workers from 1975 to 2001.
2. The information on task usage in different occupations comes from a large survey of 30,000 employees at four separate points in time

## Methods

using task data with human capital models of the labor market.

How they measure human capital: Worker  $i$ 's task productivity  $S$  (measured in log units) in occupation  $o$  at time  $t$  is then  $\ln S = \beta_0 t_{iot}^A + (1 - \beta_0) t_{iot}^M$

# Unpacking the polarization of workplace skills[1]

## Abstract

Economic inequality is one of the biggest challenges facing society today. Inequality has been recently exacerbated by growth in high- and low-wage occupations at the expense of middle-wage occupations, leading to a “hollowing” of the middle class. Yet, our understanding of how workplace skills drive this process is limited. Specifically, how do skill requirements

distinguish high- and low-wage occupations, and does this distinction constrain the mobility of individuals and urban labor markets? Using unsupervised clustering techniques from network science, we show that skills exhibit a striking polarization into two clusters that highlight the specific social-cognitive skills and sensory-physical skills of high- and low-wage occupations, respectively. The connections between skills explain various dynamics: how workers transition between occupations, how cities acquire comparative advantage in new skills, and how individual occupations change their skill requirements. We also show that the polarized skill topology constrains the career mobility of individual workers, with low-skill workers “stuck” relying on the low-wage skill set. Together, these results provide a new explanation for the persistence of occupational polarization and inform strategies to mitigate the negative effects of automation and offshoring of employment. In addition to our analysis, we provide an online tool for the public and policy makers to explore the skill network: [skillscape.mit.edu](http://skillscape.mit.edu)

## Summary

## Data

## Methods

## ONET - Basic and Cross-Functional Skills[9]

### Summary

defining skills in terms of procedures -

1. skills are not necessarily stable
2. skills can be defined at different levels of generality
3. skills cannot be defined apart from some performance domain involving the acquisition and application of certain types of knowledge

### Skills Taxonomies

1. Basic
  - (a) Content Skills - basic skills with respect to the fundamentals that should be provided by any sound educational system
  - (b) Process Skills - acquiring and applying knowledge
2. Cross-Functional Skills
  - (a) Problem-Solving Skills - the processes and procedures involved in applying knowledge to work-related tasks
  - (b) Social Skills
  - (c) Technical Skills
  - (d) Systems Skills
  - (e) Resource Management Skills

## Onet - Knowledges[9]

### Summary

14 knowledge clusters and 49 knowledges

Knowledge Requirements Taxonomy and rating scales were created from an extensive review of the cognitive, vocational, training, and job analysis literatures.

## Onet - Abilities[9]

### Summary

abilities as relatively enduring attributes of an individual's capability for performing a particular range of different tasks.

competencies has come into use to describe individual attributes related to quality of work performance.

competency has been defined as “an underlying characteristic of an individual which is causally related to effective or superior performance in a job”

An ability is a general trait of an individual that is inferred from the relationships among performances of individuals observed across a range of different tasks. Skills are more dependent on learning and represent the product of training in particular tasks. Skills are more situational and tend to improve.

Tasks can be described in terms of the abilities required to perform them.

There are multiple human abilities listed and categorized

## References

- [1] Ahmad Alabdulkareem, Morgan R. Frank, Lijun Sun, Bedoor AlShebli, César Hidalgo, and Iyad Rahwan. Unpacking the polarization of workplace skills. *Science Advances*, 4(7):eaao6030, 2018.
- [2] Katharine A Anderson. Skill networks and measures of complex human capital. *Proceedings of the National Academy of Sciences*, 114(48):12720–12724, 2017.
- [3] Gary S. Becker. Investment in human capital: A theoretical analysis. *Journal of Political Economy*, 70(5):9–49, 1962.
- [4] Christina Gathmann and Uta Schönberg. How general is human capital? a task-based approach. *Journal of Labor Economics*, 28(1):1–49, 2010.
- [5] Moh Hosseinioun, Frank Neffke, Letian, Zhang, and Hyejin Youn. Nested skills in labor ecosystems: A hidden dimension of human capital. 2023.



- [6] Robert E. Lucas. On the mechanics of economic development, 1988.
- [7] Frank Neffke and Martin Henning. Skill relatedness and firm diversification. *Strategic Management Journal*, 34(3):297–316, 2013.
- [8] Frank M. H. Neffke. The value of complementary co-workers. *Science Advances*, 5(12):eaax3370, 2019.
- [9] Norman G. Peterson, Michael D. Mumford, Walter C. Borman, P. Richard Jeanneret, and Edwin A. Fleishman. An occupational information system for the 21st century: The development of o\*net. 1999.