Quaderni del Premio «Giorgio Rota»

N. 10, 2022

Labor, value, robots

Centro
di Ricerca
e Documentazione
Luigi Einaudi

Con il sostegno di
Fondazione CRT

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Iniziativa realizzata con il sostegno di

Fondazione CRT

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Il Premio «Giorgio Rota»

L'intento del Premio «Giorgio Rota» è di riprendere l'attività di ricerca annualmente condotta dal Comitato / Fondazione Giorgio Rota prima della sua inclusione nel Centro Einaudi, sulla relazione tra il pensiero e l'agire economico e un aspetto (ogni anno diverso) del vivere in società, mantenendo vivo il ricordo e l'insegnamento dell'economista Giorgio Rota, uno dei primi animatori del Centro, prematuramente scomparso.

Dal 2012 il Centro Einaudi ha dunque raccolto questa eredità rinnovando la formula della ricerca: è stato perciò istituito questo premio annuale dedicato a giovani ricercatori, con una qualificazione accademica nei campi dell'economia, sociologia, geografia, scienza politica o altre scienze sociali. I paper possono essere presentati sia in italiano che in inglese, e non devono essere stati pubblicati prima della data della Conferenza Rota, l'evento pubblico nel quale i vincitori hanno modo di presentare il loro lavoro.

La prima edizione aveva per tema *Contemporary Economics and the Ethical Imperative* e la Conferenza Giorgio Rota si è tenuta presso il Centro Einaudi il 25 marzo 2013 con keynote speech di Alberto Petrucci, LUISS Guido Carli, Roma.

La seconda edizione è stata su *Creative Entrepreneurship and New Media con Conferenza* Giorgio Rota presso il Centro Einaudi, 14 aprile 2014 e keynote speech di Mario Deaglio, Università di Torino.

La terza edizione ha analizzato il tema *The Economics of Illegal Activities and Corruption*, con Conferenza Giorgio Rota presso il Centro Einaudi, 15 giugno 2015. Keynote speech di Friedrich Schneider, Johannes Kepler University (Linz, Austria).

La quarta edizione verteva su *The Economics of Migration*. Il 20 giugno 2016 si è tenuta la Conferenza Giorgio Rota presso il Campus Luigi Einaudi, in collaborazione con FIERI. Keynote speech di Alessandra Venturini, Università di Torino. Dal 2016 inoltre il Premio è sostenuto dalla Fondazione CRT.

La quinta edizione trattava di *Economic Consequences of Inequality*, e i saggi vincitori sono stati presentati alla Conferenza Giorgio Rota del 4 maggio 2017, tenutasi presso il Campus Einaudi in collaborazione con il Dipartimento di Economia e Statistica "Cognetti de Martiis". L'Introduzione è di Andrea Brandolini, Banca d'Italia.

La sesta edizione del Premio è incentrata sul tema *The Economics of Health and Medical Care*. I paper vincitori sono stati presentati alla Conferenza Giorgio Rota tenutasi il 1° giugno 2018 presso il Campus Einaudi, in collaborazione con il Dipartimento di Economia e Statistica "Cognetti de Martiis". L'Introduzione è di Fabio Pammolli, Politecnico di Milano.

La settima edizione del Premio è incentrata sul tema *Rural Economies, Evolutionary Dynamics and New Paradigms*. I paper vincitori, riportati qui, sono stati presentati alla Conferenza Giorgio Rota il 6 maggio 2019 presso il Campus Einaudi, in collaborazione con il Dipartimento di Economia e Statistica "Cognetti de Martiis". Gli autori sono introdotti da un intervento di Donatella Saccone, docente di Economia politica all'Università di Scienze gastronomiche di Bra.

Digital Transformation: Analysis of Economic Impact and Potential è il titolo dell'ottava edizione del Premio. I paper vincitori sono stati presentati alla Conferenza Giorgio Rota l'11 maggio 2020 che a causa della pandemia da Covid si è tenuta online, in collaborazione con il Dipartimento di Economia e Statistica "Cognetti de Martiis". Gli autori sono stati introdotti alla Conferenza e nel volume da un intervento di Pietro Terna, ex Professore ordinario di Economia dell'Università di Torino e consigliere Centro Einaudi.

La nona edizione del Premio è stata sul tema *Main Economic Tendencies in the Contemporary World Economy*. I paper sono stati presentati il 26 maggio 2021 alla Conferenza Giorgio Rota che si è ancora tenuta per via telematica. Gli autori sono introdotti nel volume da un con tributo di Jack Birner, Università di Trento e Comitato scientifico del Centro Einaudi.

La decima edizione del Premio aveva per titolo *Labor, value, robots*. I paper vincitori, durante la conferenza tenutasi il 18 maggio 2022 al Campus Luigi Einaudi, sono stati presentati da Elisabetta Ottoz – direttrice del Dipartimento di Economia e Statistica "Cognetti de Martiis" dell'Università di Torino – che introduce anche questo volume.

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The intent of the «Giorgio Rota» Best Paper Award *is to resume the research activity annually conducted by the Giorgio Rota Committee/Foundation before its inclusion in the Centro Einaudi. The focus is on the relationship between economic thought and action and a different aspect of living in society, keeping alive the memory and teaching of economist Giorgio Rota, one of the early members of the Centro, who died prematurely.*

Since 2012, the Centro Einaudi has therefore taken up this legacy by renewing the research formula: this annual prize dedicated to young researchers with an academic qualification in the fields of economics, sociology, geography, political science or other social sciences has therefore been established. Papers may be submitted either in Italian or English, and must not have been published before the date of the Rota Conference, the public event at which the winners have the opportunity to present their work.

The first edition's theme was Contemporary Economics and the Ethical Imperative *and the Giorgio Rota Conference was held at the Centro Einaudi on 25 March 2013 with keynote speech by Alberto Petrucci, LUISS Guido Carli, Rome.*

The second edition, was on Creative Entrepreneurship and New Media *with Conference Giorgio Rota at Centro Einaudi, 14 April 2014 and keynote speech by Mario Deaglio, University of Turin.*

The third edition analysed the topic The Economics of Illegal Activities and Corruption, *with Giorgio Rota Conference at Centro Einaudi, 15 June 2015. Keynote speech by Friedrich Schneider, Johannes Kepler University (Linz, Austria).*

The fourth edition focused on The Economics of Migration. *The Giorgio Rota Conference was held on 20 June 2016 at the Einaudi Campus, in cooperation with FIERI. Keynote speech by Alessandra Venturini, University of Turin. Since 2016, the Prize has also been supported by the Fondazione CRT.*

The fifth edition dealt with Economic Consequences of Inequality, *and the winning essays were presented at the Giorgio Rota Conference on 4 May 2017, held at the Einaudi Campus in collaboration with the Department of Economics and Statistics 'Cognetti de Martiis'. Introduction by Andrea Brandolini, Bank of Italy.*

*The sixth edition of the Prize, held in 2018, focused on the theme: T*he Economics of Health and Medical Care. *The winning papers were presented at the Giorgio Rota Conference held on 1 June 2018 at the Einaudi Campus, in collaboration with the "Cognetti de Martiis" Department of Economics and Statistics. Introduction by Fabio Pammolli, Politecnico di Milano.*

The seventh edition of the Prize focuses on the theme Rural Economies, Evolutionary Dynamics and New Paradigms. *The winning papers were presented at the Giorgio Rota Conference on 6 May 2019 at the Einaudi Campus, in collaboration with the "Cognetti de Martiis" Department of Economics and Statistics. Introductory talk by Donatella Saccone, Professor of Political Economy at the University of Gastronomic Sciences in Bra.*

Digital Transformation: Analysis of Economic Impact and Potential *is the title of the eighth edition of the Award. The winning papers were presented at the Giorgio Rota Conference on 11 May 2020, which was held online due to the Covid pandemic, in collaboration with the 'Cognetti de Martiis' Department of Economics and Statistics. The authors were introduced at the conference and in the volume by a speech by Pietro Terna, former Professor of Economics at the University of Turin and Centro Einaudi advisor.*

The ninth edition of the Award was on the theme Main Economic Tendencies in the Contemporary World Economy. *The papers were presented on 26 May 2021 at the Giorgio Rota Conference online. The authors are introduced in the volume by a contribution by Jack Birner, University of Trento and Centro Einaudi Scientific Committee.*

The tenth edition of the Prize was entitled Labor, value, robots. *The winning papers, during the conference held on 18 May 2022 at the Einaudi Campus, were presented by Elisabetta Ottoz - Director of the Department of Economics and Statistics 'Cognetti de Martiis' at the University of Turin - who also introduced this volume.*

Chi era Giorgio Rota

Giorgio Rota (1943-1984) è stato professore di Economia politica presso l'Università di Torino e consulente economico. Per il Centro Einaudi, è stato coordinatore agli studi e membro del comitato di direzione di «Biblioteca della libertà».
Le sue pubblicazioni scientifiche abbracciano diversi temi: l'economia dei beni di consumo durevoli, l'economia del risparmio, il mercato monetario e finanziario, l'inflazione e la variazione dei prezzi relativi, il debito pubblico. Ricordiamo tra esse: *Struttura ed evoluzione dei flussi finanziari in Italia: 1964-73* (Torino, Editoriale Valentino, 1975); *L'inflazione in Italia 1952/1974* (Torino, Editoriale Valentino, 1975); nei «Quaderni di Biblioteca della libertà», *Passato e futuro dell'inflazione in Italia* (1976) e *Inflazione per chi?* (1978); *Che cosa si produce come e per chi. Manuale italiano di microeconomia*, con Onorato Castellino, Elsa Fornero, Mario Monti, Sergio Ricossa (Torino, Giappichelli, 1978; seconda edizione 1983); *Investimenti produttivi e risparmio delle famiglie* (Milano, Il Sole 24 Ore, 1983); *Obiettivi keynesiani e spesa pubblica non keynesiana* (Torino, 1983).

Tra le sue ricerche va particolarmente citato il primo *Rapporto sul risparmio e sui risparmiatori in Italia* (1982), risultato di un'indagine sul campo condotta da BNL-Doxa-Centro Einaudi, le cui conclusioni riscossero notevole attenzione da parte degli organi di stampa. Da allora il *Rapporto sul risparmio,* ora *Indagine sul risparmio*, continua a essere pubblicato ogni anno.

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GIORGIO ROTA (1943-1984) was a professor of Political Economy at the University of Turin and an economic consultant. For the Centro Einaudi, he was coordinator of the Study Committee and member of the editorial board of "Biblioteca della libertà".

His scientific publications cover various topics: the economics of consumer durables, the economics of savings, the money market and the financial market, inflation and public debt. Among his publications: Struttura ed evoluzione dei flussi finanziari in Italia: 1964-73 *(Turin, Editoriale Valentino, 1975);* L'inflazione in Italia 1952/1974 *(Turin, Editoriale Valentino, 1975); in "Quaderni di Biblioteca della libertà":* Passato e futuro dell'inflazione in Italia *(1976) and* Inflazione per chi? *(1978);* Che cosa si produce come e per chi. Italian Handbook of Microeconomics*, with Onorato Castellino, Elsa Fornero, Mario Monti, Sergio Ricossa (Turin, Giappichelli, 1978; second edition 1983);* Productive Investments and Household Savings *(Milan, Il Sole 24 Ore, 1983);* Keynesian Objectives and Non-Keynesian Public Expenditure *(Turin, 1983).*

Particular mention must be made of the first Report on Savings and Savers in Italy *(1982), the result of a field survey conducted by BNL-Doxa-Centro Einaudi, whose conclusions received considerable attention from the press. Since then, the* Savings Report*, now* Report on the Italians' Savings and Financial Choices*, has continued to be published every year.*

ELISABETTA OTTOZ

INTRODUCTION

I am very glad that the Campus Luigi Einaudi and specifically the Department of Economics and Statistics Cognetti of the University of Turin are hosting the Conference for the 10th Giorgio Rota Best Paper Award.

I thank the organizers who asked me to address a short introductory speech on the issue chosen this year: labor, value and robots. A very challenging one.

First of all, I have to say that I am industrial economist and I approached the innovation economics by the means of intellectual property rights, patents and secrets.

What I'd like to do here is to draw your attention to what caught my attention while preparing this introductory speech on the effects of technological revolution we are undergoing: the so-called industry 4.0, characterized "by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres". See *The Fourth Industrial Revolution* (Schwab, 2017) and its effects not only on the manufacturing sector, but on services.

We are talking about interconnected processes, organizations and machines, decentralized decision-making enabled by nine main trends: big data, autonomous robots, simulation, additive manufacturing, the Internet of Things, cloud computing, augmented reality, horizontal and vertical integration, cyber security.

Despite the fact that negative prophecies on technological unemployment in the past didn't realize, there is a worried concern that advances in robotics and artificial intelligence will lead to massive job losses as well as wage inequality and employment polarization.

Industry 4.0, affects employment by two distinct ways: a displacement effect by which workers are forced out from tasks they were previously performing and/or a productivity effect increasing the demand for labor in industries or jobs that arise or develop as a result of technological progress. The net effect on total employment

depends on the balance between displacement and productivity effects (Acemoglu and Restrepo, 2019).

Frey and Osborne (2013), found that 47% of all persons employed in the US were working in jobs that could be performed by computers and algorithms within the next 10 to 20 year. Their results were overstated mainly for two reasons: they did not take into account how other sectors and jobs would respond to these changes and they considered whole occupations instead of single tasks, that could be differently automated, within an occupation. The result was that so they meant to be in the high-risk category workers who at least to some extent also performed tasks that are difficult to automate such as those involving face-to-face interaction.

Arntz *et al.* in 2016 re-estimated the share of jobs at risk of automation for 21 OECD countries including the US using a task-based approach. The share of jobs at risk of automation was found to be on average across OECD countries, 9%.

As Acemoglu and Restrepo (2020) state concentrating on the robotics industry in the United States, the two effects are at work: improvements in robotics technology negatively affect wages and employment owing to a displacement effect, as robots directly displace workers from tasks that they were previously performing, but there is also a positive productivity effect, as other industries and/or tasks increase their demand for labor.

They estimate a negative relationship between a commuting zone's exposure to robots and its post-1990 labor market outcomes. One more robot in a commuting zone reduces employment by about six workers; this estimate including both direct and indirect effects, the latter caused by the decline in the demand for nontradables as a result of reduced employment and wages in the local economy. However, this is not the end of the story as greater use of robots in a commuting zone generates benefits for the rest of the US economy by reducing the prices of tradable goods produced using robots and by creating shared capital income gains. The overall net effect on employment is still negative but weaker, one new robot reduces employment by about 3.3 workers.

Whether these technologies will increase, or (at least not decrease,) labor demand, employment, and wages is an open and important question that needs to be investigated using a number of approaches. Bessen (2019) stresses the role of demand in determining the effects of technological automation on employment: his analysis claims that "the rate of productivity growth determines the pace of employment change, but the elasticity of demand determines the sign".

Regardless of the different approaches, even the more optimistic analyses agree that the new productivity improving technologies will bring a disruptive reallocation of jobs; even if they do not permanently eliminate a large number of jobs, some form of temporary income support and retraining activities are needed. On balance, the range of empirical evidence suggests that the overall impact of robots on employment is not dramatic, so far is rather limited, and may actually be positive.

Here comes the point I'd like to raise. Hitherto the trend that we have witnessed has mainly concerned job displacement in manufacturing with a shift of workers from manufacturing to the service industries. With industry 4.0 is it still true that service jobs are protected from automation because they rely more on interpersonal interactions? Are service tasks going to be replaced by artificial intelligence and robotics?

This is a big question because the services sector is the largest component of the EU's economy (70% of GDP) and generates most of the jobs (90%), the figures in the US are analogous.

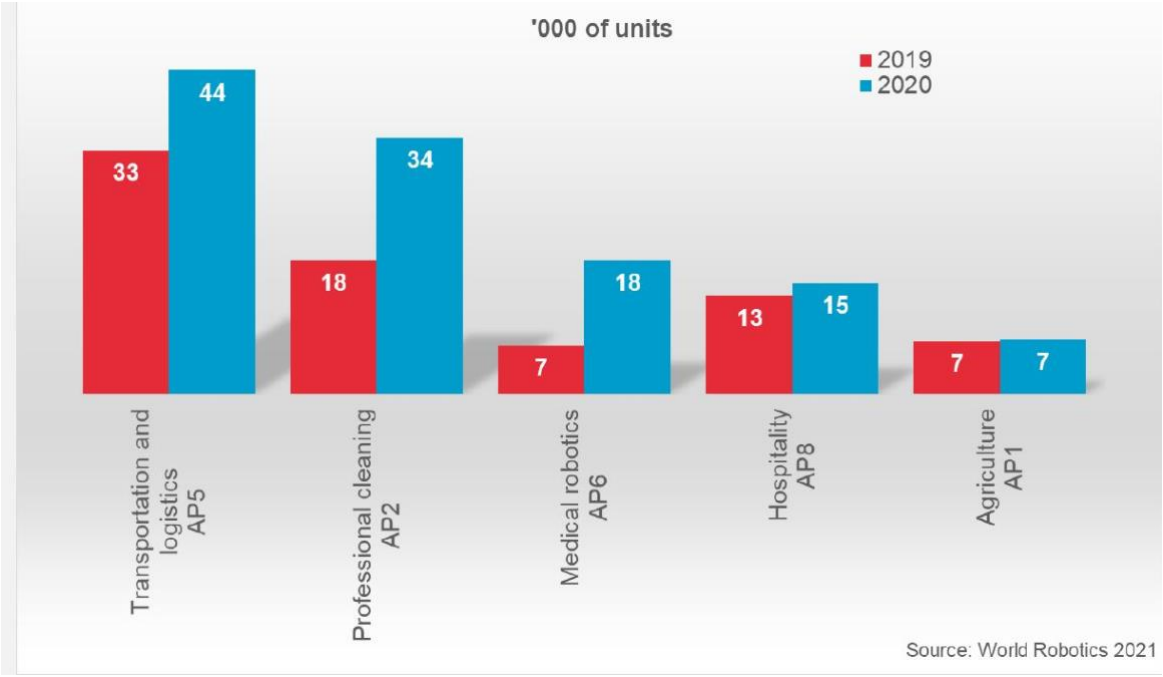
International standards now distinguish between industrial robots and service robots, defined as "physical, mobile devices with some degree of autonomy […] used to provide professional or consumer services, as opposed to manufacturing goods, performing useful tasks for humans or equipment excluding industrial automation applications.

Many technical advances in robotics, such as those presented at European Robotics Forum,[1] have applications in the service sector, including healthcare, logistics, inspection, and cleaning, entertainment, elderly or child care, hospitality.

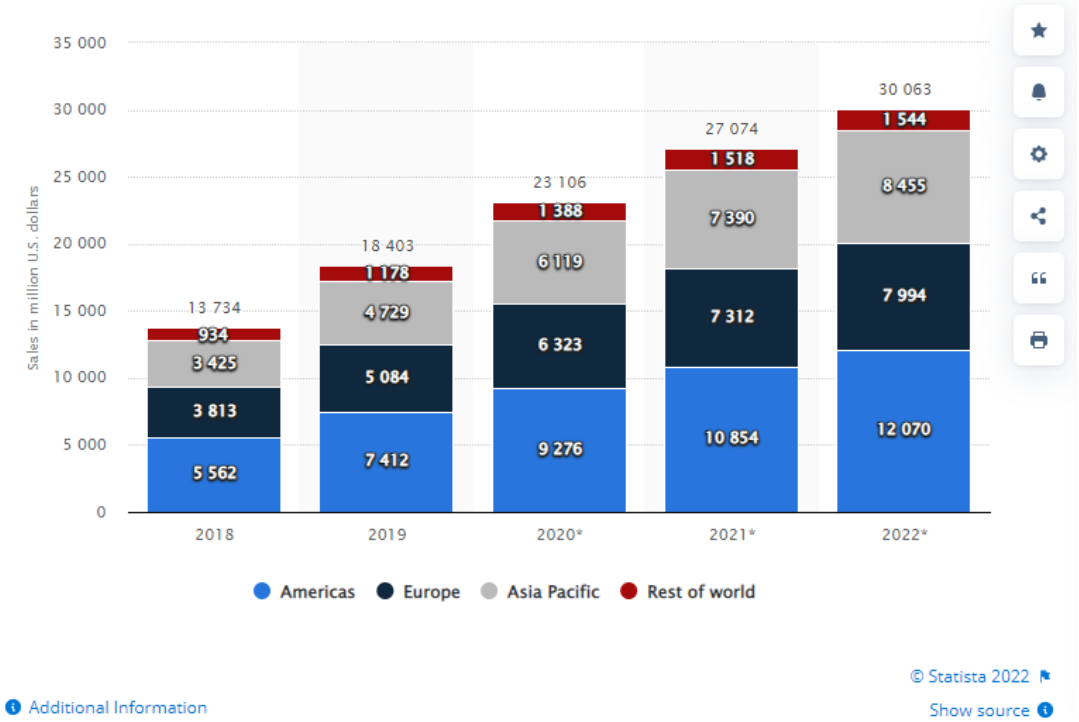
Many recent studies also cite advances in AI and robotics as a possible threat to white-collar occupations in the service sector, as the positive trend of sales value worldwide by 2018-2022 shows.

[1] https://ifr.org/ifr-press-releases/news/robot-sales-rise-again.

SERVICE ROBOTS FOR PROFESSIONAL USE TOP FIVE-APPLICATIONS
UNIT SALES 2019-2020



SERVICE ROBOTICS MARKET SALES VALUE WORLDWIDE 2018-2022, BY REGION



Despite the growing range of applications for robots in the service sector, the business case for adopting them is not always easy. For companies robots imply a relevant investment, requiring changes in the layout of their sites, adapting their organizational processes, and acquiring the necessary skills. Not all business models will find it worthwhile to make that investment. Automation in the service sector – in the form of service robots – is small but growing.

Depending on the nature of the service concerned different forms of intelligences are required: an interesting taxonomy is provided by Huang and Rust (2018) which distinguish four types of intelligences which can be mimicked with increasing effort by artificial intelligence: mechanical, analytical, intuitive and empathetic. As AI has reached a certain intelligence level, all lower types can coexist.

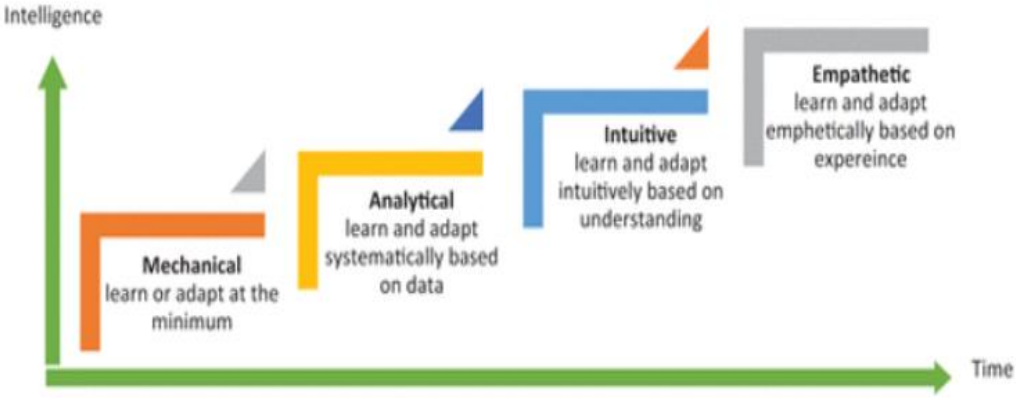
The mechanical intelligence refers to the ability to automatically perform routine, repeated tasks, which require limited training or education. At this level we find many AI applications such as McDonald's "Create you taste".

