Contemporary societies are experiencing the fastest technological advancements. While yielding the most material well-being, causes the biggest concern about human work. mass unemployment has been a long-lasting concern associated with technology since the Elizabeth…But today it is finding broader aspects. Machines can do much more than repetitive handwork. Today, autonomous technologies that utilize artificial intelligence, are able to take over cognitive tasks. They can be trained to simulate the decision-making process in humans and perform complex tasks. However, the experts believe this is not artificial intelligence yet. The impact of recent AI-powered technologies has expanded to even human cognitive ability to perform cognitive abilities that have been simulated and executable for machines.

Theoretical background

Labor Process Theory

Tracing the contemporary debates on the impact of technology on human labor, Labor Process Theory (LPT) emerged as a prominent analytical framework in the 1970s (Jaros, 2000). This theory was popularized by Harry Braverman’s 1974 book Labor and Monopoly Capital: The Degradation of Work in the Twentieth Century. In his influential book, Braverman examined the degradation of human labor tracing its roots in the logic of capitalism and Tayloristic organization of work (Knights & Willmott, 1990). He explained how breaking down complex work into simple repeatable individual tasks eroded the traditional notion of skill that used to be realized in craftwork. This fragmentation of work resulted in the appearance of a homogeneous working population whose labor was degraded to standardized, repetitious, and dexterous tasks. At the same time, technical knowledge was shifted away from labor and toward management which opened doors for managerial control of the labor process (Braverman, 1974). Braverman’s emphasis on the separation of management from labor due to advanced machinery operations and scientific organization of work enriched the stance of the technology’s deskilling impact on human labor.

Despite the dominance of degrading and deskilling arguments in the 1970s, empirical evidence appeared in the literature that exhibited an upward trend in workforce skills (Adler,2004). This body of empirical research discovered that the workforce skills have been upgraded over a longer term and in the aggregate. Digging into historical data revealed an evolution in the occupational distribution of the workforce with professional and technical occupations growing from 4% in 1900 to 16% in 2000. Some scholars cited the significant growth in the average education level of the workforce as an indicator of skill upgrading. Based on U.S. data, they reported that the population of high school graduates increased from 6% in 1900 to over 80% by the end of the century. Relying on these evidences, a considerable number of researchers, mostly among economists, concluded that technological advancement in a capitalistic context increases the demand for more skilled workers, suggesting that technology and human skills are complements rather than substitutes (Adler, 2004).

Expanding empirical research within Labor Process Theory revealed a third trend known as skill polarization. Unlike deskilling and upskilling arguments, which both identified unidirectional trends, researchers began to observe a binomial distribution of occupations. In this distribution, low-skilled and high-skilled occupations grew at the expense of disappearing middle-skilled occupations. The polarization argument gained prominence in the early 2000s when computer technology was evolving the work process. Due to its serious implications for wage gaps and societal inequality, numerous theoretical and empirical studies have delved into this phenomenon. Among the root causes of polarization, technological development stands out.

In their groundbreaking research, ‘The Skill Content of Recent Technological Change: An Empirical Exploration’ (2003), David H. Autor and his colleagues made significant contributions to understanding the impact of technology on human skills. Rather than relying on education or occupation as proxies for skill, they delved into the actual content of tasks performed by workers. Their central argument was that computer-powered technologies show a bias toward routine tasks. By routine tasks, they meant limited, well-defined tasks that can be turned into programmable rules such as organizing, storing, retrieving, and manipulating information. Accordingly, they anticipated that computers would replace workers engaged in routine tasks—whether manual or cognitive—while simultaneously complementing workers in nonroutine tasks. (Autor et.al, 2003).

Analyzing task content within occupation categories, they discovered that routine tasks have been most prevalent in middle-level occupations, such as clerical and administrative roles. Consequently, computer technologies tend to substitute middle-skilled workers. Meanwhile, the demand for high-skilled workers engaged in analytical and interactive tasks rapidly grows. Low-skilled workers performing dynamic manual tasks also remain in demand, as these tasks leave limited opportunities for codification. (Autor, et. all, 2003).

The concepts of deskilling, upskilling, and skill polarization captured significant interest and directed extensive empirical studies toward investigating trends in local labor markets. Beyond providing insightful knowledge about the workforce situation across different national contexts, this research strand also contributed to our understanding of how workforce skills can be effectively measured. The challenges related to skill measurement will be discussed subsequently.