Analytical intelligence is the ability to process information for problem-solving and learn from it by a logical, analytical and rule-based learning. Tasks involved may be complex, yet systematic, consistent, and predictable. The setting refers to complete information: IBM chess player or problem diagnose in cars are examples of this level of achievement of AI.

Intuitive intelligence is the ability to think creatively and adjust effectively to novel situations; as such it includes hard thinking professional skills that require insights and creative problem-solving typical of lawyers, doctors, managers. As an example of AI application, we can mention Poker player Libratus capable of strategic thinking in settings of incomplete information.

Empathetic intelligence is the ability to recognize and understand other peoples' emotions, respond appropriately emotionally, and influence others' emotions. Specific skill examples include communication, relationship building, leadership, advocating and negotiating, work–life balance, whereas examples of feeling jobs are represented by politicians, negotiators, psychiatrists. An AI example is Sophia, so convincing that the Saudi government in 2017 has awarded her citizenship.

THE FOUR INTELLIGENCES (HUANG AND RUST, 2018)



This trend has very interesting and bewildering consequence on the instruction policies.

As we saw, regardless of the different approaches, even the more optimistic analyses agree that the new productivity improving technologies known as industry 4.0 will bring a disruptive reallocation of jobs and as we saw the service sector is a good candidate for it.

This calls for interventions to help people undergoing a job reallocation through income supporting and training and retraining policies.

More important is to gain awareness of the need to devote not only the first part of one's life to education and training, as this is not enough in a rapidly changing environment, either technologically and socially.

What is needed is a lifelong learning attitude based on a higher education system which develops basic skills making people capable of retraining quickly to meet the rapidly changing needs of the workplace. Obviously STEM disciplines are fundamental, but considering the way in which artificial intelligence develops, soft skills connected to the intuitive and empathetic areas are not to be neglected in education.

They are going to be the last and most lasting characteristics of humans in the confrontation between human intelligence and artificial intelligence: there might lie our advantage.

As it stared in Future of jobs Report (2018)[2]": the human' skills, such as creativity, originality and initiative, critical thinking, persuasion, and negotiation will likewise retain or increase their value, as will attention to detail, resilience, flexibility and complex problem-solving… Emotional intelligence, leadership and social influence as well as service orientation also see an outsized increase in demand relative to their current prominence."

This is well represented by the Applications of Soft skills In Engineering or STEM Programs.

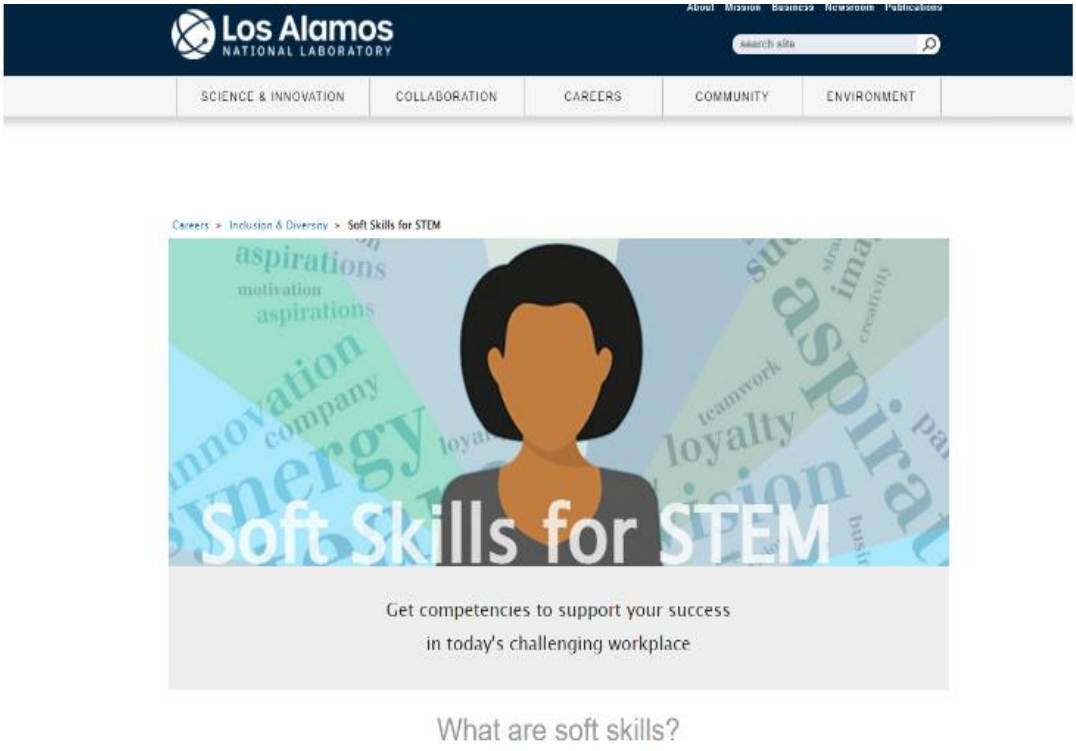
For instance, on the website of the Politecnico di Torino:[3]

> At the Doctoral School of Politecnico di Torino, doctoral candidates consolidate their scientific and technological background by taking supplementary doctoral courses on soft skills. These quality and innovative courses help them boost their skills in order to meet the needs of businesses and address the new challenges of the society of the future.
>
> They include:
>
> interacting with others, working in teams, working in open, multicultural and flexible environments, negotiating, managing conflicts; knowing how to make use of resources, optimizing time, managing projects; developing leadership skills, emotional intelligence and creative thinking; mastering the tools for communication, dissemination and public speaking; flexibility and adaptability in the workplace; ability to address work challenges; having the tools to manage change, develop innovation, work ethically with entrepreneurial spirit; managing career development and seizing professional opportunities.

Another example is the figure which refers to Los Alamos National Laboratory where the caption says: "Soft skills for STEM[4]: Soft skills are personal competencies that improve human performance, facilitate effective interactions, complement the technical requirements necessary to acquire and maintain employment".

[2] https://www.weforum.org/reports/the-future-of-jobs-report-2018/.
[3] http://dottorato.polito.it/en/soft_skills.
[4] https://www.lanl.gov/careers/diversity-inclusion/s3tem/index.php.

SOFT SKILLS FOR STEM



I may be a little biased being in a Department of Economics and Statistics which is part of a School of Law, Politics and Social-Economic Sciences, but I find it relevant, as a final message of this address, to recommend students not to forget to improve their soft skills through humanities. Not only low skilled workers can turn to a social job, even high skilled workers can benefit from having developed intuitive and empathetic skills.

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FILIPPO PASSERINI

MONOPSONY IN LABOR MARKETS: EMPIRICAL EVIDENCE FROM ITALIAN FIRMS

Abstract. I leverage on a matched employer-employee database drawn by INPS archive representative of the universe of Italian private sector workers to investigate how labor market concentration affects wages and employment in Italy. I compute concentration measures relying on new hires finding that LMs aren't on average concentrated, despite showing relevant heterogeneity. I then investigate the endogenous relationship with wages and employment finding negative effects. I finally develop a novel IV strategy based on M&As to explore whether they increase concentration at a market-level and to find a reliable source of variation to identify their effect. First stage estimates indicate that only mergers raise significantly concentration, while other events don't. Relying on the former estimated elasticities range between 0.09 and 0.14 p.p for wages and between 0.68 and 0.77 p.p for hires.

Keywords. Monopsony, Wages, Labor Market Concentration, Mergers, Employers' Power, Hires

1. INTRODUCTION & LITERATURE

The labor economics literature has often defined labor market monopsony a situation where employers' power as a buyer of labor services is not compensated by sufficient workers' bargaining power and workers have low or no outside options.

Strictly speaking, the term monopsony refers to the extreme case in which one buyer dominates a specific upstream market and, to maximize its profits, can fix input purchases and prices below the level that maximizes social welfare (OECD, 2019). There's evidence that monopsony can explain wage inequality and falling labor shares trends from a macro perspective, while from a micro one it can explain trends in wage, productivity and employment dynamics as well as the gender wage gap and migration phenomena (Manning, 2020). For these reasons, there is growing literature trying to explore this topic. My work aims at contributing to this literature by calculating a novel long-period measure of labor markets concentration in Italy, identifying the effect of concentration on wages and employment across time and linking concentration to M&A's dynamics to find

a reliable source of variation. Many papers have recently studied the issue of growing concentration in labor and product markets. Most of them have focused on US economy, which is for many reasons different from the European and Italian one. Moreover, the available research in these fields has not focused on the labor market side of this issue, thus making use of microeconomics tools to evaluate monopsony evolution through time, and its impact on the labor market. Guitierrez and Philippon (2020) analyze the growth in superstar firms - in terms of size and productivity - from 1960 up until the present.

They find a steady decline in all the dimensions, thus suggesting that the fear of weaker competition in US labor market is mostly unfounded. An ongoingwork byMertens (2021) relying on German manufacturing firm-level data shows that wage inequality is increasing due to across firms' heterogeneity. Deriving firms' specific measures of MRPL, the author proves that among the right tail of firms' distribution - those bigger, more productive and paying higherwages - there's an increasing labor market power (i.e., the wedge between MRPL and wages). The work proves that growing wage inequality hence is not due to lower-paying and low productive firms, but rather to superstars paying already high salaries but still lower than marginal revenues. A recent paper by De Loecker *et al.* (2020) based on US firm-level data investigates the evolution in market power and its relationship with firm markup and revenues. It finds that from 1980 onward markups have risen from 21% to nearly 61% in 2014, while average profit rates have increased from 1% of sales to 8%. Authors attribute this rise in market power nearly exclusively to the increase for the firms with the highest markups already, the so-called superstars. The distribution of markups has become more skewed, while the median of the distribution remains unchanged. Berger *et al.* (2019) derive instead a theoretical model to predict the evolution of market power estimated through the HH index in the US firms' market. Calibrating their model on US census data, they prove that the payroll weighted wage-bill Herfindahl fell from 0.20 to 0.14 between 1976 and 2014 indicating a significant decrease in labor market concentration. This in turn has increased labor share of income by 3% between 1976 and 2014. Different explanations were found in a recent paper by Summers and Stansbury (2020) where they, using aggregated macro data from the '80s showing the decline in labor share and increase in aggregate markups, profits and revenues driven by a small subset of superstar firms', manage to link these trends to the decline in workers powers measured by the unionization rate. Summing up,

the literature indicates that with different methodologies and data labor market concentration has increased steadily, is associated with a decrease in labor share and an increase in markups and productivity. However previous works are mostly based on US data, while the decline in labor share and the rise in labor market concentration is a worldwide phenomenon. More evidence regarding Europe and Italy is needed to prove whether the same patterns have emerged. Moreover, these works do not identify causal relationships between rising concentration and labor market outcomes. Autor *et al.* (2019) analyzing micro panel data from the US economic Census since 1982 document empirical patterns to assess the fall in the labor share due to the rise of superstar firms. Sales concentration is rising across a large set of industries. Those industries where concentration has risen the most exhibit the sharpest falls in the labor share, and the between firms' reallocation of the labor share is greatest in the industries that are concentrating the most. Aggregate markups have been rising and the industries that are becoming more concentrated are also becoming relatively more productive and innovative. Finally, these patterns are observed not only in US data but also in OECD countries. Analyzing the nurses' labor market in California, Matsudaira (2010) finds negligible evidence of growing monopsony, thus hindering the growing concerns in the US about trends in the labor share and rising market power. Azar, Marinescu and Steinbaum (2019) contribute to this growing debate by calculating measures of market concentration in more than 8000 US local labor markets for the most frequent occupations on CareerBuilder.com. They prove that concentration is high and increasing and that is associated with lower wages. Few works have also tested Manning (2003)'s predictions: increasing monopsony reduces workers' bargaining power and increases that of the employers, thus pushing wages downward. However, due to the differences between the US and European labor market in terms of employment protection legislation and wage setting, further discussion when it comes to Europe is needed. A stream of research has focused primarily on the causes of an increase in monopsony in the labor market. An increase in monopsony might hinder both worker and consumer welfare. This information has led US and in turn European authorities to warn governments on the feasible detrimental effects. OECD (2020) provides a list of main determinants of monopsony (see also Sulis, 2011): searching costs, absence of coordination, information asymmetries, regulatory barriers limiting labor mobility, workers inertia, and lack of mutual recognition of licensed professions. OECD (2019)

highlights also the growing dangers induced by an unbalanced relationship between employers and employees, claiming that it might be addressed by better regulation and more effective enforcement. The authors state that monopsony tends to emerge in situations where there are few, large firms, and where frictions in the labor market, preventing workers from easily switching jobs in response to changes in wages or working conditions, are considerable[1].

Considering thus the characteristics of the Italian labor market monopsonistic patterns might arise and expand. Langella and Manning (2021) provide the most recent and comprehensive work ad dressing monopsony from a microeconomic and theoretical perspective. They state that the attention should shift from whether monopsonistic power exists to what are its effects and how to measure it. They also discuss the most relevant methods to estimate employers' power, identifying as the most appropriate the elasticity of the labour supply curve facing the firm, whose degree gives the intensity of employers' power in a market. They also point at the fact that this power is more effective on entrants rather than incumbents. Sokolova and Sorensen (2020) meta-analysis sum up more than 1300 firm-level estimate of labor supply elasticity across countries and years obtained with a wide range of different techniques and data finding that on average there is strong evidence of monopsonistic frameworks, even though characterized by high variation. Estimations regarding Europe are higher than those regarding new world countries, suggest ing thus that European labor markets are more competitive. Regarding instead Italy, Sulis (2011) studies wage elasticity in a sample of workers drawn by *INPS* finding that a positive relationship between firm size and wages can be interpreted as a positively sloped labor supply curve, which is a sign of the presence of monopsony (Manning, 2003). Endogeneity is addressed by relying on an exog nous shock (i.e., *Scala Mobile reform*[2]). Sulis finds that in the pre-reform period there was a strong negative relationship between wages and employment that becomes less significant in the post-period (with a stronger effect for men), which indicates the presence of monopsony. The latest reforms in the Italian legislation stringency provide additional motivation for my analysis.[3] The

[1] Remedies are: extend the coverage of labor market regulations, more aggressively enforce rules against employ ers colluding in the labor market (i.e. Nonpoaching agreements), limit the range of Noncompete agreements, use labor market regulation to redress information asymmetries between employers and workers and finally reduce searching frictions and costs and enhancing labor market mobility.

[2] Basically, it was an automatic indexation of workers' wages approved in 1992 aimed at protecting their purchasing power from increases in the cost of living.

[3] Fornero's reform (2012) and Jobs Act (2015).

main works addressing labor market concentration in Europe are Marinescu *et al.* (2021), Azkarate-Askasua and Zecezero (2020), Bassanini *et al.* (2021) and Dodini *et al.* (2020). In the first, the authors use French panel microdata combining information regarding firms and workers' wages, adding the interaction between unionization rate and the local HH indexes. They find that the standard neg ative effect of concentration on wages becomes positive. In the second, relying on longitudinal employer-employee data, the authors estimate the evolution of concentration in French LLM's estimating the impact of firms' shares within each market on wages. They both rule out the potential endogeneity problem between wages and concentration by relying on two different instruments. On average, local labor markets concentration has increased and the higher the firm share, the lower is the yearly average wage paid to workers, confirming Manning (2003)'s prediction. Bassanini *et al.* (2022) instead investigate the effect of con centration across LLM's in France on incumbents' wages, rather than entrants, finding a negative and significant elasticity of approximately (0.015-0.025) p.p.. Considering the high stringency of French labor market legislation and wage rigidities, the authors believe that their estimates reflect the lower bound of labor market concentration effect on wages. Dodini *et al.* (2020) rely on concentration to proxy employer's power with a slight but significant change in the methodology. They compute thick concentration measures of workers flows in Norway across clusters of skills, as classified by the O'NET source, rather than industries and occupations. They find that this measure is more relevant in explaining standard labor outcomes than previous ones because these tend to overestimate concentration not taking into consideration workers' mobility within the same skills clusters and across occupations and industries. Their findings also indicate that women and migrant density within higher concentrated markets might additionally explain the gender wage gap and productivity dynamics. These predictions are expressed also in Manning (2020) and empirically tested in Detilleux and Deschacht (2021). They found relying on US administrative microdata that labor supply elasticity of women is lower than that of men and that children's presence has a hampering and monotonic effect for women only. According to the authors, this result indicates that women self-select into more concentrated markets where employers' power is higher and more exerted also because children's presence reduces outside options.

2. EMPIRICAL STRATEGY

I aim to contribute to this growing literature calculating the intensity through time of employment concentration within and across Italian labor markets. A market is defined as an interaction of a region, an industry and an occupation, and it's followed for each year. The goal is to provide evidence on the evolution of employers' power estimated relying on the Herfindahl-Hirschman index within and across Italian labor markets (Azar, Marinescu and Steinbaum, 2019; Marinescu *et al.*, 2021). I rely on a flow-based measure of concentration, rather than the standard one based on stocks. In fact, to the extent that new hires adequately measure available job opportunities for workers, it paints a more precise and dynamic picture of how markets' concentration evolves through time. Marinescu *et al.* (2021) prove empirically why flow-based measures are more adequate: they calculate the HHI on both stocks and flows of employment proving that they correspond to different concentration levels. For example, in their data, the standard value of 0.25 for highly concentrated markets based on stocks corresponds to 0.7 in the flow-based measure. Hence, relying on the stock-based measure seriously tends to underestimate the actual levels of concentration across labor markets. A concentration measure based on new hires is also relevant for the wages of incumbents because it reflects their potential outside options across points in time (Bassanini *et al.*, 2022), still assuming that hirings measure correctly available opportunities in the job market. I then move to estimate the impact of labor markets concentration on workers' wages and employment relying on multiple FE's specifications, addressing in turn endogeneity through an IV strategy based on mergers happening across labor markets and years.

2.1 Data

To calculate concentration and measure wages and hires, I exploit *LoSaI* (Appendix 6.1) which provides several dataset containing information on all working spells including remunerations of a sample of workers and of linked firms – such as size class (discrete as classified in 14 brackets from 15 to over 500 employees) and industry (2-digits ATECO cells) from 1985 to 2018 that can be associated to registry information of the same workers, including the region of residence. I select only new hires in the period 2005-2018, as theoretical and empirical predictions indicate that employers' power compresses entrants' wages

rather than long-period incumbents which are protected by open-ended contracts. I define new hires as the spells activated for each individual in a given year in which firm does not match the one for which the same individual has worked the previous year (Bassanini *et al.*, 2022). I additionally exclude transformations keeping only newly activated spells. Finally, I delete for each worker repeated observations within the same year keeping the longest spell. I compute the main dependent variable daily wages by dividing the overall gross remuneration for each employment contract by the number of worked days recorded both by *LoSaI*, thus ruling out the likelihood of measurement errors. The number of records with value of 0 in the dependent variable is less than 50,000 and they are discarded in the regressions.

TABLE 1 • SUMMARY STATISTICS FOR AGE AND DAILY WAGES, NOMINAL AND REAL. REAL WAGES ARE OBTAINED DEFLATING NOMINAL DAILY WAGES WITH THE 2015 CPI (SOURCE: ISTAT).

variable	N	mean	sd	min	p1	p50	p99	max
Age	3,573,677	35.556	11.194	18	18	34	62	67
Daily wage	3,573,677	61.079	42.146	0.000	0.000	56.494	213.462	700.000
Daily wage (real)	3,573,677	64.393	44.380	0.000	0.000	60.122	226.453	704.935

Note: Observations are 3,573,677 entrants' employment contracts defined as those newly activated for each individual who was not working in the same firm the previous year.

2.2 Measuring concentration within labor markets

A labor market is defined as an interaction between an industry *s*, and occupation o and a region *r* (Appendix 6.1). Industries are 2-digits cells classified according to the ATECO brackets, occupations are *employees*, *managers*, *middle managers apprentices* and *workers*, while regions are those of residence of workers. I can therefore estimate concentration across Italian labor markets relying on the Herfindhal-Hirschman formula:

$$\mathrm{HHI}_{m,t} = \sum_{\#d_m} s_{d,t}^2 \qquad (1)$$

where $\#d_m$ represents the number of class sizes in each market m and s is the ratio of the number of new hires for the representative firm in class d in m in t over the total number of hires in m and t. The representative firm's hires for each size class are computed by dividing the number of hires for each year within that size class by the number of firms hiring in the same year within that size class. The underlying idea beyond the construction of this index is that firms within the same class size pay similar wages, and that market concentration depends on the heterogeneity of hires across firms' sizes within it. The fact that larger firms or plants pay higher wages, and viceversa, in the US as well as in Europe is well established in the literature (Krueger and Summers, 1988; Brown and Medoff, 1989; Oi and Idson, 1999). In Italy, Bertola and Garibaldi (2001) find that both the mean and the variation of wages depend on firms' size while Mion and Naticchioni (2009) find that firms' size explains a relevant portion of spatial and time variation in wages.

2.3 Evidence on markets and concentration

I compute concentration measures for approximately 6,000 markets. However, several markets have only one spell which induces an upward bias in the estimation of the HHI as with one spell only the index for a mechanical bias induced by the formula in Equation (2) is equal to 1, the value that indicates the highest level of concentration. This is a widely documented weakness of the HH index. To address it, I follow a common procedure in the literature and I delete all those market-year tuples with one spell only. Finally, I obtained an almost balanced panel of 47,727 market-year tuples regarding 5,008 markets in Italy between 2005 and 2018 containing 3,600,00 employment contracts associated with 1,400,000 workers.

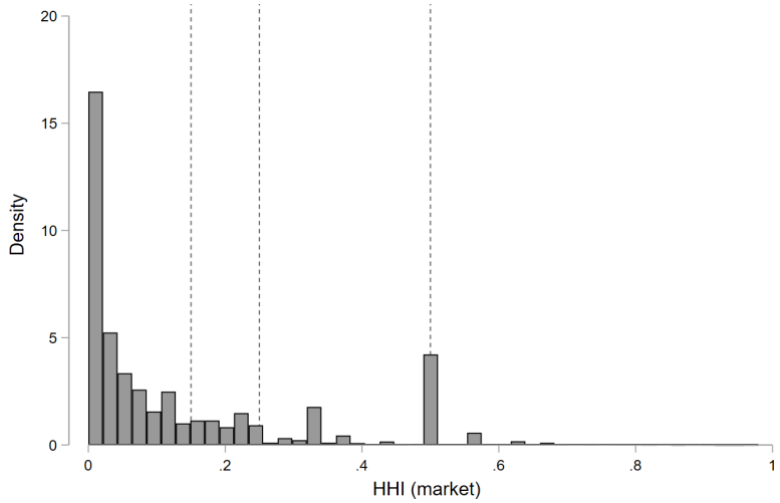
TABLE 2 • SUMMARY STATISTICS OF CONCENTRATION MEASURES ACROSS MARKETS (*M*), INDUSTRIES (*I*), REGIONS (*R*) AND OCCUPATIONS (*O*) ONLY RESPECTIVELY.

variable	N	mean	sd	min	p1	p50	p99	max
HHI_m	47,727	0.136	0.174	0.000	0.000	0.054	0.625	0.979
HHI_i	1,064	0.155	0.087	0.006	0.027	0.141	0.424	0.642
HHI_r	280	0.148	0.040	0.088	0.094	0.138	0.269	0.291
HHI_o	84	0.211	0.094	0.091	0.091	0.206	0.363	0.363

Source: Own calculation based on LoSaI, 2005-18.

Note: indexes are calculated according to formula (2) relying on entrants' spells those newly activated for each individual who was not working in the same firm the previous year. For occupations, industries and regions indexes are calculated as averages of markets HHI's within each of them.

FIGURE 1 • HISTOGRAM OF CONCENTRATION ACROSS 5,008 LOCAL LABOR MARKETS IN ITALY FROM 2005 TO 2018

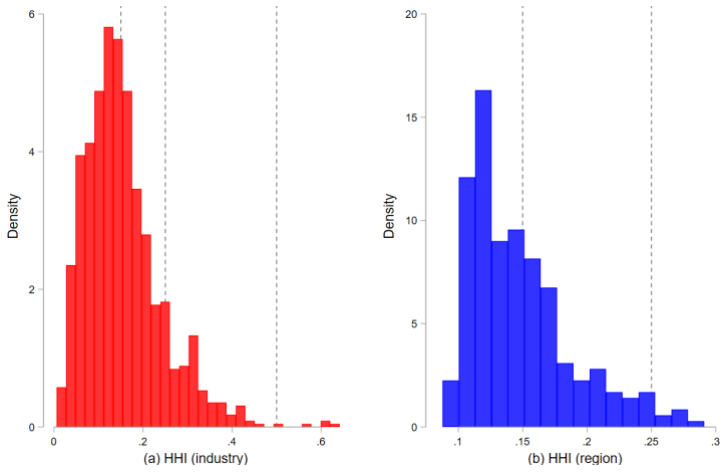


The dotted lines represent the standard thresholds to define respectively low, medium, high-medium and high levels of concentration. Markets are defined as combination of regions, industries and occupations. Markets HHI's are calculated as the squared sum of class size shares, where the share is calculated as the ration between hires by market-year tuples of the representative firm in each size class and the total number of hires in that market. Observations are 47,727 market-year tuples.

On average, concentration across markets in Italy is moderate: the median value is by far lower than the standard threshold indicating a medium level of concentration and only a few markets can be classified as concentrated. However, the average value of concentration is approximately 0.14, indicating instead a medium concentration. This proves that the distribution is right-skewed: most of the markets are not concentrated while only a few are.

Summing up, concentration distribution in Italy is heterogeneous: most of the markets show low value while few are highly concentrated driving the average value upward. When computing the measure across regions, industries and occupations only concentration increases: on average, values indicate approximately medium concentrated markets, with occupations having a value that is slightly lower than the high concentration threshold. One concern is that concentration varies with time peaking during the recessions thus eventually exacerbating their detrimental effect on workers' welfare. However, my results point in a different direction: concentration is heterogeneous across time and during the peak of the financial crisis (2009-2014 in Italy) it does not differ significantly from the whole period as proved by Figure 3 and Figure 5. Therefore, it does not seem that labor con centration is an additional channel through which recession might damage employment and wages.

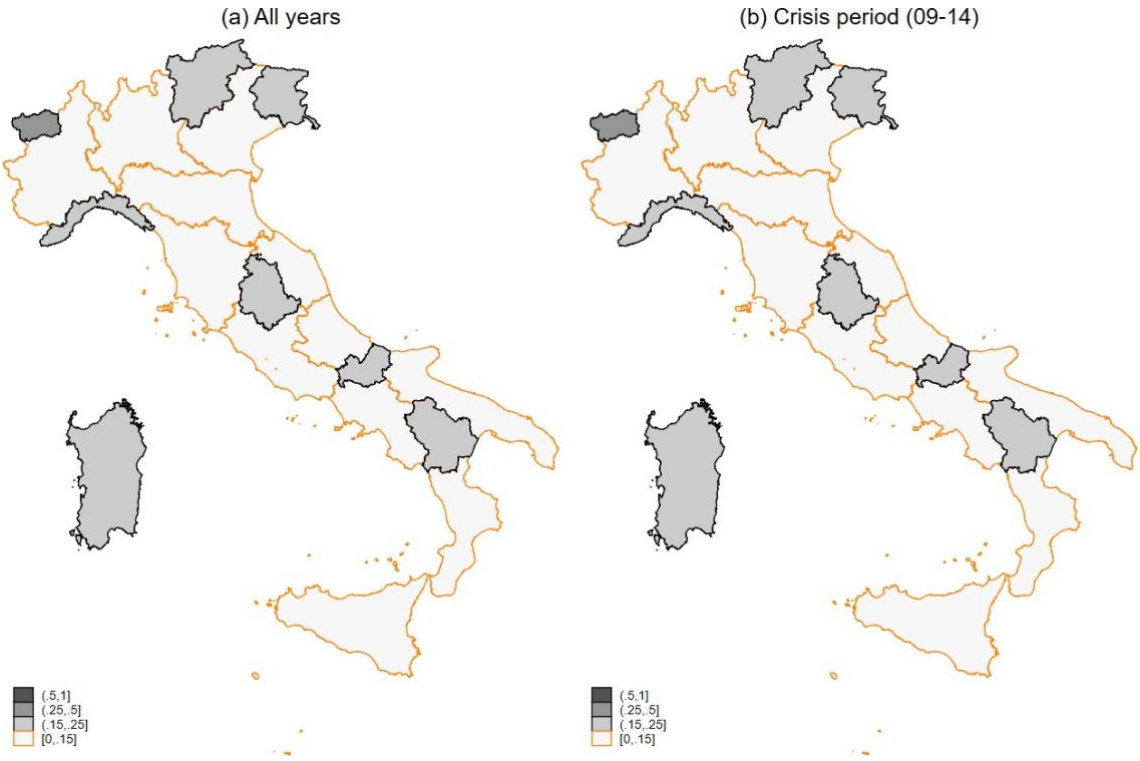
FIGURE 2 • HISTOGRAMS OF CONCENTRATION ACROSS INDUSTRIES AND REGIONS IN ITALY FROM 2005 TO 2018.



Industries are 76 2-digits ATECO cells while regions are the 20 Italians. The dotted lines represent the standard thresholds to define respectively low, medium,

high-medium and high levels of concentration. HHI's for industries and regions are calculated as averages of markets HHI's' within a given industry cell or a given regions. Markets HHI's are calculated as the squared sum of class size shares, where the share is calculated as the ration between hires by market-year tuples of the representative firm in each size class and the total number of hires in that market. Observations are respectively 1,064 industry-year and 280 region-year tuples.

FIGURE 3 • CONCENTRATION MAPS OF ITALIAN REGIONS BETWEEN 2005 AND 2018 IN PANEL (A) AND ONLY DURING THE CRISIS IN PANEL (B).



Crisis period goes from 2009 to 2014. Colors indicate the standard boundaries defining low, medium, highly medium and high levels of concentration. HHI's for regions are calculated as averages of markets HHI's' within each region and across all years in Panel (a) and for 2009-2014 in Panel (b). Markets HHI's are calculated as the squared sum of class size shares, where the share is calculated as the ration between hires by market-year tuples of the representative firm in each size class and the total number of hires in that market. Observations are 280 region-year tuples.

3. RESULTS

3.1. Concentration effect on wages

To test the impact of concentration across Italian labor markets on entrants' wages I estimate several fixed effects specifications, relying on the evidence described in Section 2.3. I estimate the following model:

$$log(Y_{i,m,dj,t}) = \delta_i + \mu_m + \gamma_s + \Gamma_{r,t} + +\Lambda_{d,t} + \Phi_{o,t} + \beta_t + \theta log(HHI_{m,t}) + \Gamma Z_{i,t} + v_{i,m,dj} \quad (2)$$

where *i* indexes workers, *r* regions, *o* occupations, *j* firms, *d* class sizes, *s* industries, and *t* years. *Y* is the gross daily remuneration for each yearly spell of worker *i* in region *r*, with occupation *o*, in firm *j* of class size *d* and industry *s* in year *t*. The others are worker-level covariates, such as a quadratic polynomial for age and spells length to proxy individuals' working experience and on-the-job specific working experience. Markets m are defined as interaction of *r*, o and *s* in *t* and shares are calculated within each *d*. θ should be interpreted as the elasticity of entrants' wages with respect to market concentration, as the model is specified as a loglog. Models are estimated with OLS with multiple FEs (Correia, 2017) assuming that observations are correlated within markets and years (Bassanini *et al.*, 2022). I hence take into the potential effects of shocks involving workers within the same market and in a given year. I do not allow for a wider clusterization at a market level as it's presumably unlikely that shocks affecting market concentration persist across all years. I exploit hence both cross-sectional and within time variation in concentration to address its effect on workers' wages, controlling for a full set of time-varying covariates at a worker and market level as well as for market and worker fixed effects. I hence aim to reduce the presence of time invariant characteristics at a worker and market level. Thanks to the length of the panel, market and worker FE's detect a considerable amount of wages variation. I also control for occupation-year, region-year and size-year fixed effects to take into account potential time-varying confounding effects influencing jointly concentration and wages at different levels. Results in Table 3 indicates that the relationship between concentration and wages exists but overall is weak, as it changes by adding additional covariates. The sign switches when I add market fixed effects, suggesting indeed that time-invariant unobserved heterogeneity at a market-level do explain a considerable amount of variation of both wages and

concentration. In the latest specification, the elasticity of wages with respect to concentration is negative, even though slightly significant and weak. The magnitude and significance of the estimates across the specifications indicate that the specifications suffer from endogeneity, mainly due to the simultaneous relationship between wages and concentration. Higher concentrated markets might be also those whose firms have attracted more skilled and productive workers offering higher wages. The opposite holds in markets where firms have less incentive to reward workers' skills and thus end up being less concentrated. I'll extensively discuss endogeneity in Section 3.3.

3.2 Concentration effect on employment

Literature has also predicted theoretically and proved empirically that labor market concentration affects employment. The effect might go through two channels: on the extensive margin, a highly concentrated market prevent firms to enter the competition and reduce employment while on the intensive margin firms holding power have the incentives to reduce labor input to implement a cost saving strategy. I'm not able to disentangle these two mechanisms because I do not observe in my data workers' in and out flows of a representative population of firms. However, I can test whether employment decreases when concentration increases. I measure new hires as the number of new employment contracts activated within each market-year tuple and estimate the Equation:

$$log(F_{m,t}) = \delta_m + \Phi_s + \gamma_{o,t} + \Theta_{r,t} + \beta_t + \theta log(HH_{m,t}) + \phi X_{m,t} + v_{m,t} \quad (3)$$

where m indexes markets, δ and β represent market and year fixed effects and γ, Φ and Θ are occupation-year, industry and region-year fixed effects. X are market-level controls. Following Marinescu *et al.* (2021) I measure employment as a flow: the number of labor contracts signed in a market during a year and denoted by $F_{m,t}$. I estimate Equation (4) with OLS adding fixed effects at a market-level and a full set of time-varying market-level controls. θ should be interpreted as the elasticity of employment with respect to labor market concentration, as the model is specified as a log-log. X includes controls as the average age and the share of men in the market.

TABLE 3 • ESTIMATES OF ELASTICITY OF ENTRANTS' WAGES WITH RESPECT TO MARKETS CONCENTRATION BETWEEN 2015 AND 2018

Dependent variable: ln(Daily wages)				
	(1)	(2)	(3)	(4)
ln(HHI)	.00209**	-.00152**	.00115	-.0014*
	(.00075)	(.00068)	(.0011)	(.00081)
Observations	2,928,818	2,928,818	2,928,474	2,928,474
spell length & age (squared)	√	√	√	√
part time dummies	√	√	√	√
worker FE	√	√	√	√
year FE	√	√	√	√
industry FE	-	√	√	√
region FE	-	√	√	-
occupation FE	-	√	√	-
size FE	-	√	√	-
reg-ind-occ FE	-	-	√	√
occupation-year FE	-	-	-	√
size-year FE	-	-	-	√
region-year FE	-	-	-	√

SE clustered at a market-year level.
Daily wages are the ratio of overall remuneration and the number of worked days
*** p<0.01, ** p<0.05, * p<0.1

Obs are 3,573,677 yearly spells between 2005 and 2018. Note: observations are lower than in the full sample and differ across specifications because singletons are iteratively dropped when including worker and markets FE's.

TABLE 4 • ESTIMATIONS OF ELASTICITY OF EMPLOYMENT WITH RESPECT TO CONCENTRATION AT A MARKET-LEVEL

	(1)	(2)	(3)
	ln(Hires)	ln(Hires)	ln(Hires)
ln(HHI)	-.1166***	-.1167***	-.0948***
	(.00445)	(.00446)	(.00332)
Observations	47,180	47,180	47,180
(mean) sex & age	√	√	√
reg-ind-occ FE	√	√	√
year FE	√	√	√
occupation FE	-	√	-
region FE	-	√	-
industry FE	-	√	√
region-year FE	-	-	√
occupation-year FE	-	-	√

SE clustered at market level
*** p<0.01, ** p<0.05, * p<0.1

Employment is measured as the number of newly activated working spells within each market and year. Full sample is made of 47,727 market-year tuples. Markets are 5,008.

Table 4 proves that there is a negative and significant correlation between market-level concentration and employment flows: when (and where) concentration increases, hires diminish. Coefficients are very similar in magnitude across all different specifications and they are very precisely estimated, as the standard errors are all very similar and small. Estimates suffer of endogeneity: concentration and hires do influence each other, even though differently with respect to wages. In fact, due to the Herfindhal-Hirschman formula, markets with higher spells tend mechanically to have a lower level of concentration while the opposite holds for markets with fewer spells. This induces a negative relationship between the two variables which biases towards zero the estimations of concentration effect, as this mechanical effect covers the true one. Moreover, there might be still shocks influencing hires and concentration simultaneously, such as a massive lay off specific to a market or an industry, that I cannot take into account without relying on a shock moving concentration only.

3.3 Threats to identification

I estimate the models including a full set of fixed effects and controls at a worker and market-level, both time-varying and not. Year fixed effects capture macro shocks – homogeneous across regions, industries and occupations – happening at a national level and possibly influencingwages and firms' hires dynamics, such as workers' out-of-work benefits which are set at a national level, macroeconomic fluctuations and trend effects. Occupation-year, size-year and region-year fixed effects capture instead specific time-varying dynamics across regions – capturing local specific employment dynamics –, firms' size – capturing yearly specific productivity trends for firms of the same size class – and occupations. However, industry-specific time trends, firms' productivity and market tightness shocks raise concerns about the robustness of Equation (3). I'm already controlling for market, occupation-year and region-year fixed effects but not for industry-year. This means that whether during the period of analysis a yearly-industry specific shock affecting wages happens estimates would be biased. Including firms' fixed effects would solve the former, but as described in the introduction *LoSaI* is not representative at a firm-level. *LoSaI* is instead representative across and within firms' size' classes and indeed I include size-year fixed effects. However, the presence of firm-specific characteristics correlated to wages – such as productivity, human capital, employers' attitude and others factors explaining wages heterogeneity – would bias the estimates. Market tightness is an additional threat: I control for both market and region-year fixed effects as proxies. Ideally, I should build more detailed measure of labor market concentration relying on the commuting zones as in the literature (Marinescu *et al.*, 2021; Bassanini *et al.*, 2022; Autor *et al.*, 2019) to precisely take into account local employment dynamics. However, I have no access to further segmentation beyond the regions in *LoSaI* and hence I cannot improve the specification. Another concern is raised by the absence of product market concentration: its omission presumably biases the estimates downward as it's established in the literature (Marinescu *et al.*, 2021; Dodidi *et al.*, 2020; Bassanini *et al.*, 2021) that it's correlated positively with concentration and negatively with wages. Unfortunately, I don't have access to firm-level information regarding prices and markups and hence I cannot improve the specifications in this sense. However, the bias is likely attenuated thanks to market and year FEs. The latter issue is reverse causality, which is induced by time-varying market-level shocks influencing simultaneously

wages and concentration that I do not control for. The main one is again market tightness which is correlated to both wages and concentration at a market-level as it depends simultaneously on hires and vacancies. Nevertheless, there might be other confounding effects. Industry-year shocks influencing simultaneously concentration and wages – such as technological or trade shocks targeting specific industries in specific years – might occur and would bias the estimates as I do not control for industry-year fixed effects. Additionally, a mass layoff occurring in a given market certainly would increase concentration, but at the same time also has a direct and significant effect on wages and hires. Ideally, I should control for market-year fixed effects, ruling out the presence of all kinds of confounding effects at this level. However, collinearity likely arises with respect to other fixed effects thus invalidating the estimates of the true effect in the exam. Moreover, there's an additional ongoing relationship between wages and concentration: on one hand, everything else equal, higher wages attract more workers and therefore increase markets' concentration. On the other hand, if there is labor market power on the employer side, I expect two workers with the same characteristics to be paid differently depending on the specific local labor market concentration. These twomechanisms cancel out and their interaction does play a relevant role in terms of the magnitude of the bias, as the endogenous estimates contained in the empirical literature are bounded to zero with respect to those exogenous. The employment specification in Equation (4) additionally suffers from reverse causality because of the mechanical relationship that assigns higher concentration to markets with fewer spells. The opposite instead holds for markets with more spells. Again, I expect the exogenous estimates to be greater in absolute terms because not constrained towards zero. To rule out all these biases I have to rely on a shock triggering a variation in concentration orthogonal with respect to wages and employment dynamics.

3.4 Addressing endogeneity through mergers

The issues previously described can be solved by relying on a shock moving only concentration. This variation should rule out the joint effect of any labor demand and offer shocks at a market-level influencing contemporaneously concentration and the outcomes of interest. Furthermore, it should also be orthogonal with respect to the joint presence within and across markets of that mechanism inducing a positive correlation between concentration andwages. To

obtain this exogenous variation I rely on an instrumental variable approach based on mergers and acquisitions. A wide literature has focused on M&A's but mostly in different fields of economics with respect to labor. However, growing theoretical evidence and concerns among competitions authorities and policy makers in US and Europe suggest that mergers and acquisitions might have consequences in the labor market also. Marinescu and Hovenkamp, 2019) discuss the role played by M&A's in the Labor market highlighting the dangers that growing concentration caused by mergers can cause for workers' wages and employment, and thus for the overall welfare. They indeed exhort authorities to consider labor markets spillovers when they evaluate mergers besides those on prices and markups. OECD (2019 and 2020) indicate that merging and acquisitions are a channel through which concentration enhances, and hence should be carefully evaluated by competition authorities. Manning (2020) and (2021) provide a list of environments in which monopsony plays a role and urge competition authorities to address the role played by M&A's. Dodini *et al.* (2021) address the threats posed by mergers to the Norwegian labor market proving that on average concentration is lower than expected and therefore many relevant M&A operations have been denied to safeguard market competition when there was no need to. Marinescu *et al.* (2021) provide one of the few empirical evidence on this topic: they simulate a merger between two top employers in a given industry finding that it would increase concentration significantly with a sizeable detrimental effect on wages and hires. Arnold (2019) addresses directly the issue relying on US data estimating a diff-in-diff comparing outcomes for entrants' workers in markets experiencing mergers with respect to those who don't. He finds that not all mergers events increase concentration and that the effect is not constant along with concentration distribution: it's indeed stronger in higher concentrated markets and negligible for others. Elasticities are significantly higher than those on average estimated in the literature as they range between -0.2 and -0.3 points. This result suggests that, beyond ruling out endogeneity, mergers account for a different channel of concentration variation that results in a more detrimental effect on wages. There's therefore evidence that mergers generate spillovers in the labor market, even though more research is needed to empirically link them to concentration increases and in turn identify effects on the outcomes of interest.

3.4.1 Data

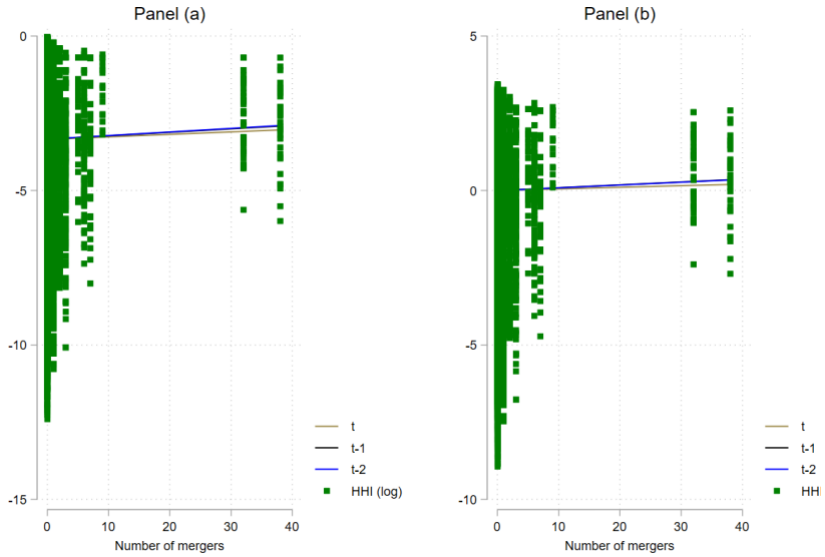
I exploit the *Zephyr* database provided by the Bureau Van Dijk. *Zephyr* is a database whose records are a times series of worldwide rumoured, announced or completed mergers and acquisitions operations of all types (partial or full acquisitions, mergers etc..) from 1997 to nowadays. I select all completed mergers and acquisitions operations whose target country is Italy from 2005 to 2018. For a subsample of these events only I also have information on the number of workers involved as well as the vendor and acquiror size. The final sample contains 5,932 events, associated to 4,237 different acquiror firms and approximately the same number of vendors. On average, approximately 423 events happen per year. For further details on the data see Appendix 6.2. In France and Germany, for example, approximately the same number of domestic operations happened between 2014 and 2018 (Source: *Oxford economics*). Hence, Italian labor market exposure to this phenomenon is relatively weak with respect to other countries. The events recorded are mergers and full or partial acquisitions between firms with different shares: considering instead only the former the number of events decrease to approximately 200.

3.4.2 Identification strategy

The idea underlying the identification strategy is that markets become more concentrated experiencing mergers through time. Markets are defined along three dimensions – occupation, industries and regions – and hence concentration could vary depending on separate channel shocks coming through different levels. The channel I aim to exploit is the national-industry-level variation in concentration induced by mergers. More specifically, I rely on the fact that the more a given industry experience mergers in a given year, the more it will become concentrated. This, to some extent that has to be tested, translates into an increase in labor market concentration for those markets associated with the industries experiencing mergers. The strategy thus is that these events represent a shock at an industry-level able to predict an upward movement in market concentration that involves a further segmentation by occupations and regions. The literature on the relationship between concentration and M&A's (Marinescu *et al.*, 2021; Marinescu and Hovenkamp, 2019; Arnold, 2019) focuses on mergers events only. Arnold (2019) proves that not all M&A's increase concentration, and that only those that significantly do that affect wages. First stages estimates prove the validity of this

mechanism in my data: when building the instruments based on all M&A's events selected from *Zephyr* results indicate that they increase concentration only in some specifications and slightly.[4] The opposite holds indeed when considering only mergers events: first stage estimates prove that they always significantly affect concentration. I additionally rely on lagged measures to ensure exogeneity with respect to local labor market dynamics that might be correlated with respect to mergers and wages simultaneously and because merged firms need some time to consolidate and display their power raising in turn concentration.

FIGURE 4 • SCATTERPLOT OF MARKET CONCENTRATION (IN LOG) WITH RESPECT TO THE NUMBER OF MERGERS HAPPENING WITHIN THE SAME MARKET AND YEAR ACROSS 5,008 LABOR MARKETS IN ITALY BETWEEN 2005 AND 2018.



Note: Panel (a) contains market HHI's as calculated in Eq. (2) while Panel (b) contains the seasonally adjusted market HHI's obtained subtracting the yearly means to the HHI's to rule out time trends. Lines represent the predicted values obtained through a regression of log of concentration w.r.t current, one-year and two-years lagged mergers. Mergers event are approximately 200 events in the period of analysis. t-1 and t-2 indicate respectively the number of mergers events happened in the previous and in the previous two years for each market-year tuple considered. Observations are 47,727 market-year tuples.