Social Shaping of Technology

Another influential paradigm for understanding the relationship between technology and human work is the Social Shaping of Technology (SST) that emerged in the 1980s. SST challenges the technological determinism underpinning the Labor Process Theory and similar viewpoints.

In a deterministic view of technology, changes occur due to scientific innovations or internal technical logic, and these changes subsequently impact society in specific ways. However, the social shaping approach recognizes that technology is intertwined with society. It is not a neutral entity, and technological changes do not follow a purely engineering logic. Instead, they are influenced by social circumstances, designed to create certain opportunities while closing others, and aligned with specific patterns of social relations. Therefore technological changes are not independent, autonomous forces that affect society from the outside. Rather, they are shaped by and within social contexts (MacKenzie & Wajcman, 1999).

In his important article New Connections: Social Studies of Science and Technology and Studies of Work (2006), Judy Wajcman discussed that studies of work have long been under the dominance of technological determinism which considers human labor as a passive factor merely reacting to ever-advancing technology. He argued that predictions of the future of work, whether optimistic accounts of upgrading or pessimistic accounts of degrading and polarizing trends, often overlook the potential role of social forces in revising the direction of technological advancements. Thus narrowing the possibilities for democratic engagement with technology. (Wajcman, 2006, p. 774)

In contrast, SST encourages viewing technology as a socio-technical entity that both shapes and is shaped by the existing social, cultural, and political patterns. Developing and deploying new technologies involves deciding among various technical alternatives. Social, political, and cultural factors play an important role in determining which options are adopted. Accordingly, the relationship between technology and work can not be captured through a snapshot view of technological evolution and its direct impact on human labor. Instead, it requires a more complex analysis of the coevolution of technology and the work environment consisting of individual workers, workplace relationships, culture, and management (Joyce, 2023, p.152).

This approach shifted the focus of studies of work from statistically predicting job loss toward understanding the everyday work practice at workplaces (Health, et.al., 2000). Everyday work practice is where newly adapted technologies intersect with long-lasting privilege patterns. Not all workers experience technology the same way; factors such as gender, age, and race influence how they are affected by technology. Moreover, everyday work practices are situated within an organizational setting. Practical organizational conduct, such as management methods, division of tasks, and forms of cooperation differentiate in the way workers interact with workplace technologies (Health, et.al., 2000).

The fruit of SST has been a substantial corpus of fieldwork and ethnographies investigating the coexistence of workers and technologies in a certain workplace and exploring how work and technologies mutually evolve during the work process. One classic example is the ethnographic study conducted by Health and Luff (1992) on Underground Line Control Rooms in London. Line Control Rooms are complex multimedia work environments equipped with advanced technologies including computer monitors, large displays, and various communication devices. Personnel in these rooms have distinct roles and act on a strict division of tasks, while simultaneously being aware of each other's tasks. In this context, technologies mediate collaborative work among personnel allowing them to make their activities visible, share necessary information with others, and coordinate their activities. The study emphasized the crucial role of technologies in creating a collaborative work environment where individuals have distinct obligations and skills, yet their work is highly interconnected. The findings also suggested that technology developers and designers should prioritize features that make the information public and exchangeable in an organizational setting (Health & Luff, 1992).

These types of workplace studies opened up opportunities for multidisciplinary collaboration between social scientists and computer scientists, informing designs and evaluation of technological innovations. Presently, the field of Human-Computer Interaction (HCI) takes the lead in conducting empirical studies in this domain.

Empirical background

Exploring the relationship between human labor and technology has raised enormous empirical studies whether quantitative research which tries to measure the impact of technologies on human skills and total employment or qualitative research with a focus on how workers experience and perceive technologies at work. This literature review is centered on the quantitative strand of research.

Workforce skill; measure and level of measurement

Most of the efforts of quantitative researchers have been devoted to measuring the workers' skills and linking them to the recent capabilities of ever-changing technologies. In this research tradition, human labor is viewed as a combination of skills and abilities put into a certain job (Felten, et.al., 2019). Thus ‘skill’ has been the central concept in these studies and a variety of strategies for measuring skill has been introduced. Primarily, years of schooling were considered the main builder of skill. The individuals with higher education level were known as the high-skill workers. However, education as a proxy for skill has been heavily criticized due to its static nature which neither diminishes due to lack of use nor enhances through work experience (Martinaitis, et.al. 2021). Additionally, the education people receive significantly varies in terms of content and quality (Esposto, 2008).