[4] Results not attached but available.

The positive relationship between market concentration and mergers is proved in Panel (a) of Figure 4. The relationship persists considering seasonally adjusted market HHI's in Panel (b). Based on this evidence, I build two different instruments defined respectively as follows:

$$IV1 : \forall \text{ t in [2005,2018]}, \text{I}_t(\#Mergers_{s,t-1} > 0) = 1 \rightarrow \text{HHI}_{m,t} \quad (4)$$

$$IV2 : \forall \text{ t in [2005,2018]}, \text{I}_t(\#Mergers_{s,t-2} > 0) = 1 \rightarrow \text{HHI}_{m,t} \quad (5)$$

where t-1 and t-2 stand for one and two previous years. More formally, I instrument concentration within each market-year with a dummy variable indicating whether the industry associated with that market has experienced at least a merger event one or two years previous to the current one. On average the number of employment contracts located in markets experiencing full mergers events ranges from 7 to 10% approximately 200250,000 spells depending on whether I rely on 1 or 2 years lagged mergers. Estimates should be hence interpreted as LATE's: differences in the outcomes of interest between treated and not units classified accordingly by the binary treatment which consists in experiencing at least a merger in 1 or 2 years before the current one. Errors are clustered at a market-year (market) level to address the correlation between workers (markets) affected by the same shock. First stage results are displayed in Table 7 of Section 6.3 and prove that the instruments are always significant F-statistics are all by far greater than 10 (Stock and Yogo, 2005) and predict an upward variation in concentration for treated with respect to not treated observations of 14-17 and of 17-21 p.p. with respectively instruments of Equations (5) and (6) and of 28-35 p.p. with both.

3.5 IV estimates

3.5.1 Wages

In this section, I present the IV estimations on wages. I present results for three different specifications: in Panel (a) I rely on the instrument defined in Equation (6), in (b) I rely on the instrument defined in Equation (5) while in (c) I use both.

Results are displayed in Table 5 and prove that concentration has a size able negative impact on entrants' wages. Estimates magnitude and significance differ little across specifications while the IV of Equation (6) seems to be the most relevant. However, all three empirical strategies produce similar results in terms of magnitude. A 10% increase in market concentration induced by the instruments reduces new hires' wages by approximately 0.9-1.4%. Estimates differ from those of the literature: Marinescu *et al.* (2021) preferred elasticities range between 0.067 and 0.052 points, which indicate a reduction in wages following a 10% increase in market HHI of 0.67 and 0.52%. Other works contain similar for entrants and slightly lower for incumbents' elasticities in terms of magnitude. However, my results are more in line with Marinescu *et al.* (2021) simulation as they find a reduction in the new firm wage-bill of approximately 7% following a 10% increase in concentration induced by a merger between two top-employing firms. Arnold (2019) is the only work to address entirely this issue relying on mergers, even though setting up a diff in diff. He estimates elasticities ranging between 0.3 and 0.2 p.p. depending on the controls, which are significantly higher than those on average estimated in the literature. The difference might be due to the use of different identification strategies and exogenous shocks in con centration. Summing up my estimates lay in the middle between those obtained by Marinescu *et al.* (2021), Azkarate-Askasua and Zerecero (2020), Dodini *et al.* (2021) or Bassanini *et al.* (2022) and those obtained relying on mergers as a shock in concentration (Arnold, 2019).

TABLE 5 • IV ESTIMATES OF THE ELASTICITY OF ENTRANTS' WAGES WITH RESPECT TO MARKET CONCENTRATION BETWEEN 2015 AND 2018

Dependent variable: ln(Daily wages)				
Panel (a)	(1)	(2)	(3)	(4)
ln(HHI)	-.319**	-.114**	-.1258**	-.134***
	(.1354)	(.0471)	(.04514)	(.03803)
Panel (b)	(1)	(2)	(3)	(4)
ln(HHI)	-.282**	-.0525	-.0684*	-.209
	(.1189)	(.04419)	(.0404)	(.1754)
Panel (c)	(1)	(2)	(3)	(4)
ln(HHI)	-.300**	-.0920**	-.1052**	-.1393***
	(.0890)	(.0326)	(.0315)	(.0375)
Observations	2,928,818	2,928,818	2,928,474	2,928,474
spell length & age (squared)	√	√	√	√
part time dummies	√	√	√	√
worker FE	√	√	√	√
year FE	√	√	√	√
industry FE	-	√	√	√
region FE	-	√	√	-
occupation FE	-	√	√	-
size FE	-	√	√	-
reg-ind-occ FE	-	-	√	√
occupation-year FE	-	-	-	√
size-year FE	-	-	-	√
region-year FE	-	-	-	√

SE clustered at a market-year level.
Daily wages are the ratio of overall remuneration and the number of worked days
*** p<0.01, ** p<0.05, * p<0.1

Obs are 3,573,677 yearly spells between 2005 and 2018. Panel indicate different instruments use: (a) 2-years lagged mergers as in Eq. (6); (b) 1-year lagged mergers as in Eq. (5) and (c) both jointly. Note: observations are lower than in the full sample and differ across specifications because singletons are iteratively dropped when including worker and markets FE's.

3.5.2 Employment

I then move to estimate the effect of a mergers-induced increase in concentration on employment as identified by the three different empirical strategies. Errors are clustered at a market-level to allow observations within the same market to be correlated across time. Results displayed in Table 6 indicate very stable estimates across Panels, with elasticities ranging between 0.68 and 0.77 points. Magnitude is slightly greater than in the literature: Marinescu *et al.* (2021) elasticities range between 0.31 and 0.585 points. The difference might be due to

the different framework and identification strategy, as well to a different definition of new hires. They define new hires as those who have employment contract start dates during the quarter of observation deleting those observations whose job spells start on January 1st for each year. I have additionally deleted all transformations keeping only new activations and all observations for each year whose individual was working in the same firm the previous year. Thus, my definition is more conservative, and the higher magnitude might be due to that. Results indicate that following a 10% increase in market concentration hires reduce by slightly less than 7-8 p.p.

TABLE 6 • IV ESTIMATES OF THE ELASTICITY OF EMPLOYMENT WITH RESPECT TO CONCENTRATION AT A MARKET LEVEL BETWEEN 2005 AND 2018

	(1)	(2)	(3)
	ln(Hires)	ln(Hires)	ln(Hires)
Panel (a)	(1)	(2)	(3)
ln(HHI)	-.681**	-.681**	-.692**
	(.2819)	(.2821)	(.2867)
Panel (b)	(1)	(2)	(3)
ln(HHI)	-.771*	-.771*	-.747*
	(.4689)	(.4694)	(.4402)
Panel (c)	(1)	(2)	(3)
ln(HHI)	-.699**	-.699**	-.704**
	(.2791)	(.2794)	(.2792)
Observations	47,180	47,180	47,180
(mean) sex & age	√	√	√
reg-ind-occ FE	√	√	√
year FE	√	√	√
occupation FE	-	√	-
region FE	-	√	-
industry FE	-	√	√
region-year FE	-	-	√
occupation-year FE	-	-	√

SE clustered at market-level
*** p<0.01, ** p<0.05, * p<0.1

Employment is measured as the number of newly activated working spells within each market and year. Full sample is made of 47,727 market-year tuples. Markets are 5,008. Panel indicate different instruments use: (a) 2years lagged mergers as in Eq. (6); (b) 1year lagged mergers as in Eq (5) and (c) both jointly.

4. CONCLUSIONS

In this paper I investigate empirically the presence of monopsony across Italian labor markets, relying on labor market concentration as the trigger, to identify its effect on entrants' wages and markets' hires. I first calculate a novel measure of concentration based on hires relying on *LoSaI* in the period 200518 that takes into account data structure and representativeness. Concerning the standard index based on employment stocks, one based on flows captures more precisely current monopsonistic dynamics and so improves the identification of the mechanisms in exam. On average, concentration across Italian labor markets is weaker than expected: approximately the median is 0.05 while the mean is 0.135. This indicates that most of the markets are weakly concentrated while only a few are instead highly concentrated. However, as their weight is sizeable, they drive average concentration upward. Additionally, concentration does not vary within time. This indicates that the fear that the financial crisis has damaged workers' welfare through an additional channel does not seem to be supported by empirical evidence. Concentration slightly increases when computed across regions and industries only. The relationship with wages is not straightforward: the estimates across all specifications show different signs and significance. The preferred one points at a negative, but overall weak and slightly significant, effect. This is due to the presence of endogeneity going through several channels. With respect to employment instead, the effect is precisely estimated and negative, even though lowered towards zero due to the presence of endogeneity. I thus try to clean the estimates relying on a novel IV strategy supported by the theoretical predictions that mergers increase concentration. This relationship is confirmed by descriptive and preliminary evidence in my data. I consider only lagged measures to address endogeneity issues and I exploit only mergers events happening across markets and time in the period of analysis to predict a reliable variation in concentration. The instruments, both separately and jointly, explain a sizeable amount of variation in market concentration within time which in turn has a significant and sizeable effect on wages and employment.

Estimated elasticities range from 0.09 to 0.14 points for daily entrants' wages and between 0.68 and 0.77 points for employment. These effects translate into a loss following a 10% increase in market concentration of approximately 0.9-1.4 p.p. for wages and 7-8 p.p. for hires. I try to answer policy concerns arising from different fields of literature indicating that mergers have side effects in the labor market, increasing concentration and damaging in turn workers and overall welfare. However, Italy overall does not experience many mergers, both across markets and within time, and therefore the economic damages identified are not widespread across markets but rather concentrated across a few. Nevertheless, my results corroborate findings and concerns raised in the literature (Marinescu and Hovenkamp, 2019; Arnold, 2019; Marinescu *et al.*, 2021) suggesting that, besides the well-known product market spillovers, also labor market ones should be taken into account by competition authorities when they deal with mergers evaluation.

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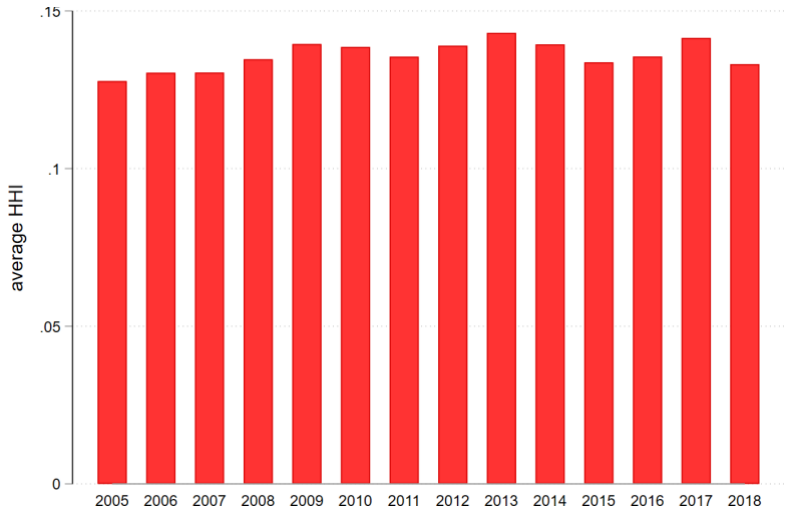
6. APPENDIX

6.1 LoSai

LoSaI contains several datasets extracted from the *INPS* administrative archive. The first provides a random set of individuals working spells with many information such as gross remuneration, date (d/m/y) of start/end of the spell, type of contract, linked firm to the spell and other standard information from 1990 to 2018. Spells contained are those associated to a random sample of individuals born in days 1 and 9 of any month and year from 1990 to 2018. The second dataset provides instead registry information regarding the same workers - including the region of residence which can be linked to the first through a unique code. In the last dataset, I obtain firms' information regarding class size and industry (ATECO 2007, 2-digits) ranging from 1990 to 2018. Firms can be linked to those in the first dataset with an additional unique code. By merging all these sources, I can get an employer-employee dataset in which I observe working spells remunerations within and across triples as defined by the interaction of firms size classes, regions and industry sectors. However, the sample of firms is not obtained based on stratified randomization by size class, region and industry, but according to workers' date of birth. Firms' population thus is likely not representative of the Italian one.

FIGURE 5 • MEANS OF MARKETS CONCENTRATION ACROSS YEARS FROM 2005 TO 2018



Markets HHI's are calculated as the squared sum of class size shares, where the share is calculated as the ration between hires by market-year tuples of the representative firm

in each size class and the total number of hires in that market. Observations are respectively 47,727 market-year tuples.

6.2 Zephyr

The Bureau Van Djik is the worldwide leader providing all sorts of information regarding business and industries, across the world. It also has information on an unrivalled number of deals, stored in the *Zephyr* database. *Zephyr* covers over ten years of history for deals around the world and an even longer history for deals with a European counterpart. It also has information on rumours, as well as announced and completed deals, from the end of the '90 to Nowadays. It covers all types of deals, from standard M&A's to joint ventures, delocalization or closures. The full database contains more than a billion records. Headline, type, status, value and details of the target, acquirer and vendor including country and activities plus regulatory bodies are contained in the database, as well as information regarding target, acquiror and vendor employment volume.

6.3 IV first stages

In this section, I display the results of the first stage estimates for different instruments and different sets of controls. Controls are those in Equation (4) of Table 4. I only present the results with the market specifications controls and not with worker FE's only as in Table 3. Coefficient always positive and significant across all specifications. Results indicate that instruments predict an increase in concentration that ranges between approximately 14 and 17 for the instrument in Equation (5) and between 17 and 21% for that in Equation (6). First stage F statistics are all significantly greater than 10 (Stock and Yogo, 2005). The interesting fact is that instruments even though correlated capture different sources of variation of concentration, as Panel (c) shows that when they are considered jointly they both remain significant and sizeable. Results in Panel (c) indicate that workers belonging to treated markets on average experience higher concentration induced by the instruments by 28-35% with respect to workers in not treated markets.

TABLE 7 • IV FIST STAGE ESTIMATES INDICATING INSTRUMENTS RELATIONSHIP WITH RESPECT TO CONCENTRATION ACROSS DIFFERENT SPECIFICATIONS

	(1)	(2)	(3)
	ln(HHI)	ln(HHI)	ln(HHI)
Panel (a)	(1)	(2)	(3)
IV2	.2109**	.2109**	.1708**
	(.07448)	(.07448)	(.05573)
Panel (b)	(1)	(2)	(3)
IV1	.1740**	.1740**	.1387***
	(.0520)	(.0520)	(.0372)
Panel (c)	(1)	(2)	(3)
IV2	.1973**	.1973**	.160**
	(.0703)	(.0703)	(.0530)
IV1	.1542**	.1542**	.1229***
	(.0456)	(.04567)	(.0336)
Observations	3,573,677	3,573,677	3,573,677
(mean) sex & age	√	√	√
reg-ind-occ FE	√	√	√
year FE	√	√	√
occupation FE	-	√	-
region FE	-	√	-
industry FE	-	√	√
region-year FE	-	-	√
occupation-year FE	-	-	√

SE clustered at market-level
*** p<0.01, ** p<0.05, * p<0.1

Panel contain different instruments use: (a) 2-years lagged mergers as in Equation (6); (b) 1-year lagged mergers as in Equation (5) and (c) both jointly. Observations are 3,573,677 employment contracts between 2005 and 2018. Controls are those of Equation (4) and are displayed in Table 4. Errors are clustered at a market level.

ANA SOFIA PESSOA

EARNINGS DYNAMICS IN GERMANY[1]

Abstract. This paper characterizes the distribution of labor earnings changes and documents earnings dynamics over the life-cycle using a large administrative database from German tax records. I find that labor earnings display important deviations from the typical assumptions of linearity and normality, featuring excess kurtosis and negative skewness whose levels depend on age and earnings level. For bottom earners, large income changes are driven equally by hours and wages, which is consistent with transitions between labor force status or jobs, whereas, for those at the top, earnings changes are mainly induced by wage rate growth. There are also asymmetries in the mean reversion of earnings growth mainly driven by the asymmetric hours' dynamics. Finally, there is no evidence of an added-worker effect from spouses' earnings response but government insurance and income pooling can mitigate the pass-through of individual earnings changes to the household level and attenuate the deviations from normality documented for the male earnings growth distribution.

Keywords. Earnings dynamics, Insurance, Higher-order earnings risk, Skewness, Kurtosis.

1. INTRODUCTION

Earnings dynamics play a key role in models of household behavior which are important tools for macroeconomics research. The common approach of these models is to focus on uniform income processes so that all agents face the same income shocks. Recent empirical work with newly available micro data documents significant deviations of labor earnings changes from standard assumptions of normality and important state dependencies of earnings dynamics for the United States (Guvenen, Karahan, Ozkan and Song, 2021). This paper contributes to the literature by studying the distribution and dynamics of earnings changes in Germany.

1 I thank the participants and discussants at the 11th ifo Conference on Macroeconomics and Survey Data, the Workshop on Labour Economics 2021, the International Conference on Household Finance, the 2021 Meeting of SEHO for their feedback and suggestions, the Ninth ECINEQ Meeting, EEA-ESEM 2021, EALE conference 2021, and Giorgio Rota Conference 2022. I also thank the Research Data Lab of the German Federal Statistical Agency and in particular Maurice Brandt and Hannes Fauser for his continuous support to data access. I acknowledge financial support from from the Fundação para a Ciência e Tecnologia (projects references SFRH/BD/144820/2019), the CRC TR 224 (Project A03), the Deutsche Forschungsgemeinschaft (German Research Foundation) under Germany's Excellence Strategy (EXC 2126/1 - 390838866) and under the RTG 2281 - The Macroeconomics of Inequality.

I start by characterizing the distribution of earnings growth and its differences over the life-cycle and along the earnings distribution. Secondly, I study the mean reversion patterns of earnings changes which are frequently modeled as simple AR(1) or low-order ARMA processes imposing strong premises as, for example, uniformity of mean reversion. Contrarily to these assumptions, I examine its state dependencies with respect to the income level, sign, and size of the changes. Then, motivated by the importance of extreme observations for deviations from normality, I examine the contribution of hours and wages for large earnings changes as well as the role of some life-cycle and employment events in explaining large fluctuations. Finally, given that for households the risk of disposable income is more relevant than the earnings risk, this paper also assesses whether families and the welfare system can provide any insurance against individuals' earnings risk and attenuate the heterogeneities and deviations from normality documented for the male workers.

For this analysis, I use administrative data from the German Taxpayer Panel consisting of tax records from 2001 to 2016. It contains information on individual and household income, taxes, transfers, and some demographic characteristics. Given that the data is not censored, it contains the very top earners. It allows precise estimates of the dynamics of earnings shocks as well as studying the role of family and government insurance. I supplement the analysis using survey data from the German Socio-Economic Panel as, unlike the Taxpayer Panel, it contains information about total hours worked and more details on life-cycle events. Provided that the nature of the deviations from normality and linearity is difficult to anticipate, I take on a non-parametric approach to characterize the earnings dynamics in Germany.

I find strong deviations from normality and salient heterogeneities in the distribution and dynamics of earnings changes across age groups and along the earnings distribution. First, the distribution of earnings growth is more dispersed for the young and poor workers and more negatively skewed and leptokurtic for older and richer workers. Yet, when excluding the tails of the distribution and analyzing outlier robust measures for the second and third moments, the distribution becomes negatively skewed only for the 45-54 age group and more leptokurtic for the workers at the bottom half of the distribution. Furthermore, decomposing labor earnings shows that deviations from normality, such as excess kurtosis, are also present in the distributions of hours and wage changes.

Moreover, I find that there are clear asymmetries in the mean reversion of earnings shocks which are not compatible with frequent modeling choices of earnings dynamics, like AR(1) processes. For poor workers, negative shocks are transitory and positive changes are permanent but, as we move to the top of the earnings distribution, negative shocks become more permanent and positive more transitory. This non-linearity in mean reversion is mainly driven by the hours' growth dynamics since wage dynamics are close to linear.

Secondly, the drivers behind large earnings swings, which are important for the sharp non-normalities documented, differ across income groups. The role of wage and hours changes is highly dependent on the sign of the change and earnings history of the workers. Small labor earnings changes are mainly driven by wages. Large income changes experienced by poor workers are driven by a mix of hours and wage changes, which is consistent with unemployment spells and job switches. However, as we move up the earnings distribution, wage growth becomes considerably more relevant than hours, highlighting the job stability of the top earners.

Finally, I quantify the role of families and the welfare system in attenuating individual earnings changes across income groups. Spouses' labor supply remains, on average, unchanged after a change in the head's earnings, which implies that families' ability to self-insure against income risk is solely driven by income pooling. On the other hand, the German government is able to provide considerable insurance as taxes and transfers significantly reduce the pass-through of large individual earnings shocks to the household level, especially for the bottom earners. In addition, accounting for taxes and transfers attenuates the heterogeneities and deviations from log-normality documented for the male earnings growth distribution.

This paper directly contributes to the fast-growing literature on earnings dynamics using non-parametric methods started by Guvenen *et al.* (2021) for the United States. The authors use a large administrative dataset to document significant deviations of earnings changes from a normal distribution and strong state-dependencies in earnings dynamics with respect to the income level and age of the workers. This approach has been followed, among others, by Pora and Wilner (2020), Halvorsen *et al.* (2020), and De Nardi *et al.* (2021a) for European countries, who have further studied the causes and consequences of the documented earnings dynamics. Halvorsen *et al.* (2020) investigate the determinants of these non-normalities for Norway by dissecting earnings into wages and hours. De Nardi *et al.* (2021a) have

further studied the life-cycle dynamics of household earnings, pre- and post-tax income and the role of welfare systems to attenuate individual earnings changes for the Netherlands and the United States.

This study is broadly related to the literature, influenced by the seminal work by Guvenen *et al.* (2014), that investigates the evolution of the income risk and inequality over time with special focus on the role of business cycles (Drechsel-Grau *et al.* 2022; Friedrich *et al.*, 2021; Pruitt and Turner, 2020; Hoffmann and Malacrino, 2019; Busch, *et al.*, 2018). Drechsel-Grau *et al.* (2022) provide a broad analysis of income inequality and income dynamics for Germany over the last two decades using tax and social security records. The authors find that the cross-sectional income inequality rose continuously until 2009 for both genders, but since then, has also been increasing only for males. Moreover, men's earnings changes are on average smaller than women's but substantially more affected by business cycle fluctuations. Drechsel-Grau *et al.* (2022) also document that except for recession periods, the distribution of earnings changes is right-skewed, which goes in the direction of my results when using Kelley's skewness measure.

Using German Social Security data, Busch *et al.* (2018) find that the skewness of individual income growth is procyclical, while the variance is cyclical with both hours and wage margins being important. Regarding the role of the second earner and the welfare system, the authors find that household smoothing does not effectively mitigate skewness fluctuations but tax-and-transfer policies do. Evidence from survey data by Bartels and Bönke (2013) also suggests that taking into account institutions of the welfare state and risk-sharing households decreases transitory and permanent variances of net household income, even though over time both have remained fairly stable.

However, this is the first comprehensive study of the earnings income process and dynamics for Germany, which focuses not only on characterizing the distribution and persistence of labor earnings changes but also links them back to its life-cycle events and sources of insurance against individual earnings changes by analyzing the dynamics of household income. Moreover, this paper uses German tax records which present a significant improvement relative to other available data sources for Germany. For example, these data allow not only studying the income process of the very top earners but also analyzing household dynamics of couples that file taxes

together. Given the granularity of the data, this study goes beyond studying labor earnings and also analyses the role of other disposable income sources as transfers from the government.