Autor and Handel (2013) added to this discussion by emphasizing the demand side of skills in the job market. They elaborated that the skills people use in their work depend on the tasks they are required to carry out. Thus the content of tasks determines the level of skill (Autor & Handel, 2013). This task-oriented approach found popularity as a strategy for measuring skill. The researchers using this approach, heavily relied on the dictionaries of occupations such as Occupational Information Network (O\*NET) that contain detailed descriptions of occupations in terms of their task content and skill requirements.

A pioneer empirical research within task framework was conducted by Autor, Levy, and Murnane (2003). Besides the novel implication of the task model, the additional value of this research was the categorization of tasks based on to what extent they are attributable to computerization. They distinguished four types of tasks: routine manual, non-routine manual, routine cognitive, and non-routine cognitive tasks consisting of analytical and interactive tasks, identifying routine tasks with precise and explicit rules potentially automatable by computers. Using the Dictionary of Occupational Titles (DOT) and occupational employment data (1970-1998), they found that the development of computer technologies has significantly increased the non-routine task input of occupations, and the trend in the US labor market has shifted in favor of educated workers involved in analytical and interactive tasks.

Another famous study in this stream is The Future of Employment: How Susceptible Are Jobs to Computerisation? (2013, 2016) conducted by Frey and Osborne. Unlike Autor et. al. (2003) who assumed that only routine tasks are codifiable and amenable to computerization, Frey and Osborne believe that recent developments in machine learning, robotics, and big data have extended computerization to a wide range of non-routine tasks. Alternative to routine and non-routine categorization of tasks, they suggested three types of tasks that are bottlenecks to computerization: Perception and Manipulation tasks, Creative Intelligence tasks, and Social Intelligence tasks. Using the O\*NET description of occupations they coded 702 occupations based on three bottlenecks and estimated the probability of computerization for each occupation. They input U.S. employment data (2o10) into their model and found out that 47% of U.S. total employment is at high risk of computerization.

-----------------Suitability to computarization----------------

This estimation raised concerns bout the future of work in the U.S. and inspired follow-up research. Arntz, Gregory, and Zierahn (2017) published a paper Revisiting the Risk of Automation wherein they made a valuable methodological contribution to this topic. They highlighted that Frey and Osborn's method overestimated the proportion of automatable jobs since it overlooked the variation of tasks within occupations and the adaptability of jobs to technological changes. They discussed that this heterogeneity can be captured by shifting from occupation-level analysis to job-level analysis which makes it possible to account for the worker competencies and workplace capacities when measuring the potential risk of job automation. Incorporating the workers' data from the Survey of Adult Skills (PIIAC) and accounting for worker’s characteristics and their tasks’ content, their estimation of automation risk in the US job market dropped to 9%.

Although their estimate deviated greatly from previous scenarios, Arntz and her colleagues' emphasis on the tasks and skills that workers employ in their jobs was groundbreaking. This approach situates human work within the organizational and social structure of the workplace allowing a deeper understanding of the dynamics involved in human-technology coexistence.

Another alternative approach to occupation-level analyses was presented by Zˇilvinas Martinaitis in his innovative work Measuring Skill in Europe (2013). He distinguished between the “potential to act” and “actually realized skills” (Martinaitis, 2013. 201). He suggested a new framework for measuring skills based on “how” workers do their tasks rather than “what” tasks their jobs contain. By taking the realized skill into account according to workers' self-reports, this framework allows to capture the interaction between individual qualities, job task requirements, and workplace potentials. To evaluate “how” tasks are performed, he proposed the Work Complexity Index which measures to what extent workers’ tasks are involved with Degree of Uncertainty, Level of Autonomy, and Continuous Skill-building.

Martinaitis implemented his proposed measure in an empirical cross-national study at the EU level (Martinaitis, et.al. 2021) using data from the European Working Condition Survey spanning time from 2005 to 2015. ‌The study revealed a significant difference in the workforce skills across European countries with the highest work complexity in Nordic countries. Investigating the skill distribution change over time (2005-2015), the findings demonstrated that the European labor markets witnessed the upskilling of the workforce in the aggregate, however, deskilling and skill polarization were observed in some countries.