The remainder of the paper proceeds as follows. Section 2 describes the data and approach. Sections 3, 4, and 5 present the results. Section 3 characterizes the distribution of earnings changes and the asymmetric mean reversion patterns of earnings dynamics, while Section 4 discusses the sources of the non-normalities documented. Section 5 investigates the role of household and government insurances in mitigating individual income risk and attenuating the deviations from normality present in male earnings changes. Finally, Section 6 concludes.

2. DATA AND VARIABLES CONSTRUCTION

2.1 Data

The German Taxpayer Panel (TPP) and Socio-Economic Panel (SOEP) are the main databases used in the analysis. The TPP is an administrative dataset collected by German tax authorities, provided and administered by the German Federal Statistical Office, based on the universe of personal income tax returns. The unit of observation is the taxpayer, i.e., either a single individual or a couple filing taxes jointly.[2] It includes a detailed decomposition of labor and asset income, taxable income, allowances and special benefits, taxes, and transfers. Furthermore, it contains demographic information about individual taxpayers and households as for example gender, year of birth, and the number of children.

Annual individual labor income is the main variable used in the analysis and it is computed as the sum of total wage income and a labor share of self-employment income. The total household labor earnings, total income, and income net of taxes and transfers are then used in Section 5. I use a 5% representative sample from 2001 until 2016 and employ the respective weights provided by the German Federal Statistical Office.

Given the design of the data, the measurement error is much lower than in survey data where earnings are self-reported. The TPP has nonetheless some caveats. First,

[2] In the case of joint filing, income is still reported at the individual level, that is, separately for the head and spouse. It is not possible to link couples who deliver separate tax forms.

given that tax filing is mostly optional, low income taxpayers are likely to be non-filers and therefore to be misrepresented in the sample (Hauck and Wallossek, 2020). However, there are certain cases in which filing tax returns is strongly beneficial or even mandatory, for example, when taxpayers have other income sources for which taxes are not or only partially withheld. This allows good coverage of the German population with some labor market attachment, which is the primary focus of this analysis.[3]

The second caveat is that the dataset does not contain information about the number of hours worked which would be important to understand the drivers of income swings. Finally, since 2005, some important social assistance subsidies received, like unemployment, maternity, or sickness benefits, are reported together and thus, the individual amounts from different social programs cannot be recovered.

To overcome these last limitations, I supplement the analysis with survey data from the German SOEP. This survey has been running annually since 1984 and interviewing nearly 15,000 households and about 30,000 persons. It contains detailed information about labor status, income statements, and demographics. Importantly, it also asks exhaustive questions about live events and employment experiences like job changes and unemployment.

2.2 Sample selection

The base sample is a panel consisting of males with some labor market attachment and it is designed to maximize the sample size which is important for precise computation of higher-order moments in finely defined groups. The baseline sample is composed only of males between 25 and 59 to abstract from education and retirement decisions.

Moreover, an observation is included only if earnings are above a minimum income threshold defined as 5% of each year's median labor earnings. The panel for year t then selects individuals that are admissible in t-1 and at least in t-2 or t-3. This ensures labor market participation and that an accurate measure of recent earnings can be computed – a variable that is described next.[4]

[3] See Hauck and Wallossek (2020) for more detail on tax return (non-)filers.
[4] To avoid possible outliers, the top 1% of labor earnings observations in the SOEP are excluded.

2.3 Variable construction

Recent earnings

I now define "recent earnings" (RE), a term that will be used throughout the paper. For a given worker i, RE $\overline{Y}^{i}_{t-1}$ are computed between t-1 and t-3 as follows:

$$\overline{Y}^{i}_{t-1} \equiv \sum_{\{k=1\}}^{3} \frac{Y^{i}_{\mathrm{t-k,h-k}}}{\exp\left(d_{\mathrm{t-k,h-k}}\right)}$$

where $y^{i}_{t,h} \equiv \log\left(Y^{i}_{\mathrm{t-k,h-k}}\right)$ denotes the log of labor earnings of individual i who is h years old in year t. To control for age and year effects, $d_{\mathrm{t,h}}$ denotes average earnings obtained by regressing log individual earnings on a set of age and year dummies. Next, workers are grouped by gender and age in t-1 and, within each group, ranked into 10 deciles with respect to their recent earnings $\overline{Y}^{i}_{t-1}$.

Growth rate measures

I compute income changes up to the five years, which is useful to distinguish between income growth over short (1-year change) and long (5-year change) horizons to study "transitory" and "persistent" earnings changes. For each k=1,..., 5, the k-year log change of income net of age and year effects is defined as:

$$\Delta_k \tilde{y}^{i}_{t} = \tilde{y}^{i}_{t+k,h+k} - \tilde{y}^{i}_{t,h} = \left(y^{i}_{t+k,h+k} + d^{z}_{t+k,h+k}\right) - \left(y^{i}_{t,h} + d^{z}_{t,h}\right)$$

where $y^{i}_{t,h}$ is the log of income and $\tilde{y}^{i}_{t+k,h+k}$ is the log of income net of age and year effects. Income can be male or female labor earnings or household level income.

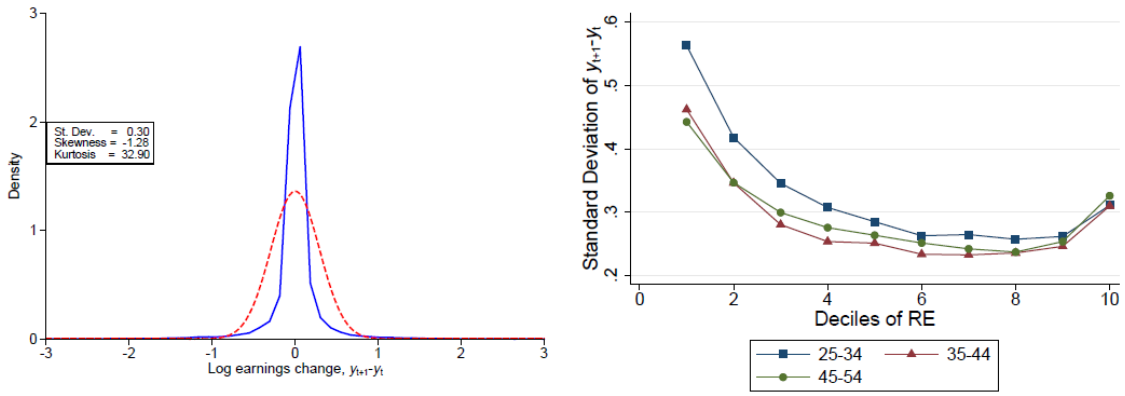
3. DISTRIBUTION OF EARNINGS GROWTH

Figure 1a displays the distribution of one-year labor earnings growth for male workers in the base sample, along with Gaussian densities chosen to have the same standard deviation as in the data. The distribution features left skewness and excess kurtosis relative to a Gaussian density characterized by no skewness and kurtosis of 3. The negative skewness indicates that there are more positive earnings changes than negative ones but while income increases are mostly very small, the long left-tail

suggests that there are more large income drops than large rises. The excess kurtosis reveals that most changes are very small but that from time to time, there are very large ones.

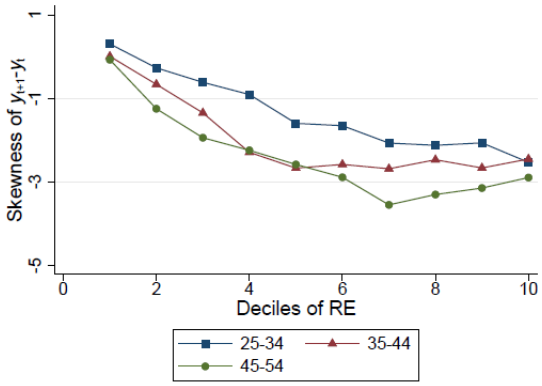
This Section studies in more detail the distribution of one-year earnings growth for German male workers by documenting its second, third, and fourth moments over the life-cycle and along the RE distribution.[5]

FIGURE 1 • DISTRIBUTION OF ONE-YEAR EARNINGS GROWTH

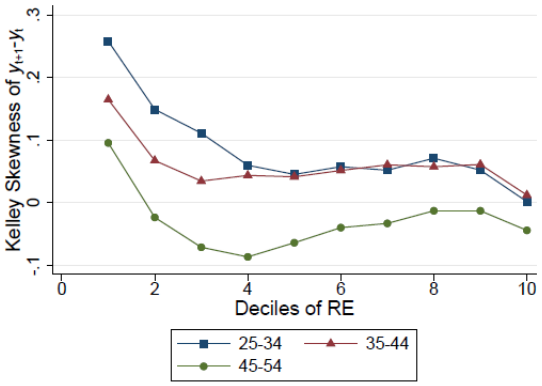


(a) Distribution

(b) Standard Deviation

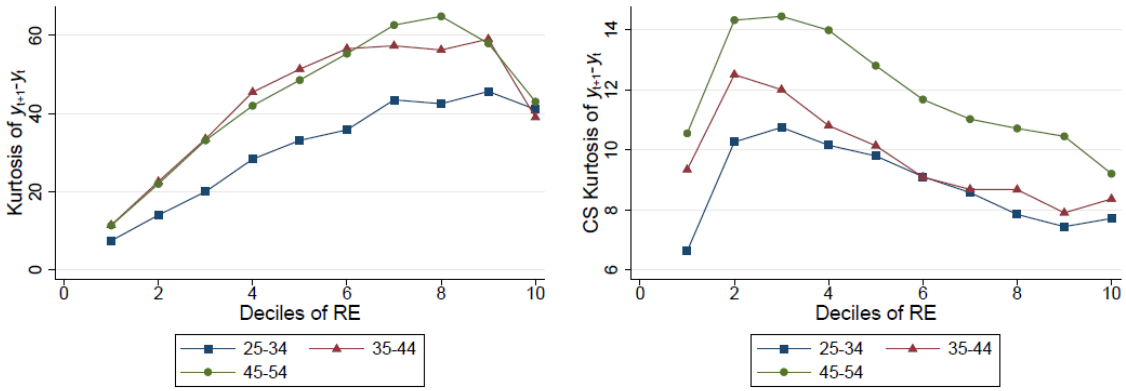


(c) Standardized Skewness



(d) Kelley Skewness

[5] Appendix B and C show the results five-year earnings changes and female workers, respectively.



(e) Standardized Kurtosis (f) Crow-Siddiqui Kurtosis

Notes: Panel 1a depicts the empirical densities of one-year earnings changes along with Gaussian densities with the same standard deviation as the data. Data is from 2007 German tax records and only male workers between 25 and 59 years old are included. The remaining panels show the cross-sectional moments of one-year labor earnings growth of male workers over the life-cycle. Source: German TPP.

3.1 Empirical methodology

The main goal of this Section is to document heterogeneities of higher-order moments of earnings growth with respect to RE and age. To this end, for each year t, individuals are divided into seven equally-sized groups based on their age in year t-1 and then, within each age group, they are sorted into ten deciles by their RE. If these groupings are done at a sufficiently fine level, we can think of all individuals within a given age/RE group to be ex-ante identical or at least very similar. Then, for each such group, the cross-sectional moments of earnings growth between t and t+k can be viewed as the properties of earnings changes that workers within that group expect to face looking ahead.

The figures that follow plot, for each age/RE group, the average moments between 2004 and 2016-k. This approach allows computing higher-order moments precisely because each bin contains a large number of observations, especially for administrative data like the taxpayer panel. In what follows, the conventional second to fourth moments of earnings changes are reported together with outlier robust measures of skewness and kurtosis. In particular, the Kelley coefficient of skewness (Kelley, 1947) is given by:

$$\text{Kelley Skewness} = \frac{(P_{90} - P_{50}) - (P_{50} - P_{10})}{(P_{90} - P_{10})}$$

where a zero implies a symmetric distribution, positive values represent right skewness, and negative values represent left skewness.

Concerning kurtosis, Crow-Siddiqui (CS) measure (Crow and Siddiqui 1967) is also less sensitive to outliers than the centered fourth moment and can be computed as follows:

$$\text{CS Kurtosis} = \frac{(P_{97.5} - P_{2.5})}{(P_{75} - P_{25})}$$

CS Kurtosis is high $P_{75} - P_{25}$ is large relative to the probability mass that is concentrated between the 75th and the 25th percentiles, corresponding to heavy tails.

3.2 Cross-sectional moments of male earnings growth

Second moment: variance

Figure 1b shows that the standard deviation of earnings changes displays a U-shape along the RE distribution. Earnings changes are more than twice as dispersed for workers at the lowest percentiles of RE than for workers around the median. There are significant differences in earnings volatility over the life cycle as well, especially for bottom earners, with young workers experiencing the largest volatility. This is in line with the results by Bönke *et al.* (2019) who, using other methods and data from the SOEP, show that younger cohorts face higher total earnings variance. Panel 1b shows this is the case up to the 90th percentile.

Despite the higher volatility, earnings changes persistence is smaller at the beginning of the working life. Figure A.1 in the appendix shows that there is significant age variation in the persistence of labor earnings changes, unlike typically assumed by standard AR(1) processes. Earnings persistence starts from a value of about 0.7 at age 27, consistent with younger people switching jobs and careers frequently without a permanent impact on their labor income. It then increases fast, reaching 0.9 at age 40, where it stabilizes. This evidence indicates that shocks to labor earnings at younger ages are not as long-lived as at older ages.

Figure C.2 in the appendix depicts the cross-sectional moments that characterize the distribution of one-year labor earnings changes for female workers. Relative to men, females' distribution presents even deeper life-cycle differences with changes

being more dispersed for younger women. This is potentially associated with maternity as discussed later in Section 4.2.

Third moment: skewness

Figure 1c plots the centralized third moment over the life-cycle and RE distribution. Skewness starts around zero at low levels of RE but becomes negative as the income level increases, meaning that experiencing very large income declines becomes more likely than seeing a large increase. This seems to imply that the higher the RE, the more room for earnings to fall and the less room for rises. Figure 1c also shows that the distribution is more negatively skewed for older workers which supports the idea that younger workers are still climbing up the job ladder and therefore, are less likely to experience very large income drops.

The conventional centered measure of skewness can be very sensitive to the existence of long tails. Thus, Figure 1d plots the Kelley measure of skewness for labor earnings changes which is robust to outliers. It is very close to zero, slightly positive for the younger age groups and marginally negative for most deciles of the oldest group. This indicates a symmetric distribution of earnings growth outside the tails of the distribution.

One important question is whether skewness becomes more negative over the life cycle because of compression of the upper tail (fewer opportunities for large gains) or because of an expansion in the lower tail (higher risk of large declines). Figure A.2 in the appendix plots the P90-P50 and P50-P10 for different age groups. With the exception of the top RE deciles, it shows compression of both upper and lower tails over the life cycle. However, since P90-P50 changes more between age groups than P50-P10, the upper tail compress more strongly, implying that this result is mainly driven by fewer large gains. This figure documents an expansion of the lower tail and an increase in the risk of large declines only for top earners.

Regarding the distribution of female earnings growth, Figure C.2 documents strong differences in the level and patterns of skewness for females relative to males. Life-cycle and RE heterogeneities are even more salient for women.

Fourth moment: kurtosis

Figure 1e shows that the distribution of earnings changes features excess kurtosis implying that, even though most changes are very small, there are some large income swings at the tails. Moreover, the kurtosis of earnings growth has an inverted-U shape

that is especially striking for prime-aged workers. Thus, kurtosis is increasing with previous earnings up to the 7th or 8th decile indicating that changes become less frequent but larger at these percentiles of RE. Kurtosis is larger for older than for younger workers, even though this difference is more salient only for middle-class earners.

Since kurtosis can be sensitive to extreme observations, Figure 1f plots a version of kurtosis that is outlier robust and shows that indeed a considerable part of excess kurtosis can be explained by the changes at the tails. Crow-Siddiqui kurtosis is still significantly larger for older workers but it is now higher for workers at the bottom half of the distribution.

For females, the distribution of earnings growth features higher kurtosis when compared to male workers and varies more over the life-cycle (Figure C.2). These patterns are similar to the evidence provided for Norway by Halvorsen et al. (2020) but contrast with the results for the UK by De Nardi, Fella and Paz-Pardo (2021), for which age differences are less striking.

3.3 Earnings dynamics

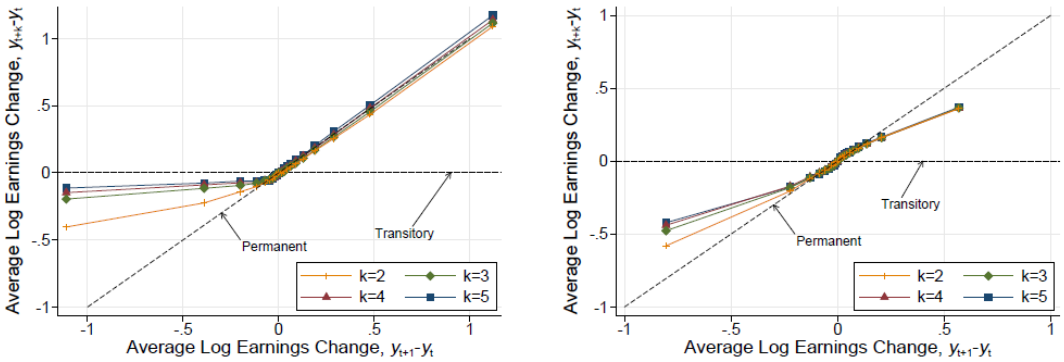
Earnings dynamics are frequently modeled as simple AR(1) or low-order ARMA processes which impose strong assumptions as, for example, uniformity of mean reversion. This Section examines the mean reversion patterns of the earnings, wages, and hours changes and their dependencies on the level of income, size and sign of the changes. In particular, to describe the mean reversion patterns of earnings growth, I estimate their non-parametric impulse responses conditional on workers' RE, size and sign of the change. In particular, within each RE group, workers are sorted by the size of their log earnings change between t and t+1 and grouped into twenty equally-sized quantiles. Hence, all individuals within a group have similar earnings history and experience a similar earnings change from t to t+1 and thus, such finely defined group can be treated as homogeneous.[6]

Figure 2 shows the response of positive and negative earnings changes of different sizes conditional on the workers RE. In particular, it plots the average earnings change after up to five years against the initial change in labor earnings. The x-axis represents the initial average log change $y_{t+1}^i - y_t^i$ for each RE group of workers, sorted by the

[6] For this analysis, the entire baseline sample is used but Appendix D presents the results for a sub-sample of prime-aged workers.

size of their earnings shock. The y-axis plots the average log change of earnings from t to t+k, where k=2,...,5.

FIGURE 2 • PERSISTENCE OF LABOR EARNINGS CHANGES BY RE DECILE



(a) Bottom RE deciles (b) Top RE deciles

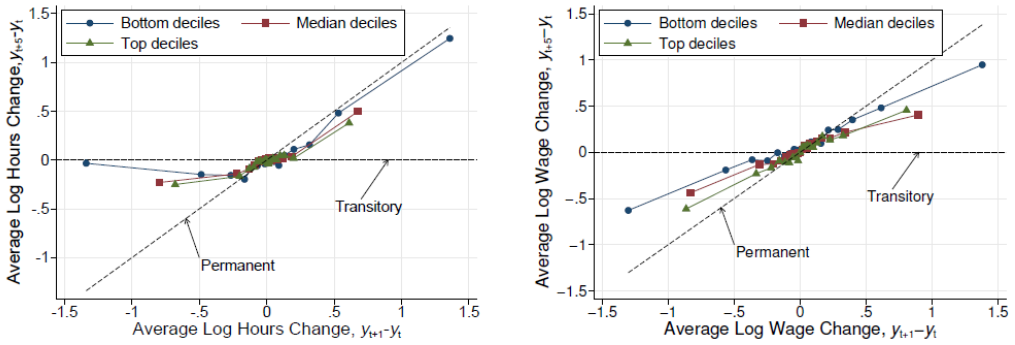
Notes: The figure displays the k-year average log change of annual labor earnings for 20 different groups of male workers in the bottom (first and second) and top (ninth and tenth) RE deciles, plotted against their contemporaneous one-year average log change in annual labor earnings. Figure A.5 in the appendix shows the results for the median RE deciles. Source: German TPP.

Importantly, Figure 2 indicates that there are strong asymmetries depending on the sign of the change and along the distribution of RE. Positive earnings changes are almost permanent, especially for bottom earners. Earnings drops are almost completely transitory for the bottom workers, but more permanent when experienced by those at the top. The results for the median RE deciles are somewhat an intermediate case between the bottom and the top (Figure A.5).

Figure 2 also shows that labor earnings shocks are partially reversible within the first two years after the change takes place. Nevertheless, for some cases, a non-negligible fraction of these changes is still present after five years, suggesting a very persistent component in earnings growth. This is particularity true for top earners. Panel 2b indicates that top RE workers with earnings drops of almost 80 log points recover, on average, less than 50% of the earnings loss in the following five years. This contrasts with the figure for bottom earners - those who experience very large drops recover about 60% of their income within the next year and more than 90% over the next five.

To understand what explains the asymmetric mean reversion pattern of earnings, it is important to study the persistence of hours and wage changes separately. In line with the strategy for labor earnings, conditional on their RE, workers are grouped with respect to their hours or wage growth between t and t + 1. Using data from the SOEP, Figure 3 presents, for each group, the average change in hours and wages from t to t+5 against their average initial changes.[7] It shows significant differences between hours and wage dynamics.

FIGURE 3 • PERSISTENCE OF HOURS AND WAGES CHANGES



(a) Hours (b) Wages

Notes: The figure displays the five-year average change in hours and wages for 20 different groups of male workers in the bottom (first and second), median (fifth and sixth), and top (ninth and tenth) RE deciles, plotted against their respective one-year average change. Source: German SOEP.

Figure 3a shows that large increases in hours are persistent but large negative changes are more transitory. This indicates that employment tends to last much longer than the duration of unemployment spells. Unlike hours, wage changes are more symmetric and both drops and rises are only partially transitory or persistent (Figure 3b). This indicates that the non-linear persistence of labor earnings documented in Figure 2 is mainly driven by the non-linearity of hours changes.

There are also some noticeable differences in the persistence of hours and wage changes across RE groups. As one moves to higher RE deciles, increases in hours and wages become slightly more transitory, while declines become somewhat more persistent. For hours, this evidence is consistent with transitions between

[7] Figure 3 shows that the patterns documented using the TPP and the SOEP for earnings are very similar, reassuring confidence on the SOEP.

unemployment and employment being one of the main drivers of income fluctuations for workers at the bottom of the income distribution. This contrasts with the hours and wage fluctuations for other RE groups which are possibly related to more flexible occupations, overtime work, accumulation of tasks, or complex compensation packages which tend to be cyclical and performance related (Parker and Vissing-Jorgensen, 2011).

Overall, these findings suggest that earnings changes in Germany exhibit strong deviations from the assumptions of the canonical income process used in many macroeconomic applications. First, it is commonly assumed that the shocks are normally distributed and age-independent. However, the distribution deviates strongly from normality, varying also over the life-cycle as suggested by high-order moments. Second, the persistence component is assumed to follow a linear process which is at odds with the evidence that the third and fourth moments are dependent on the previous realizations of earnings.

This Section provides evidence consistent with job ladder models in which most workers keep their jobs and face very small earnings changes, while few of them become unemployed and experience large earnings drops. Differences over the life-cycle indicate that younger workers are more likely to experience positive earnings changes associated with career switches up, whereas older workers (with long job tenures) are more likely to experience relatively large cuts when they find a new job after displacement. These qualitative properties are in line with findings for other countries like the United States, Norway, and the Netherlands (Guvenen *et al.*, 2021; Halvorsen *et al.*, 2020; De Nardi *et al.*, 2021).

4. SOURCES OF NON-NORMALITIES

So far the analysis has focused on the distribution of annual labor earnings changes, but one important question to ask is what are the sources of the deviations from normality and linearity. Motivated by the importance of extreme earnings changes for negative skewness and excess kurtosis and using data from the SOEP, this Section provides evidence on the contribution of hours and wages and the role of life events for large earnings swings experienced by male workers.[8]

[8] Appendix C and Appendix D show the results for females and prime-aged workers, respectively.

4.1 Decomposing earnings changes

For many economic questions, it is not only important to understand the earnings dynamics but also its sources, that is, if they are induced by hours, wages, or both. To investigate the drivers behind the deviations from normality, this Section starts by documenting whether the left skewness and excess kurtosis reported for earnings are also present in the hours and wage growth distributions. Table A.1 documents the non-Gaussian features of one-year earnings, hours, and wages changes over the life-cycle in the SOEP.[9] It shows that there are significant deviations from normality also in the distributions of both hours and wage changes, especially for older workers. Yet, the distribution of wage growth features less negative skewness and excess kurtosis than those of earnings and hours independently of the age group.

Figure A.3 reports the cross-sectional moments of wage and hours changes along the RE distribution, reinforcing the deviations from normality. Kurtosis is especially higher for hours than for wages, suggesting that hours' adjustments are very infrequent but that, when they happen, they tend to be of a large magnitude (plot A.3c). This provides some support for models of life-cycle labor supply where workers' labor supply is inelastic and subject to unemployment shocks or only subject to adjustments of a discrete nature.

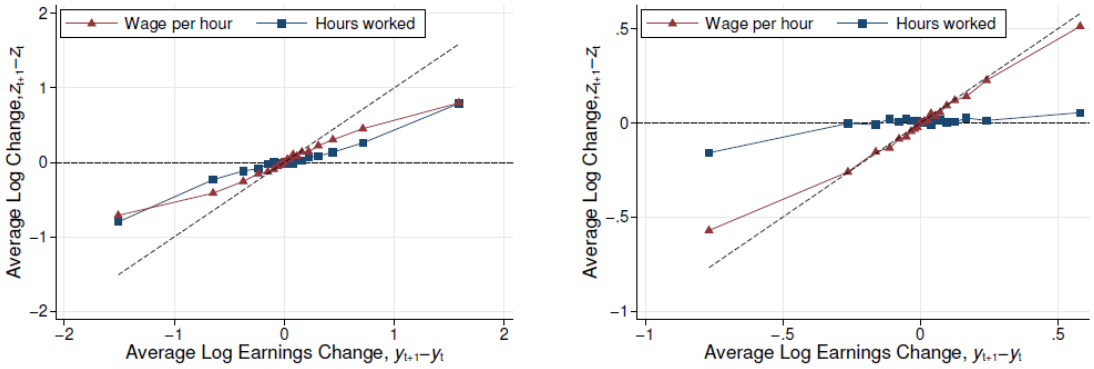
A complementary way of understanding the sources of earnings swings is to dissect them into the contribution of wage and hours changes. While most literature has focused on uniform relations between movements in wages and hours, I now investigate their co-movement for different income levels and earnings changes of different signs and sizes. Figure 4 plots, for different groups of workers, the average growth of hours and wages on the y-axis conditional on their average labor earnings growth between t and t+1 on the x-axis. For this purpose, on top of conditioning on workers' recent earnings, individuals are grouped according to their earnings growth.[10] In particular, within each RE group, workers are sorted by the size of their log earnings change between t and t+1 and grouped into twenty equally-sized quantiles. Hence, all individuals within a group have similar earnings history and experience a

[9] Consistent with the taxpayer panel evidence, Table A.1 indicates that the distribution of labor income changes is left-skewed and exhibits excess kurtosis, with age patterns that are also in line with those computed using administrative data.

[10] Alternatively to conditioning only on the workers' RE, I consider also their age by grouping them into young and prime-age earners, 25-34 and 35-54 years old, respectively. Results remain unchanged and are documented on Figure D.2 in the appendix.

similar earnings change from t to t+1 and thus, such finely defined group can be treated as homogeneous. For simplicity, results are documented only for the bottom (first and second) and top (ninth and tenth) RE deciles.[11]

FIGURE 4 • CONTRIBUTION OF HOURS AND WAGES TO EARNINGS CHANGES



(a) Bottom RE deciles (b) Top RE deciles

Notes: The figure displays the one-year average log change of annual hours and hourly wage for 20 different groups of male workers in the bottom (first and second) and top (ninth and tenth) RE deciles, plotted against their contemporaneous one-year average log change in annual labor earnings. Figure A.2 in the appendix shows the results for the median RE deciles. Source: German SOEP.

Figure 4 indicates that small earnings changes are mainly driven by wage growth independently of the earnings history. However, for larger labor income swings, there is some heterogeneity with respect to the sign of the change and level of RE. Panel 4a shows that, for the bottom RE deciles, large income changes (both negative and positive) are driven by a combination of changes in wages and hours. For example, the group of bottom earners whose earnings increased around 160 log points on average experience an increase of about 80 log points in hours and an increase of 80 log points in hourly wages. For the top earners, independently of the size, earnings changes are mainly driven by changes in wage per hour rather than by changes in the number of hours worked (Figure 4b). The results for the middle deciles are somewhat an intermediate case between the bottom and the top (Figure A.4).

[11] To control for differences in mean reversion between different groups of workers, the changes on both the x- and y-axes such that their values at the median quantile of $y_{t+1}^i - y_t^i$ cross at zero.

These findings imply that, along the RE distribution, different mechanisms account for large earnings swings. Moreover, the heterogeneous role of hours suggests a large unemployment risk for the poor, but consistent job stability for the top earners independently of the earnings change experienced.

4.2 The role of life events

A natural question to ask in this context is what are the drivers of large earnings swings and whether some specific life events can account for part of the risk faced by the workers, e.g. job change, a transition to unemployment, a long-term sickness, parental or maternity leaves. Tracing changes in earnings back to the labor market or life events is not merely of interest from a positive perspective but also from a normative perspective as many changes in earnings might not constitute risk from the household perspective but could result from labor market choices (Hubmer, 2018; Low *et al.*, 2010).

The analysis starts by splitting, according to their magnitude, one-year earnings changes computed from the administrative data into six groups. Then, Table A.2 documents the share of workers who experience certain life events contemporaneously to these income changes. In particular, with the TPP it is possible to trace some life and work events as workers having one more child, receiving social assistance or unemployment benefits, and being covered by short-time work schemes. Table A.2 shows that, on the one hand, many workers with large earnings drops experience a contemporaneous increase in social assistance received by the government (which includes unemployment, sickness, and maternity/parental benefits). The opposite is true for workers whose income rises, i.e., their total welfare benefits received decrease on average when labor earnings increase. On the other hand, becoming handicapped or having more children are only marginally relevant in accounting for the earnings changes experienced by male workers in Germany.

To shed more light on the role of life and employment events for which the TPP does not provide sufficient detail, the German SOEP is used in analogous way. In particular, the SOEP contains detailed data about job changes and labor status transitions. Similar to the evidence from the administrative data, Tables 1 and 2 present the share of workers who experienced certain events contemporaneously to large, medium, and small negative or positive income changes, respectively.

Job changes are the main driver of earnings decreases for male workers in Germany – more than 26% of the workers who experience large income drops, change their job. Compared to the workers with small changes, they are four times more likely to transition between jobs. Moreover, 15% of the workers with large earnings cuts were forced to change their job either because the employment contract was terminated by the employer, the company closed down or the temporary employment tie was not renovated. Halvorsen *et al.* (2020) and Guvenen *et al.* (2021) find for Norway and the U.S. significant differences in the distribution of earnings changes for job stayers and job switchers. While for skewness their results differ, both find that annual earnings changes for switchers tend to be substantially more dispersed and less leptokurtic than those for stayers.

TABLE 1 • NEGATIVE INCOME SHOCKS AND LIFE-CYCLE EVENTS

	One-Year Earnings Change, $\Delta y \in$		
	< -1	$[-1, -0.25)$	$[-0.25, 0)$
Into non-employment	22.80	10.65	1.82
Into unemployment	16.53	7.54	1.22
Into regular part-time	1.48	1.66	0.58
Changed job	26.54	16.71	6.66
Involuntary changes	16.46	12.15	2.83
Due to parental leave	0.25	0.28	0.09
Change no. of children	3.45	4.10	4.03
Lost second job	4.09	4.36	3.06
Into disability	4.02	1.93	1.08
Share (%)	1.90	8.41	36.14
$\mathbb{E}\,\Delta^1_{log} y^i_t$	-1.64	-0.47	-0.07
$\mathbb{E}\,\Delta^1_{log} w^i_t$	-0.81	-0.34	-0.07
$\mathbb{E}\,\Delta^1_{log} h^i_t$	-0.82	-0.12	-0.01
$\mathbb{E}\,\Delta^5_{log} y^i_t$	-0.31	-0.20	-0.04
$\mathbb{E}\,\Delta^5_{log} w^i_t$	-0.27	-0.19	-0.01
$\mathbb{E}\,\Delta^5_{log} h^i_t$	-0.02	-0.02	-0.03

Notes: Part-time worker accounts only for regular part-time employment. Individuals are considered unemployed if are not working and are registered unemployed and excluded those who are not working but sometimes have a second job, were working past the seven days, or have a regular second job. Individuals are considered not employed if they are not full- or part-time employed or attending vocational training. Workers experience a job change if their

jobs in t and t+1 are not the same and a change of employer can happen either via an unemployment spell or through a direct job-to-job movement. I consider a forced job change in the following cases: the employment link was terminated by the employer, a temporary contract expired, the education or training was completed, the company transfers the employee, and the company closed down. The option of job change due to maternity/parental leave is only asked in some waves of the survey (from 1991 to 1998 and since 2011). Source: German SOEP.

Another important driver of earnings losses is the transition between labor force statuses. 22% of the workers who suffer large income drops became non-employed, from which 16% became unemployed. Table 1 shows that, for the workers in this group, the average income changes are equally driven by a drop in wages and hours worked. So, this confirms the idea that unemployment risk and unstable employment play an important role in explaining earnings drops and is consistent with the evidence provided in Figure 4 for the bottom RE workers. Extensive margin events (e.g. layoffs) can also lead to large declines in hours and wages at the same time. These results underline the importance of the extensive margin for the tails of the earnings change distribution.

Similarly to drops, Table 2 shows that switching jobs and becoming employed, especially at full-time jobs, are the main reasons for positive income changes. About 10% move out of unemployment or inactivity into a full-time or a regular part-time job. Extra jobs seem relatively more important to explain intermediate than large labor income changes.

TABLE 2 • POSITIVE INCOME SHOCKS AND LIFE-CYCLE EVENTS

	One-Year Earnings Change, $\Delta y \in$		
	$[0, 0.25]$	$(0.25, 1]$	> 1
Into full-time			
from not full-time	1.20	6.00	17.18
from regular part-time	0.49	1.62	3.94
Into full- or regular part-time			
from not working	0.64	3.28	9.43
from unemployment	0.44	2.26	5.39
Changed job	5.95	13.89	25.47
Involuntary change	2.08	6.47	9.50
Extra job	2.88	4.27	4.04
Out of disability	0.49	0.76	0.33
Share (%)	42.52	9.43	1.60
$\mathbb{E}\,\Delta^1_{log} y^i_t$	0.08	0.46	1.60
$\mathbb{E}\,\Delta^1_{log} w^i_t$	0.07	0.35	0.91
$\mathbb{E}\,\Delta^1_{log} h^i_t$	0.01	0.10	0.68
$\mathbb{E}\,\Delta^5_{log} y^i_t$	0.06	0.34	1.58
$\mathbb{E}\,\Delta^5_{log} w^i_t$	0.08	0.27	0.86
$\mathbb{E}\,\Delta^5_{log} h^i_t$	-0.01	0.07	0.73

Notes: Part-time worker accounts only for regular part-time employment. Individuals are considered unemployed if are not working and are registered unemployed and excluded those who are not working but sometimes have a second job, were working past the seven days, or have a regular second job. Individuals are considered not employed if they are not full- or part-time employed or attending vocational training. Workers experience a job change if their jobs in t and t+1 are not the same and a change of employer can happen either via an unemployment spell or through a direct job-to-job movement. I consider a forced job change in the following cases: the employment link was terminated by the employer, a temporary contract expired, the education or training was completed, the company transfers the employee, and the company closed down. Source: German SOEP.

In addition, large positive income changes are, on average, driven by a mix of wage and hours changes which is again consistent with evidence for the bottom RE workers documented in Section 4.1. Tables 1 and 2 show that independently of the sign of the change, small and intermediate income changes are mainly accounted for by wage changes, which are only mildly related to job switching.

Table C.1 in the appendix provides the counterpart for female workers in Germany. Similarly to males, switching jobs and, in particular, unwanted job changes are the main reason for the income cuts. However, the share of females who claim to have been forced to change jobs because of parental leave is considerably larger than for their male counterparts. Maternity seems to be an important driver of income dynamics for women in the German labor market since it is also clear that many of them experience a fall in earnings contemporaneously to an increase in the number of children or taking maternity leave. Unlike males, transitions into and out of inactivity and part-time employment are important to account for labor income fluctuations. These results are in line with evidence by Kleven *et al.* (2019) who find strong and persistent earnings penalties for females after the birth of their first child. For Germany, they find that the penalty is driven by the intensive margin (hours worked) and wage-rate effects.

5. HOUSEHOLD AND PUBLIC INSURANCE

Given that for households the risk of disposable income is more relevant than the earnings risk of an individual family member, this Section discusses the extent to which German families are insured against individual labor income risk through private and public insurances. First, I discuss the role of the second earner and document the pass-through of individual earnings changes to the household level (Section 5.1). Then, Section 5.2 studies whether accounting for family and government insurances can attenuate the deviations from normality and state dependencies of the cross-sectional moments documented before for male earnings changes.[12]

5.1 Household earnings dynamics

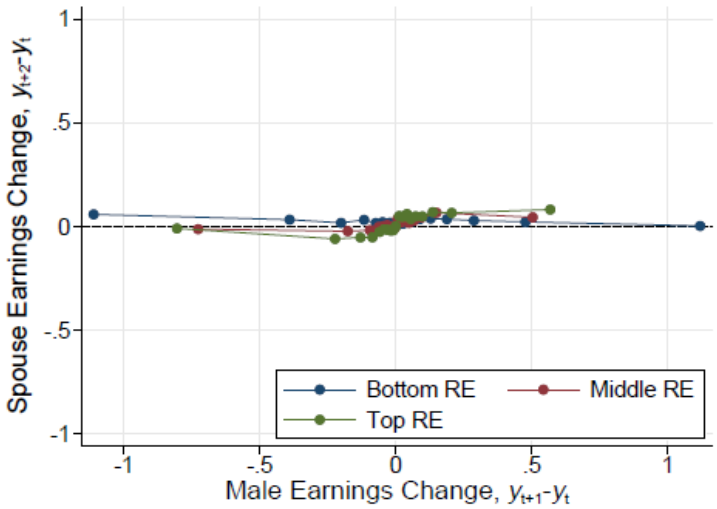
Income pooling within a household can potentially be a source of insurance for two reasons. First, when only the male head experiences an earnings shock, part of the family income remains unchanged. Then, the second earner of the household may react to earnings changes experienced by the head by changing the number of hours

[12] Whenever applicable, the analysis for five-year changes is also documented in Appendix B. Even though the results presented in this section consider the whole baseline sample, the counterparts for prime-aged workers are documented in Section D.

worked. Thus, spouses' labor earnings can be informative about the role of families as a source of insurance because, if there was an added worker effect after an earnings shock experienced by the male head, spouses would adjust the number of hours worked.

For this reason, this analysis starts by investigating the spouses' reaction to the heads' earnings changes. For couples that file taxes together, the TPP provides information about spouses' income. Figure 5 plots, for these couples in the sample, the two-year response of spouses' labor earnings to changes in the male head's earnings between t and t + 1. Conditional on their RE, male workers are grouped in twenty deciles according to their earnings change between t and t + 1 (x axis). The y-axis represents the average spouses' labor income changes. Studying two-year windows allows for capturing changes in spousal labor supply that are not exactly contemporaneous to the head's earnings shock but that may be a delayed response to them.

FIGURE 5 • TWO-YEAR SPOUSE LABOR EARNINGS RESPONSES TO MALE EARNINGS CHANGES



Notes: The figure displays the average two-year change of spouse labor earnings for 20 different groups of males married workers, plotted against their one-year log change in average labor earnings. The sample comprises married male workers. Results are documented only for the bottom RE deciles (first and second), Median RE deciles (fifth and sixth), and top RE deciles (ninth and tenth). Source: German TPP.

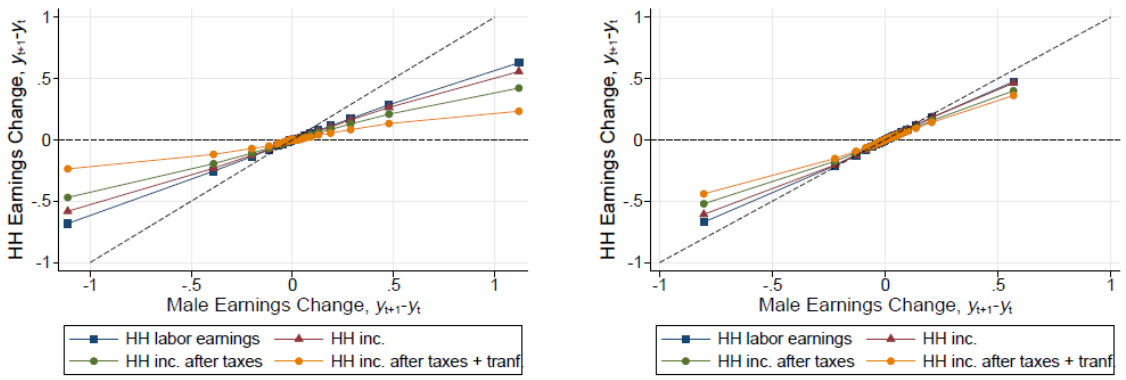
Figure 5 shows that there is no apparent relation between changes in male heads' and female spouses' earnings, indicating no evidence of an added worker effect in Germany.[13] This evidence suggests that any household insurance recorded can only be driven by income pooling at the family level rather than labor supply reactions of secondary earners, which is also in line with findings for other countries (Halvorsen *et al.*, 2020; De Nardi *et al.*, 2021).

Figure 6 summarizes the roles of family and government insurance by showing the pass-through of male earnings shocks to the household level. In particular, it reports the average one-year change of household income as a response to changes in male labor earnings between t and t + 1 for male married workers. When comparing male and household labor earnings, Figure 6 shows that there is some insurance provided by income pooling at the family level, especially for the bottom earners. For instance, for workers at the bottom, families whose head's labor income drops by 120 log points only experience about half this change when pooling labor earnings at the household level.

Comparing total household income to income net of taxes and transfers helps shed light on the role of the welfare system as a source of insurance against labor income risk. Figure 6 indicates that government insurance through taxes and transfers is not negligible, especially for bottom earners and against large income swings. Households in the first deciles of RE with a negative household income change of about 60 log points experience on average a drop of only 20 log points in household disposable income (Figure 6a). Households with a top earner head receive, as expected, less insurance from progressive taxation and transfers in case of negative shocks (the difference between the slopes n Figure 6b is smaller).

[13] Figure A.7 in the appendix shows that the same results also apply to contemporaneous changes in spouses' earnings.

FIGURE 6 • RESPONSE OF HOUSEHOLD INCOME TO MALE EARNINGS CHANGES



(a) Bottom RE deciles, 1-year

(b) Top RE deciles, 1-year

Notes: The x axis shows the average one-year male earnings growth and the y-axis plots the average one-year growth of household labor earnings, gross income and income after taxes and transfers. The sample used includes all male married workers between 25 and 55 years old from the baseline sample. Results are documented only for the bottom RE deciles (first and second) and top RE deciles (ninth and tenth). Figure A.8 in the appendix shows the results for median RE deciles. Source: German TPP.

Overall, income pooling at the family level and the welfare system together provide a great source of insurance to households and can attenuate disposable income fluctuations against individual earnings swings. A household whose male experiences a very large earnings drop is, on average, insured against over 80% of the earnings loss if he is at the bottom of the distribution and almost 50% if he is a top earner.

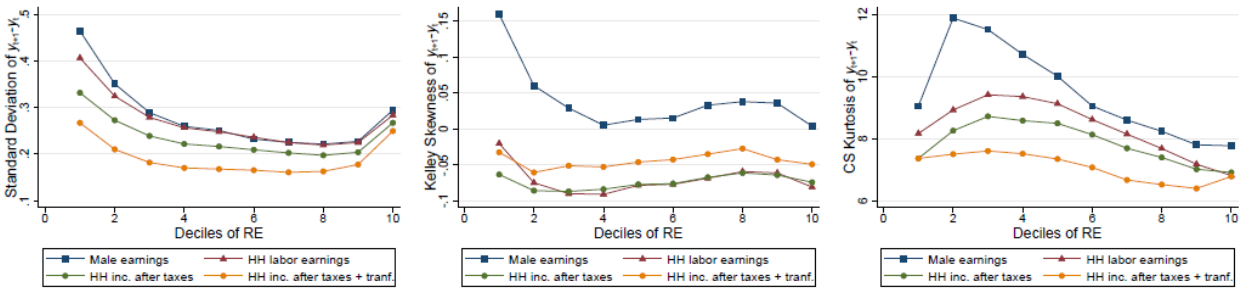
This evidence is broadly in line with evidence from administrative datasets for other countries (De Nardi *et al.*, 2021; Halvorsen *et al.*, 2020), but also from survey data for Germany (Bartels and Bönke, 2013). Bartels and Bönke (2013) find that taking institutions of the welfare state and risk-sharing households into account decreases transitory and permanent variances of net household income, even though over time both have remained fairly stable.

5.2 Cross-sectional moments of household income growth

We now turn back to the cross-sectional moments of income changes to investigate the role of household and government insurance in attenuating the

deviations from log normality documented for male labor earnings. Following the approach described in Section 3.1, Figure 7 reports the cross-sectional moments for household labor earnings and income net of taxes and transfers.[14] It shows that the cross-sectional moments for household earnings differ sharply from those of male earnings growth.

FIGURE 7 • CROSS-SECTIONAL MOMENTS FOR ONE-YEAR HOUSEHOLD EARNINGS GROWTH



(a) Standard Deviation (b) Kelley Skewness (c) Crow-Siddiqui Kurtosis

Notes: cross-sectional moments of one-year growth of individual and household labor earnings, household gross and net income of married male workers. Source: German TPP.

Income pooling with spouse labor earnings significantly helps attenuating the differences in skewness and the kurtosis along the RE deciles (Figures 7b and 7c). However, as discussed before, this should be interpreted as a mechanical second-earner effect. Figure 7 also shows that taxes and transfers mitigate the risk experienced by individual earners, especially for those at the bottom half of the RE distribution. In particular, these sources of public insurance can attenuate the volatility, negative skewness, and excess kurtosis of income changes as depicted in the three panels of Figure 7.

For instance, at the lowest percentiles of RE, the standard deviation declines in total from about almost 0.5 to below 0.3 after considering private and public insurances. The Crow-Siddiqui kurtosis at the household level falls from a peak of 12 to below 8 for bottom deciles and skewness becomes very close to zero along all RE deciles. This means that, at the household level, income changes are relatively more

[14] This analysis focuses only on households whose souses file tax returns together. So, the moments reported for male heads slightly differ from those presented in Section 3.2 for the whole sample.

frequent but smaller, while at the individual level changes in earnings are more infrequent but, when they happen, they are large. Even though this represents considerable mitigation of the risk, the distribution of household income after taxes and transfers is still mildly leptokurtic and features excess kurtosis compared to a normal distribution.