Evidence on Finnish workforce skills

The Finnish labor market has been extensively explored by national and cross-national research. Aligning with the methodological trend for skill measurement described in the last section, these studies have provided valuable insights into the changes in employment structure (macro-level) and the workers' situation (micro-level) under the influence of technological advancement.

Following the routinization hypothesis and task model of Autor, Levy, and Murnane (2003), Jari Vianiomäki (2014) monitored the changes in the Finnish private sector labor market for the period 1995-2008. He reported that the structure of employment in the private sector witnessed a decrease in the share of routine-intensive occupations while increasing the proportion of non-routine occupations (abstract and service work) signifying an upskilling trend within the sector. In addition, by examining the changes in wage distribution across occupations, he observed wage polarization at the private firm level over the specified time.

Replicating the method of Frey and Osborne (2013), Pajarinen and Rouvinen (2014) investigated the risk of computerization for employment in Finland. They discovered that approximately one-third of occupations are susceptible to computerization. This estimate was 10 percentage points lower than the corresponding estimate for the US (47%). However, similar to the US, occupations with low wages and low skill levels were found to be more vulnerable. Also, they found that service jobs will be relatively more secure compared to manufacturing jobs.

In a similar occupation-level analysis, based on the AI Occupational Impact measure proposed by Felten, Raj, and Seamans (2019) and PIIAC survey data, Georgieff and Hyee (2022) reported that occupations are highly exposed to AI in Northern European countries compared to eastern countries. Specifically, Finland obtained the higher average score of AI exposure across occupations (0.72) among the 23 countries that participated in this study.

Putting emphasis on the realized skill or skill-in-action (Martinaitis, 2013) rather than the potential skill requirement for occupations opens space for the contribution of “job quality” studies to the skill debate. This research tradition which gained special popularity in Finland due to its close association with workforce well-being, added to the literature by identifying the work conditions that allow or limit the realization of skills. Although job quality contains a variety of domains, Autonomy and Access to Training appear as two skill-specific domains, frequently used in empirical work.

In the Finnish context, Hartikainen et. al. (2010) evaluated the job quality of the workforce across European countries using self-report data from European Working Condition Survey (2005). Their results, with a focus on workforce skills, demonstrated that 60% of Finnish employees were involved in jobs with unforeseen and complex tasks requiring learning new things. However, Finnish employees reported lower work autonomy and discretion (51%) over their job tasks compared to other Nordic countries’ employees (60%).

Another research on Finnish workforce skills within the job quality framework was conducted by Mustosmäk, Oinas, and Antilas (2017). This study concerns the class and gendered inequalities in the workforce. In their trend analysis based on the Finnish Quality of Work Life survey data (1977–2013), they showed that Finnish blue-collar workers have seen improvements in their autonomy and opportunities for development, denoting the low risk of social class gap and polarization of job quality in the future. Regarding gender, their findings showed that the gender gap continued among blue-collar workers, while gradually disappearing for lower white-collar and upper white-collar women.

How does the current study utilize and add to the existing literature?

(Need more content on the priority of WCI)

Reviewing the theoretical and empirical literature, it is evident that the field has benefited from extensive multidisciplinary analyses and still has remained appealing to further exploration due to the ever-evolving technologies and dynamic world of work.

Labor Process Theory and the spectrum of empirical research inspired by this theory have dominantly produced the most hypotheses and methodological innovations for measuring the impact of technologies on human labor. In this section, we introduced some of the proposed measures and indices for evaluating workforce skills and discussed how these measures gradually evolved from analyzing the potential effect of technology on occupations to capturing the materialized effect of workplace technologies on workers.

In earlier studies, human labor was viewed as a passive entity at high risk of being displaced by technology. Compatible with the insight from the Social Shaping of Technology discourse, the more recent studies view human skills and technologies situated in the workplace. In this approach, workers' skills and their job tasks change alongside technological progress as the technology is developed and adapted according to the workers' and organizations’ needs. Furthermore, by shifting the level of measurement from the occupation level to the worker level, more nuanced and subjective analyses of the workforce skills and capturing heterogeneities among workers have been possible.