Figure 7 shows that family and household insurance are able to attenuate the presence of state dependencies. The amplitude of cross-sectional moments across RE groups is much smaller when accounting for these sources of insurance than for male earnings. Comparing Figure 7 to Figure D.6 highlights that the age dependencies are also mitigated. Therefore, even though some deviations from log-normality are still noticeable, this section makes documents that accounting for government and family insurances can attenuate their magnitude and heterogeneities with respect to income level and age.

6. CONCLUSIONS

This paper studies the nature of earnings changes in Germany and investigates the drivers of potential deviations from standard linear and symmetric models of labor income risk using a large dataset based on workers' tax records. First, it documents large deviations of earnings growth from a Gaussian distribution, namely negative skewness and excess kurtosis. The extent of these deviations depends on the income level and changes over the life-cycle.

Secondly, the drivers behind large earnings swings, which are important for the sharp non-normalities documented, differ across income groups. For the top earners, large labor income growth is solely explained by wage rate changes, while for the bottom earners, they are driven by a mix of changes in hours and wages which is consistent with periods of unemployment and job switches. This is consistent with evidence showing the important role of job changes and transition between employment and unemployment in explaining earnings fluctuations of bottom workers.

Then, this paper identifies considerable asymmetries in mean reversion patterns of earnings changes, which are not compatible with frequent modeling choices of earnings dynamics, like AR(1) processes. Positive income changes are more permanent, while negative changes are transitory for the bottom earners and more

permanent for the top. These non-linearities are mainly accounted for by the dynamics of hours worked since wage rate dynamics are close to linear.

Finally, I investigate the role of family and government insurance to mitigate individual earnings risk and attenuate deviations from log-normality. I find that the presence of a secondary earner in the household can smooth out earnings shocks. However, as the data does not provide evidence of an added worker effect, this is purely driven by income pooling. Moreover, government taxes and transfers in Germany mitigate the pass-through of large individual earnings swings to the household level. Both sources of insurance can attenuate the large deviations from log-normality of male earnings growth and its heterogeneities across income levels and age groups.

Despite all the labor institutional and welfare state differences, the moments and dynamics documented for Germany are qualitatively similar to the ones documented for other countries like the Netherlands, Norway, and the United States.

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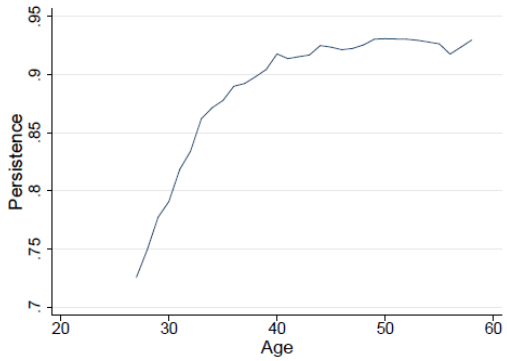
8. APPENDIX

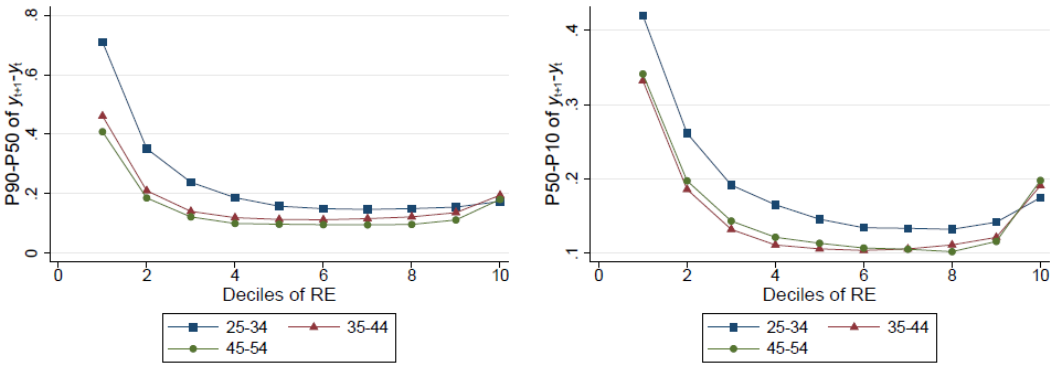
A. ADDITIONAL RESULTS FOR MALE WORKERS

FIGURE A.1 • PERSISTENCE OF EARNINGS



Notes: Persistence of male earnings as function of age. Source: German TPP.

FIGURE A.2 • SKEWNESS DECOMPOSED: P90-P50 AND P50-P10



(a) P90-P50 (b) P50-P10

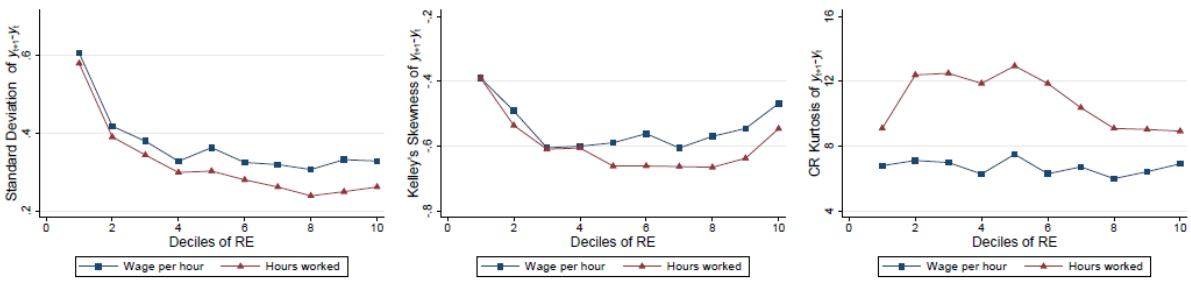
Notes: Figure A.9a plots the difference between P90-P50 for older age groups and age 25–34. Figure A.9b plots the same for P50-P10. Source: German TPP.

TABLE A.1: CROSS-SECTIONAL MOMENTS OF ONE-YEAR EARNINGS, WAGE, AND HOURS GROWTH

	All			25-34			35-54		
	earnings	wage	hours	earnings	wage	hours	earnings	wage	hours
Variance	0.35	0.37	0.32	0.36	0.37	0.33	0.33	0.34	0.29
Kelley Skewness	-0.56	-0.54	-0.60	-0.34	-0.36	-0.44	-0.52	-0.50	-0.57
CS Kurtosis	7.84	6.69	10.80	6.69	5.92	9.05	8.14	6.96	11.28

Notes: The Figure plots the empirical densities of one- and five-year labor earnings change superimposed on Gaussian densities with the same standard deviation. Data is from SOEP and only male workers between 25 and 54 years of age are used. Wages are obtained by dividing annual labor earnings of male heads of households by their annual hours worked. Source: German SOEP.

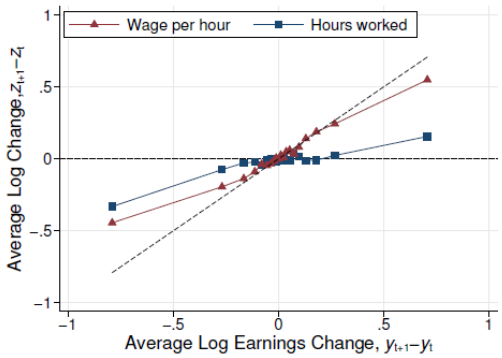
FIGURE A.3 • CROSS-SECTIONAL MOMENTS FOR ONE-YEAR HOURS AND WAGE GROWTH



(a) Standard Deviation (b) Kelley Skewness (c) Crow-Siddiqui Kurtosis

Notes: Cross-sectional moments of one-year growth in annual hours worked and hourly wage of male workers in the baseline sample. Source: German SOEP.

FIGURE A.4 • CONTRIBUTION OF HOURS AND WAGES TO EARNINGS CHANGES, MEDIAN RE DECILES



Notes: The figure displays the one-year average log change of annual hours and hourly wage for 20 different groups of male workers in the median (5th and 6th) RE deciles, plotted against their contemporaneous one-year average log change in annual labor earnings. Source: German SOEP.

TABLE A.2 • IMPORTANT LIFE CYCLE EVENTS ASSOCIATED WITH EARNINGS CHANGES

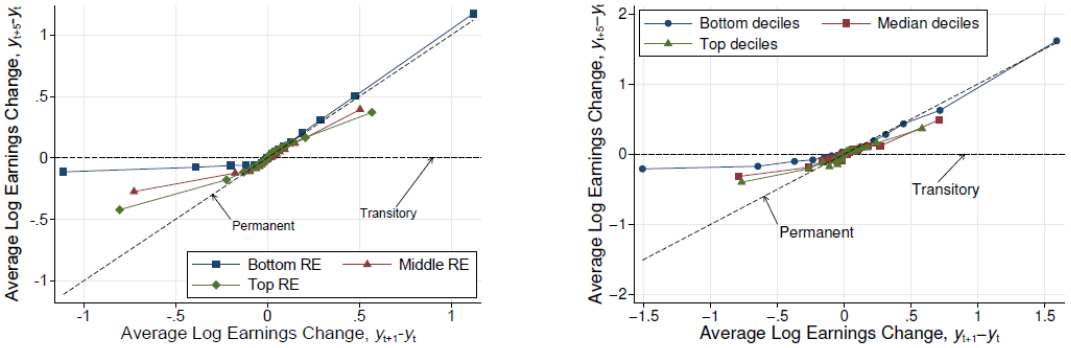
	One-Year Earnings Change, $\Delta y \in$					
	< -1	$[-1, -0.25)$	$[-0.25, 0)$	$[0, 0.25]$	$(0.25, 1]$	> 1
Short-time work	6.9	17.2	4.1	3.3	5.1	3.9
Unemployment	64.3	44.5	7.7	5.8	40.8	59.9
Short-term allowances	5.6	15.3	5.6	4.5	6.6	4.2
Social assistance allowances	42.4	30.9	7.1	6.4	30.0	41.2
Handicapped	5.9	4.1	1.5	0.5	0.5	0.6
Change no. children	4.0	4.7	4.4	3.3	4.8	5.1

Notes: In this table, individuals are sorted into six groups according to the size of their earnings change from t to t + 1 and documents the share of workers who contemporaneously experience certain life events. Short-time work (*Kurzarbeiter*) and unemployment account for the households who get in or out of these status for negative and positive income changes respectively. These are documented only until 2005. Short-term allowances include short-time work allowances/subsidies (*Kurzarbeitergeld Zuschuss*), maternity benefits (*Mutterschaftsgeld*) and top-up amounts under the partial retirement law (*Aufstockungsbeträge nach dem Altersteilzeitgesetz*). Social assistance allowances account for unemployment (Arbeitslosengeld}), sickness (*Krankengeld*), maternity (*Mutterschaftsgeld*), and parental (*Elterngeld*) benefits. Handicapped documents the share of workers who experience an increase or decrease in the handicapped allowance contemporaneously to a decrease or increase in the labor earnings, respectively. Change in the number of children accounts for workers whose number of children increased contemporaneously to the income change. Source: German TPP.

FIGURE A.5 • PERSISTENCE OF LABOR EARNINGS CHANGES, MEDIAN RE DECILES

Notes: The figure displays the k-year average log change of annual labor earnings for 20 different groups of male workers in the median (5th and 6th) RE deciles, plotted against their contemporaneous one-year average log change in annual labor earnings. Source: German TPP.

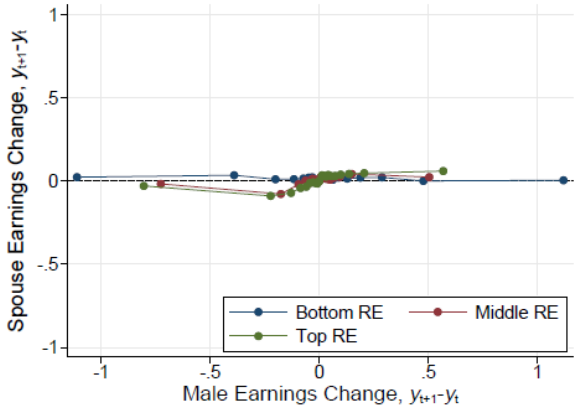
FIGURE A.6 • PERSISTENCE OF LABOR EARNINGS CHANGES, TPP AND SOEP



(a) TPP (b) SOEP

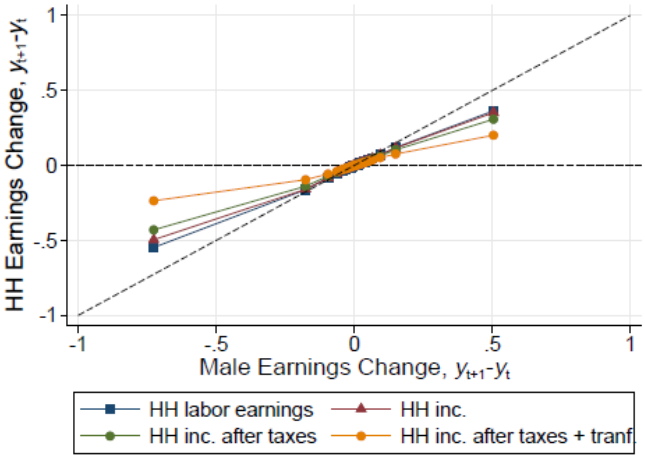
Notes: The figure displays the five-year average change in labor earnings for 20 different groups of males workers in the bottom (first and second), median (fifth and sixth) and top (ninth and tenth) RE deciles, plotted against their respective one-year average change. Source: German TPP and SOEP.

FIGURE A.7 • ONE-YEAR SPOUSE LABOR EARNINGS RESPONSES TO MALE EARNINGS SHOCKS



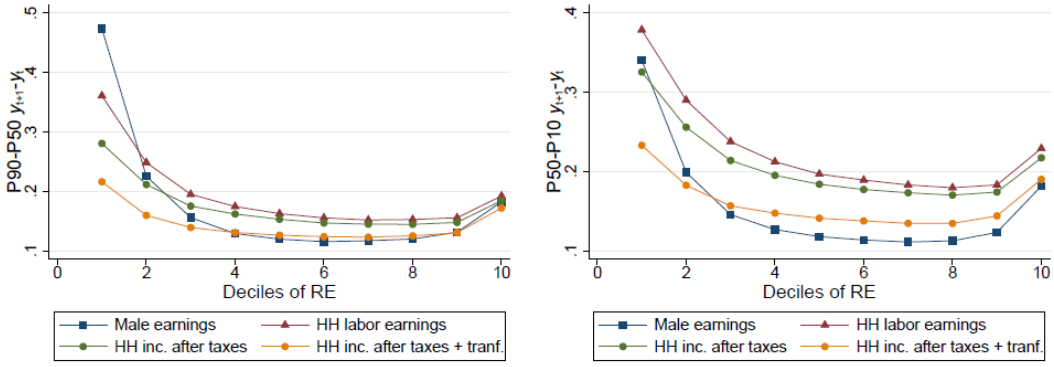
Notes: The figure displays the average one-year change of spouse labor earnings for 20 different groups of males married workers, plotted against their one-year log change in average labor earnings. The sample comprises married male workers. Results are documented only for the bottom RE deciles (first and second), Median RE deciles (fifth and sixth), and top RE deciles (ninth and tenth). Source: German TPP.

FIGURE A.8: ONE-YEAR GROWTH OF HOUSEHOLD LABOR EARNINGS, GROSS AND NET INCOME, MEDIAN RE DECILES



Notes: The x axis shows the average one-year male earnings growth and the y-axis plots the average one-year growth of household labor earnings, gross and net income. The sample comprises married male workers. Results are documented only for the median RE deciles (fifth and sixth) RE deciles. The sample used includes all male married workers between 25 and 55 years old from the baseline sample. Source: German TPP.

FIGURE A.9: SKEWNESS DECOMPOSED FOR HOUSEHOLD LABOR EARNINGS, GROSS AND NET INCOME

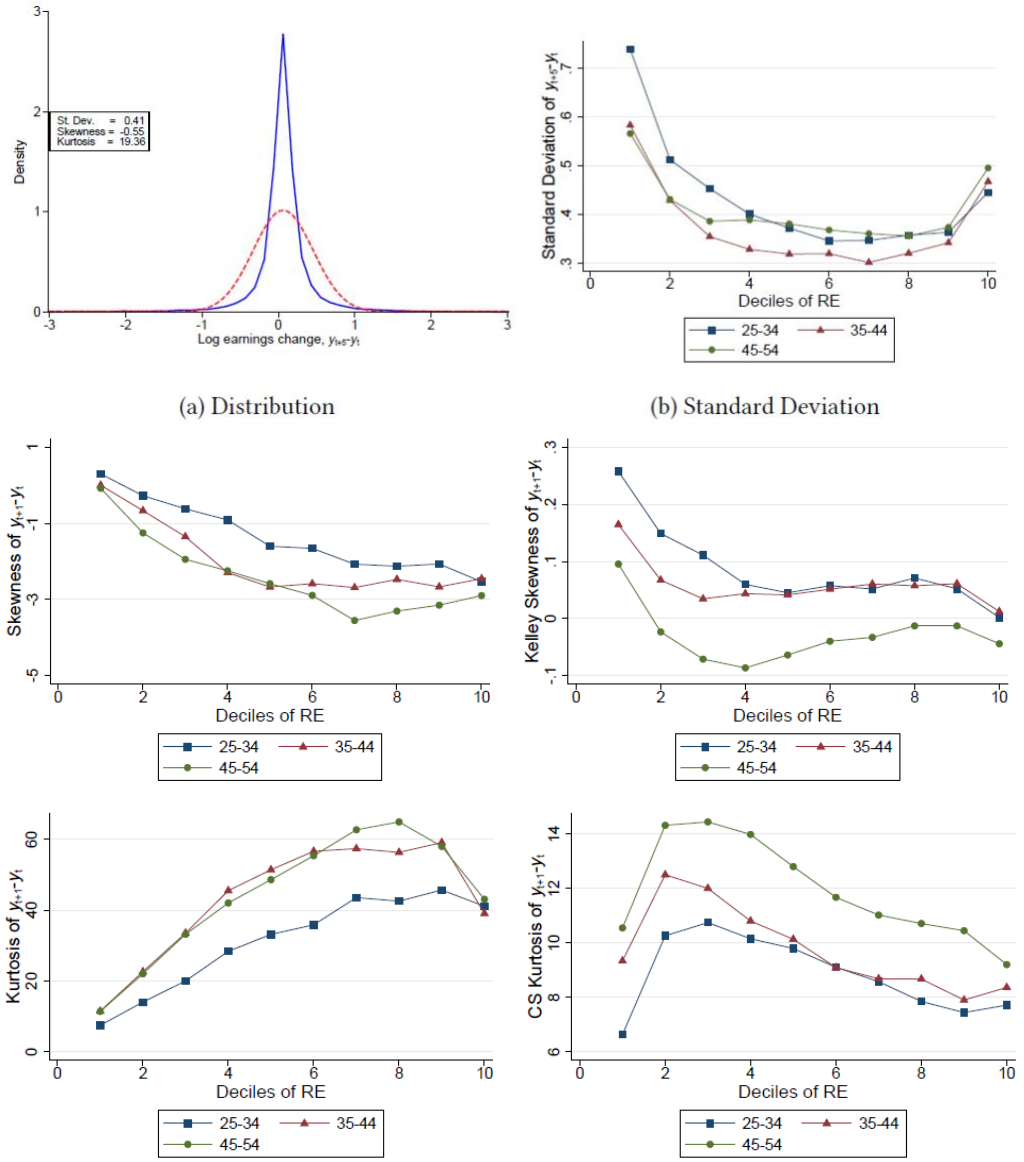


(a) P90-P50 (b) P50-P10

Notes: Figure 1a plots the difference between P90-P50 for older age groups and age 25–34. Figure 1b plots the same for P50-P10.Source: German TPP.

B. RESULTS FOR FIVE-YEAR INCOME CHANGES OF MALE WORKERS

FIGURE B.1 • DISTRIBUTION OF FIVE-YEAR EARNINGS GROWTH

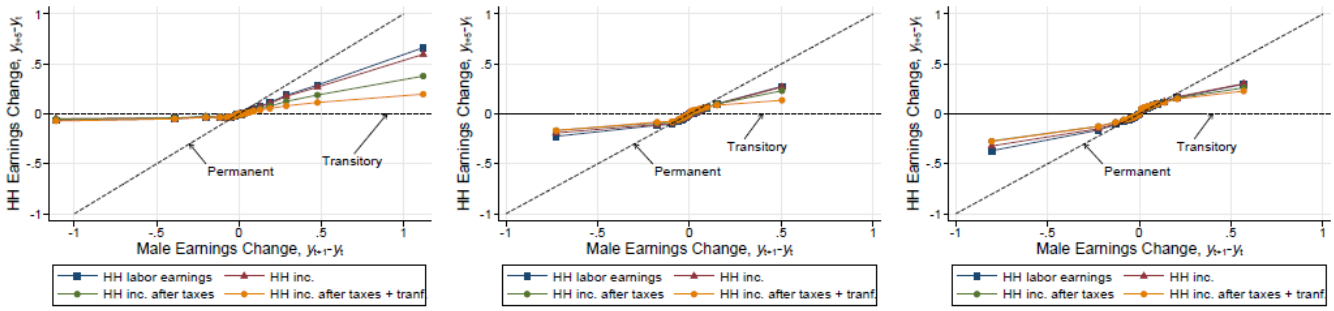


(a) Distribution (b) Standard Deviation

(e) Kurtosis (f) Crow-Siddiqui Kurtosis

Notes: Panel B.1a depicts the empirical densities of five-year earnings changes along with Gaussian densities with the same standard deviation as the data. Data is from 2007 German tax records and only male workers between 25 and 59 years old are included. The remaining panels show the cross-sectional moments of five-year labor earnings growth of male workers over the life-cycle. Source: German TPP.

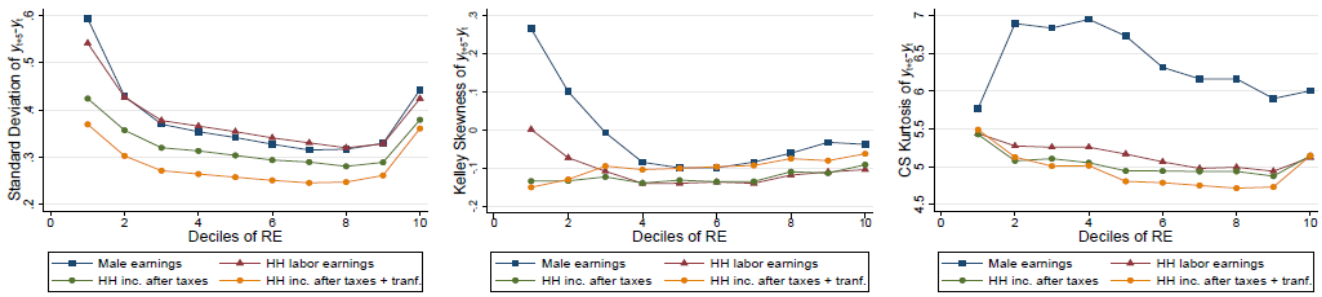
FIGURE B.2 • FIVE-YEAR GROWTH OF HOUSEHOLD INCOME



(a) Bottom RE deciles, 5-year (b) Median RE deciles, 5-year (c) Top RE deciles, 5-year

Notes: The x axis shows the average one-year male earnings growth and the y-axis plots the average five-year growth of household labor earnings, gross and net income. The sample comprises married male workers. Results are documented only for the bottom RE deciles (first and second), Median RE deciles (fifth and sixth), and top RE deciles (ninth and tenth). The sample used includes all male married workers between 25 and 55 years old from the baseline sample. Source: German TPP.