This thesis contributes to the literature by deploying and developing the Work Complexity Index (WCI) proposed by Martinaitis (2013, 2021)\_a skill measurement strategy concentrated on how tasks are performed by workers at the workplace\_ and producing the most recent evidence on Finnish workforce skills using the Finnish Working Life Barometer data (2018-2022).

Three dimensions should be defined

Method and Data

Work Complexity Index

The Work Complexity Index (WCI), proposed by Martinaitis (2013), is a measure for assessing workforce skills that is concerned with “how” workers perform their job tasks. WCI consists of three dimensions: Degree of Uncertainty, Level of Autonomy, and Continuous Skill-building. The index \_a value in the range of 0-1\_ is calculated by the sum of the average scores in all three dimensions for each worker. A larger value of WCI indicates a job involves more complexity which protects the job holder from the risk of skill erosion and consequently job loss.

In this study, the worker-level data comes from the Finnish Working Life Barometer (FWLB), a national repeated cross-sectional survey. FWLB is chosen due to its high quality, the most updated data on the workforce in Finland, and also its availability to the public. Additionally, FWLB provides annual data allowing us to monitor the changes in work complexity over time. For this trend analysis, aggregate work complexity is obtained from the average of individuals' work complexity scores for each year.

Although nationwide surveys are extensively beneficial for workforce studies, they have a number of limitations. First and foremost, they are pre-generated data which means researchers face an existing set of variables that are not primarily collected for the purpose of their research. Therefore, utilizing these survey data to address specific research questions might involve trade-offs in selecting and including variables.

Another limitation, specifically related to repeated cross-sectional surveys, is that different rounds of surveys might adapt different modes of data collection or include different sets of variables. This inconsistency causes serious restrictions for trend analysts as they might encounter with absence of a certain variable in some rounds of the survey, forcing them to exclude that variable from the entire analysis. Changing data collection mode also makes different rounds of surveys incomparable due to different weighting systems and their potential biases for estimation. These issues are addressed and discussed in expert forums, however, no solution is found to be offered to data analysts who deal with such challenges while having limited access to auxiliary information to fix them.

Keeping these limitations in mind, I generated a pool of variables, included in the last five rounds of FWLB (2018 – 2022), that pertained to the quality of performing tasks by the workers. Among existing variables, two sets of variables perfectly corresponded to two dimensions of WCI: Level of Autonomy and Continuous Skill-building, however, no variable is found in the dataset corresponding to the third dimension of WCI, Degree of Uncertainty. On the other hand, the dataset contains an interesting variable asking workers about the collaborative nature of their tasks that explicitly reflects the complexity of their work.

According to the organizational management discussions (Leonardi et al., 2013, Kane, 2017, Benbya et al., 2020, Baptistaa et al.,2020), collaborative work is known as an indicator of complex work design in computer-mediated work environments. These articles highlight that Information and Communication Technologies (ICT), widely adopted in today’s workplaces, have facilitated real-time information sharing, connected individual tasks, and created a more interdependent workflow where the output of one task comes as the input of other tasks. This interdependency requires coordination, process thinking, and effective communication from workers to ensure a cohesive outcome.

In addition to approaches that emphasize the material ICT-related facilities underpinning collaborative work, it is heavily discussed that collaboration or teamwork requires social skills such as social perceptiveness, negotiation, persuasion, and assisting and caring for others (Frey & Osborne, 2016), which are skills that are very difficult for machines to replicate. So it can be concluded that workers engaged in collaborative work requiring human edge skills are more immune to the risk of automation.

Relying on these theoretical supports, Collaborative Work can be accounted as a dimension of work complexity, however, deciding about the inclusion of a new dimension in the construct of WCI requires examining its correlation with other dimensions. Before delving into the statistical examination, an overview of the revised construct of WCI and the FWLB variables corresponding to each dimension of the WCI is provided in Table 1.

Table 1

Construct reliability and validity

To ensure the reliability of the WCI construct, I examine the Internal Consistency between items within each dimension by calculating Cronbach’s Alpha. Cronbach’s Alpha determines how well all items within a single dimension measure the same concept.

Thus far, two wings: Martinaitis’s skill measurement method and the Finnish Working Life Barometer have directed the construction of the Work Complexity Index which is intended to assess the workforce skills in Finland and analyze the changes over time across different groups. The Findings will be discussed in the Results and Discussion section.

**Level of Autonomy:**

**Continuous Skill-building:**

**Collaborative Work:**

Table 1 indicates the revised construct of WCI based on the FWLB data and set of variables measuring each dimension.

Theory guided us toward workers' data to assess realized skill

* WCI was selected to employ having 3 dimensions (brief explanation for each)
* FWLB was chosen due to its relevance and updated data and availability
* Two wings: theory and data at hand
* Following the guideline in the book: generate a pool of items from data that pertain to affect the workers' skills and should include in the measure/items that reflect the scale's purpose.
* Data is available for two dimentions. For first dimention, we have no data (his is a limitation we take onboard)
* On the other hand there is an variable that seems highly relevant to the topic (brief explanation: subjective/objective)
* We have to skip one dim. We include the new variable that our data offer
* Reconstructed WCI based on FWLB data is shown in a table

Construct Reliability and Validity: AC focus on the internal consistency between items and their underlying dimension assuming all items measure the same thing/ CFA focus on the fitness of the entire construct model the data

* Internal consistency (table)
* Confirmatory factor analysis (table): model specification based on theoretical expectation/ this model fit the data?
* We use this reconstructed measure to address the thesis's central questions

Finnish Working Life Barometer

* National, repeated cross-sectional survey
* Time coverage
* Sampling
* Integration and harmonization: process, size, software
* Exploratory analysis

We decided on the measurement strategy. His way of approaching to workers skill is the guideline in this work. We know that two factors are extensively appeared in the literature. Being exposed to He constructed this measure based on variables in EWCS. Here, I revise this index based on FWLB which is superior because it is national data and provides more recent data. new data is important since today more than ever computer technologies are adopted in the workplace.

to extract insight on the topic from our data and develop the index based on FWLB, I used EFA.

All items pertaining to affect the quality of performing tasks are collected.

Underlying phenomenon

Importance of design and features in technology

subjectivity/locality/social relations (gender, class, …)

importance of revaluation and redefining human participation in work/augmentation

promotes a passive attitude to technological change. It focuses our minds on how to adapt to technological change, not on how to shape it. I

Skill Measurement

The most recent empirical

Status of my work within literature

Empowered subjects

Output: individual-level workforce analysis + changes over years + changes across groups

Technology and human labor, class conflict, under control of capital logic and scientific management: degrading

Empirical research /historical data analysis revealed different trends

Deterministic view

Sociotechnical view: leave room for empowering workers and redesigning the technological objects/

participatory design of work/Participatory design of technology

situate their work within the existing body of knowledge in the field

to provide context and justification for their research

identifies research gaps, and how the research being done will add to current knowledge.

Literatures:

Universal:

Finland: theoretical articles (discussion)

* understanding work in the age of information, Passi Pyoria
* the information society and the welfare state, Castells & Himanen
* Coordinated economy, state-led social partnership skill systems (Mustosmaki)/institutional setting can mitigate the risk of technological transformations.

Finland: empirical articles

* quality of working life (job quality: Hartikainen 2010) under the labor market transformations including technological changes
* This time may be a little different” – exploring the Finnish view on the future of work, Pulkka 2018
* Vianiomaki 2014, polarization in Finland
* Computerization Threatens One-Third of Finnish Employment, Pajarinen & Rouvinen 2014
* Does ICT Usage Erode Routine Occupations at the Firm Level? Bockerman 2019
* Mustosmäki, Oinas, and Anttila (2017) Abating inequalities? Job quality at the
* intersection of class and gender in Finland 1977–2013.

اونایی که نگاه یونیورسال و کلان دارند با داده های کلان کار می کنند و به مگاترندها می رسند: اقتصاد کار

اونایی که فاکتورهای متنوع تر و در سطح فردی رو لحاظ می کنند: اجتماعی

با وجود دشواری اندازه گیری مقوله متفییری مثل اسکیل پز/شهش های خوبی انجام شده تا این را تعریف و قابل اندازه گیری کنند

workers need to both learn to work effectively with the new technology and to adapt to a changing task composition that puts more emphasis on tasks that AI cannot yet perform. Such adaptation is costly and the cost will depend on worker characteristics. / Artificial Intelligence and Employment: New Cross-Country Evidence

The skill index is based on workers’ subjective evaluations of their job requirements (Hartikainen 2010)