FIGURE B.3: CROSS-SECTIONAL MOMENTS FOR FIVE-YEAR HOUSEHOLD INCOME GROWTH



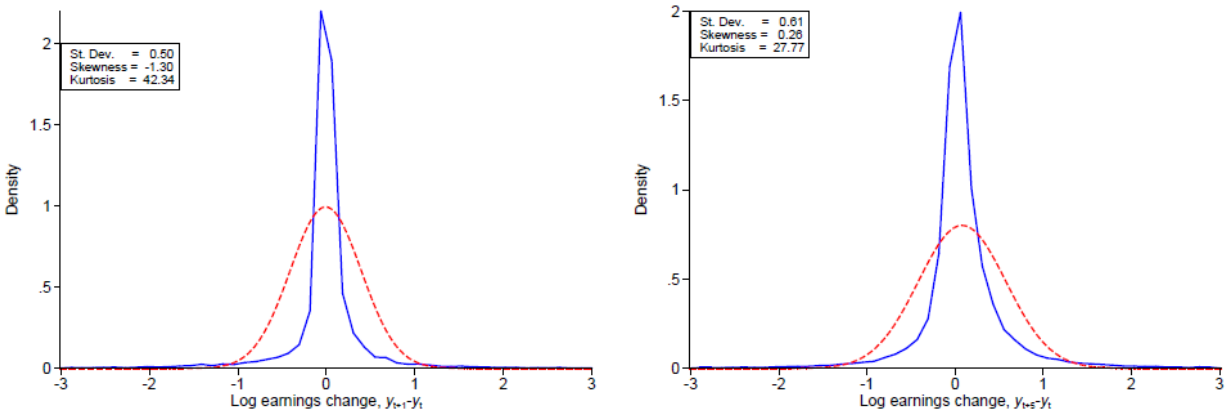
(a) Variance (b) Kelley Skewness (c) Crow-Siddiqui Kurtosis

Notes: Cross sectional moments of five-year growth of individual and household labor earnings, household gross and net income of married male workers. Source: German TPP.

C. RESULTS FOR FEMALE WORKERS

Similarly to men, Figure C.1 shows that the distributions of one- and five-year female earnings changes also comprise strong deviations from log-normality. Then, Figure C.2 presents the persistence and higher-order moments of these distributions over the life-cycle and earnings distribution. Regarding the standard deviation, Figure C.2b shows that, for women above 35, the distribution of earnings growth is both qualitatively and quantitatively quite similar to those of men. However, earnings changes for young females are significantly more volatile than of young males, which is likely explained by the role of maternity, leaves of absence and part-time work (as will be discussed in Section 4.2). Figure C.2c displays the negative skewness of the earnings growth distribution for females. Relative to males, there are more differences over the life cycle and along the RE groups, however, when accounting for possible outliers, the distribution is close to symmetric (Figure C.2d). For most RE deciles, the kurtosis of earnings growth is lower for young females than for young males, but higher for older females than older males (Figure C.2e). Thus, the distribution of female earnings growth also displays strong deviations from normality but differences over the life-cycle are even more pronounced than for males.

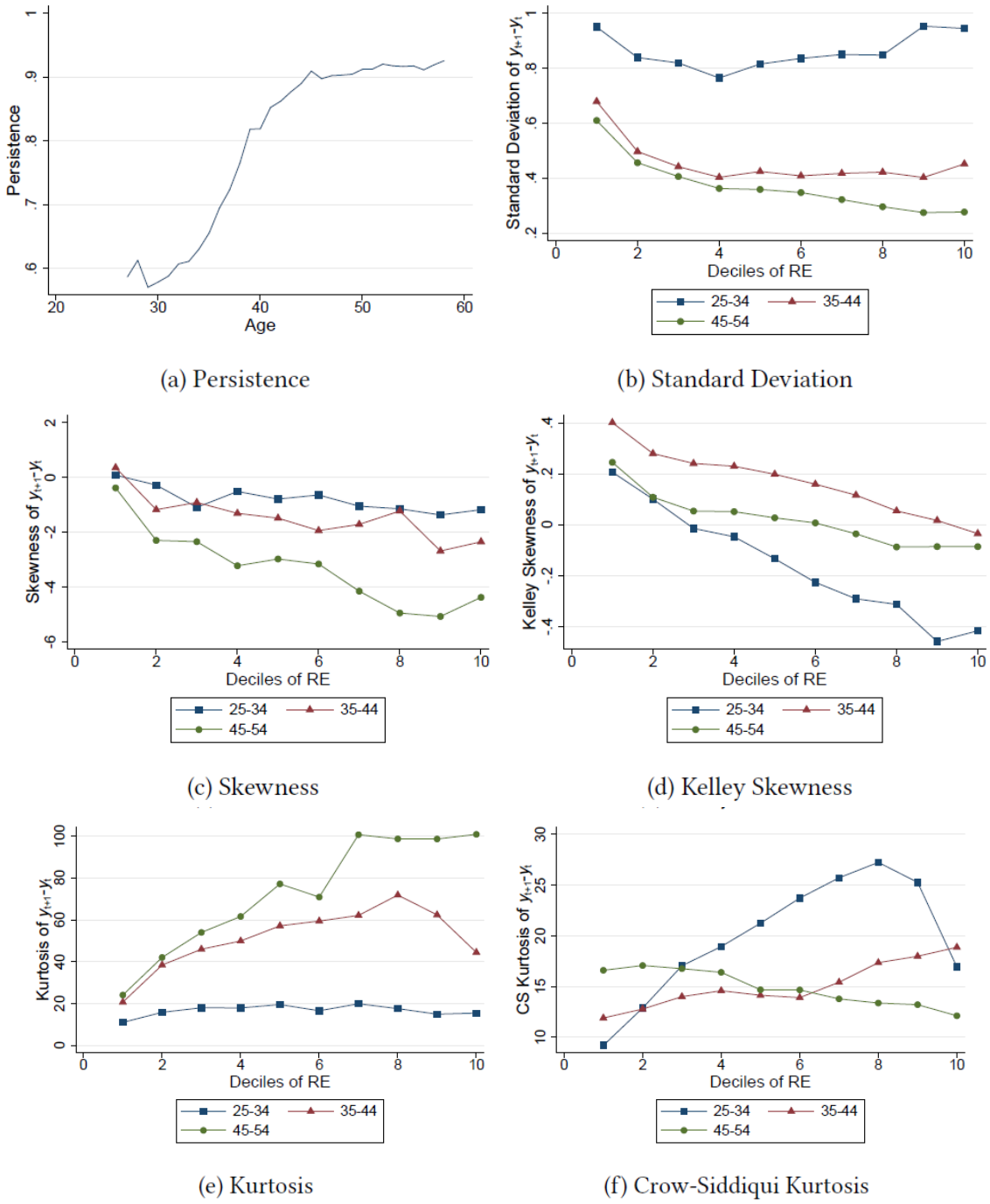
FIGURE C.1 • HISTOGRAMS OF ONE- AND FIVE-YEAR LOG EARNINGS CHANGE OF FEMALES



(a) 1-Year earnings growth (b) 5-Year earnings growth

Notes: The figure plots the empirical densities of one- and five-year labor earnings change superimposed on Gaussian densities with the same standard deviation. Data is from TPP and only female workers between 25 and 60 years of age are used. Source: German TPP.

FIGURE C.2 • PERSISTENCE AND CROSS-SECTIONAL MOMENTS FOR ONE-YEAR EARNINGS GROWTH



(a) Persistence

(b) Standard Deviation

(c) Skewness

(d) Kelley Skewness

(e) Kurtosis

(f) Crow-Siddiqui Kurtosis

Notes: Cross-sectional moments of one-year labor earnings growth of female workers over the life-cycle. Source: German TPP.

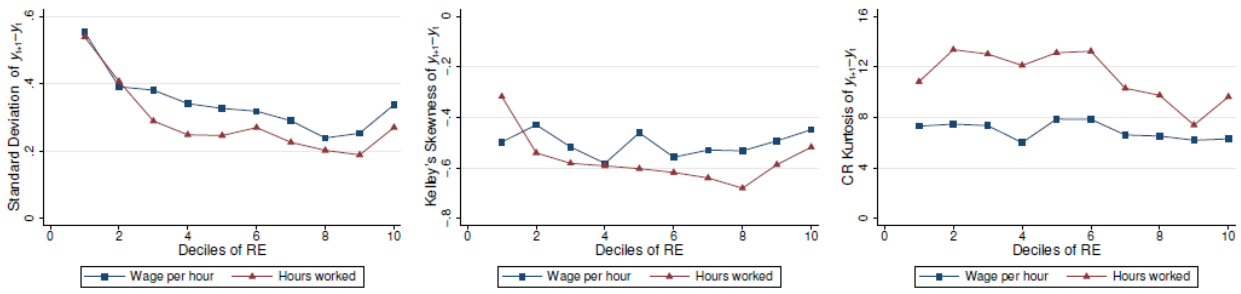
TABLE C.1 • LABOR EARNINGS SHOCKS AND LIFE EVENTS FOR FEMALE WORKERS

	1-Year Negative Change, $\Delta y \in$				1-Year Positive Change, $\Delta y \in$		
	< -1	$[-1, -0.25)$	$[-0.25, 0)$		> 1	$(0.25, 1]$	$[0, 0.25]$
Into non-employment	23.22	15.98	3.44	Into full-time			
Into unemployment	6.42	5.73	1.26	from not full-time	12.58	8.19	3.11
Into regular part-time	2.94	5.37	2.90	from regular part-time	5.07	5.88	2.67
Changed job	23.93	16.97	6.499	Into full- or regular part-time			
Involuntary change	10.37	9.06	2.40	from not working	9.64	3.17	0.62
Due to parental leave	6.19	4.05	0.70	form unemployed	2.39	1.17	0.23
Change no. of children	16.14	10.20	1.74	Changed job	22.22	12.92	5.49
In maternity leave	13.47	6.27	1.07	Involuntary change	5.88	4.58	1.75
Lost second job	5.50	7.00	3.52	Out of maternity leave	3.19	1.85	1.36
Into disability	1.80	1.90	1.10	Extra job	7.00	6.96	3.19
				Out of disability	0.34	0.47	0.56
Share (%)	3.98	10.88	32.83	Share (%)	3.38	12.09	36.84
$\mathbb{E}\,\Delta^1_{log} y^i_t$	-1.63	-0.51	-0.07	$\mathbb{E}\,\Delta^1_{log} y^i_t$	1.57	0.50	0.08
$\mathbb{E}\,\Delta^1_{log} w^i_t$	-1.63	-0.51	-0.07	$\mathbb{E}\,\Delta^1_{log} w^i_t$	0.88	0.33	0.07
$\mathbb{E}\,\Delta^1_{log} h^i_t$	-0.90	-0.21	-0.01	$\mathbb{E}\,\Delta^1_{log} h^i_t$	0.68	0.17	0.01
$\mathbb{E}\,\Delta^5_{log} y^i_t$	-0.45	-0.17	-0.06	$\mathbb{E}\,\Delta^5_{log} y^i_t$	1.40	0.41	0.05
$\mathbb{E}\,\Delta^5_{log} w^i_t$	-0.35	-0.12	-0.01	$\mathbb{E}\,\Delta^5_{log} w^i_t$	0.69	0.24	0.07
$\mathbb{E}\,\Delta^5_{log} h^i_t$	-0.10	-0.04	-0.04	$\mathbb{E}\,\Delta^5_{log} h^i_t$	0.71	0.17	-0.01

Notes: Part-time worker accounts only for regular part-time employment. Individuals are considered unemployed if are not working and are registered unemployed and excluded those who are not working but sometimes have a second job, were working past the 7 days, or have a regular second job. Individuals are considered not employed if they are not full- or part-time employed or attending vocational training. I consider a forced job change in the following cases: the employment link was terminated by the employer, a temporary contract expired, the education or training was completed, the company transfers the employee, the company closed down. The option of job change due to maternity/parental leave is only asked in some waves of the survey (from 1991 to 1998 and since 2011). Source: German SOEP.

D. RESULTS FOR PRIME-AGE WORKERS

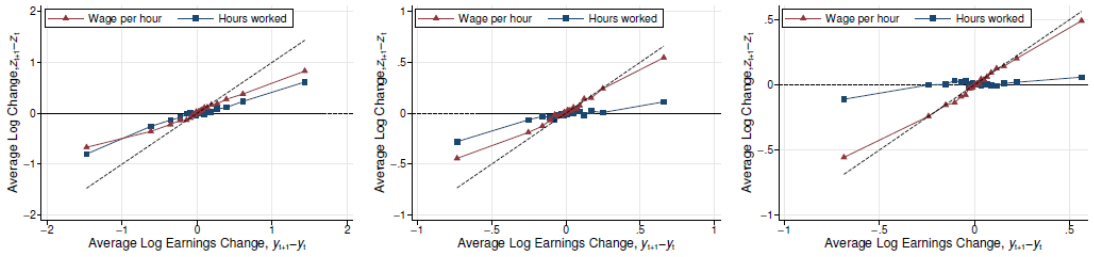
FIGURE D.1 • CROSS-SECTIONAL MOMENTS OF HOURS AND WAGE GROWTH



(a) Variance (b) Kelley Skewness (c) CS Kurtosis

Notes: Cross sectional moments of one- and five-year growth in annual hours worked and hourly wage of male workers between 35 and 54 years old. Source: German SOEP.

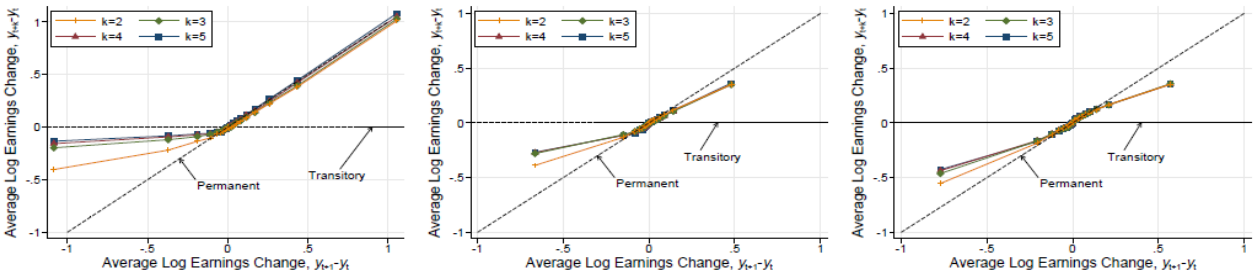
FIGURE D.2 • CONTRIBUTION OF HOURS AND WAGES



(a) Bottom RE deciles (b) Median RE deciles (c) Top RE deciles

Notes: The figure displays the one-year average log change of annual hours and hourly wage for 20 different groups of male workers between 35 and 54 years old in the bottom (first and second), median (fifth and sixth) and top (ninth and tenth) RE deciles, plotted against their contemporaneous one-year average log change in annual labor earnings. Source: German SOEP.

FIGURE D.3 • PERSISTENCE OF LABOR EARNINGS CHANGES BY RE DECILE



(a) Bottom RE deciles (b) Median RE deciles (c) Top RE deciles

Notes: The figure displays the k-year average log change of annual labor earnings for 20 different groups of male workers in the bottom (first and second), median (fifth and sixth) and top (ninth and tenth) RE deciles, plotted against their contemporaneous one-year average log change in annual labor earnings. Source: German TPP.

FIGURE D.4: PERSISTENCE OF EARNINGS, HOURS, AND WAGES CHANGES

(a) Earnings (b) Hours (c) Wages

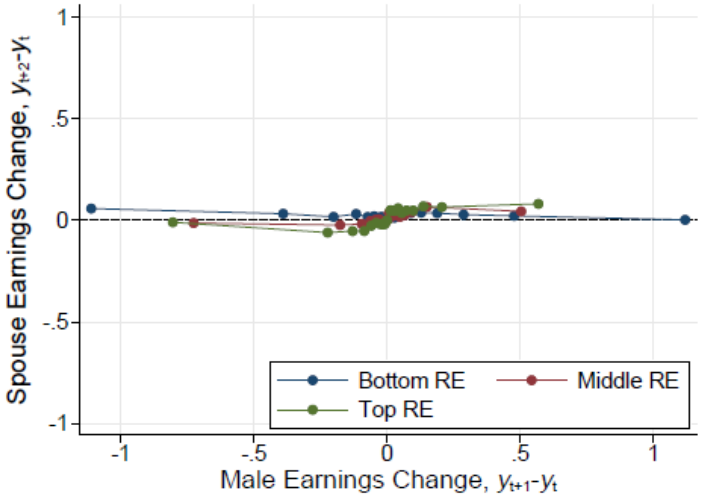
Notes: The figure displays the five-year average change in earnings, hours and wages for 20 different groups of males workers in the bottom (first and second), median (fifth and sixth) and top (ninth and tenth) RE deciles, plotted against their respective one-year average change. Source: German SOEP.

TABLE D.1 • LABOR EARNINGS SHOCKS AND LIFE EVENTS
FOR PRIME-AGED MALE WORKERS

	1-Year Negative Change, $\Delta y \in$				1-Year Positive Change, $\Delta y \in$		
	< -1	$[-1, -0.25)$	$[-0.25, 0)$		> 1	$(0.25, 1]$	$[0, 0.25]$
Into non-employment	21.46	10.24	1.44	Into Full-time			
into unemployment	16.66	7.68	0.98	from not full-time	17.80	4.97	1.02
Into regular part-time	1.98	1.70	0.51	from regular part-time	4.67	1.42	0.45
Changed job	28.02	14.25	5.24	Into full- or regular part-time			
involuntary change	16.85	11.49	2.37	form not working	9.96	3.12	0.53
due to parental leave	0.36	0.23	0.08	from unemployment	5.75	2.23	0.38
Change no. of children	2.87	2.66	2.55	Changed job	21.39	11.62	4.78
Lost second job	3.69	3.70	2.92	involuntary change	9.35	6.45	1.79
Into disability	4.45	2.07	1.10	Extra job	3.29	3.99	2.75
				Out of disability	0.63	0.82	0.49
Share (%)	1.65	8.05	37.04	Share (%)	1.22	8.80	43.24
$\mathbb{E}\,\Delta^1_{log} y^i_t$	-1.65	-0.46	-0.07	$\mathbb{E}\,\Delta^1_{log} y^i_t$	1.64	0.45	0.08
$\mathbb{E}\,\Delta^1_{log} w^i_t$	-0.81	-0.35	-0.07	$\mathbb{E}\,\Delta^1_{log} w^i_t$	1.03	0.35	0.07
$\mathbb{E}\,\Delta^1_{log} h^i_t$	-0.83	-0.11	-0.01	$\mathbb{E}\,\Delta^1_{log} h^i_t$	0.61	0.10	0.01
$\mathbb{E}\,\Delta^5_{log} y^i_t$	-.39	-0.23	-0.05	$\mathbb{E}\,\Delta^5_{log} y^i_t$	1.49	0.29	0.06
$\mathbb{E}\,\Delta^5_{log} w^i_t$	-0.30	-0.19	-0.01	$\mathbb{E}\,\Delta^5_{log} w^i_t$	0.89	0.26	0.08
$\mathbb{E}\,\Delta^5_{log} h^i_t$	-0.08	-0.04	-0.04	$\mathbb{E}\,\Delta^5_{log} h^i_t$	0.62	0.04	-0.02

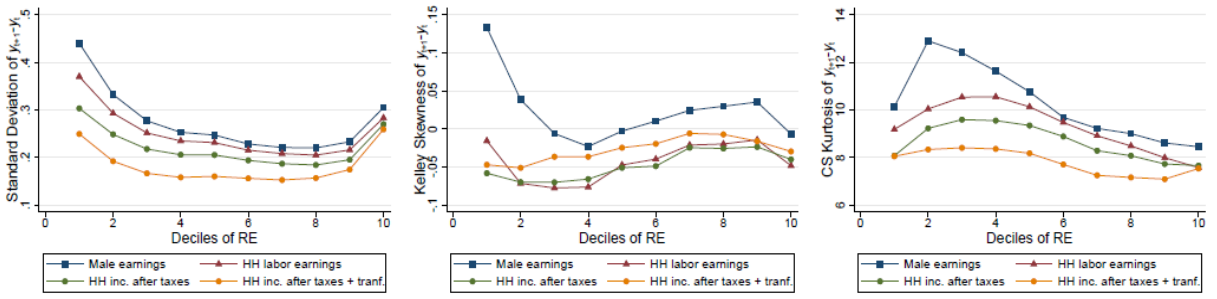
Notes: Part-time worker accounts only for regular part-time employment. Individuals are considered unemployed if are not working and are registered unemployed and excluded those who are not working but sometimes have a second job, were working past the 7 days, or have a regular second job. Individuals are considered not employed if they are not full- or part-time employed or attending vocational training. I consider a forced job change in the following cases: the employment link was terminated by the employer, a temporary contract expired, the education or training was completed, the company transfers the employee, the company closed down. The option of job change due to maternity/parental leave is only asked in some waves of the survey (from 1991 to 1998 and since 2011). Source: German SOEP.

FIGURE D.5 • TWO-YEAR GROWTH OF SPOUSES" LABOR EARNINGS



Notes: The x axis shows the average one-year male earnings growth and the y-axis plots the average two-year growth of spouses earnings. The sample used includes all male married workers between 35 and 54 years old from the baseline sample. Source: German TPP.

FIGURE D.6 • CROSS-SECTIONAL MOMENTS OF HOUSEHOLD INCOME GROWTH



(a) Standard Deviation, 1-year (b) Kelley Skewness, 1-year (c) Crow-Siddiqui Kurtosis, 1-year

Notes: Cross sectional moments of one- and five-year growth of individual and household labor earnings, household gross and net income of married prime-aged male workers. Source: German TPP.

ELEONORA PRIORI

SIMULATING A BASIC INCOME TO COPE WITH THE TECHNOLOGICAL TRANSITION: AN AGENT-BASED MODEL

Abstract. The "machinery question" has been a hot topic for at least two centuries, with many thinkers discussing the impact of machinery on the interests of the different classes of society. The Covid-19 pandemics, together with the raise of Artificial Intelligence, impressed a further acceleration to the automation of the productive processes, and the consequent disappearance of many traditional jobs is a well-documented fact. Technological unemployment is then outlining a structural change of the labor market, and this should impose a paradigm shift in the way that we think at welfare systems. I propose an agent-based model (ABM) to study the impact of technological shocks automating productive processes, then I simulate how a universal basic income would face the challenge of these structural changes. In the model agents interact both on the good market and on the labor market, with endogenous mechanisms defining their ecology and developing some adaptive behaviors. The model explores alternative scenarios of firms' coping strategies when an exogenous technological shock intervenes. The simulation is thought to discuss the role of innovation in driving paradigm shifts and to analyze whether and how a universal basic income would help face the latter. Results display the feasibility of the measure showing that it provides a larger stability of the model, which guarantees its sustainability in the long run..

Keywords. Agent-based modelling, Universal basic income, Technological transition, Paradigm shift.

1. INTRODUCTION

Technological unemployment stands as one of the most compelling challenges of nowadays. The automation of productive processes, boosted by the raise of Artificial Intelligence (AI), is causing a paradigm shift in the way that we think at the role of human labor in society. Moreover, the outbreak of the Covid-19, and its relapse on the economic system, both speeded this process up and pushed millions of people into harsh economic conditions. All this made even more urgent to open a debate on how to update the welfare system supporting individuals toward this transition. This work aims at analyzing the dynamics driving from technological innovation to labor market's structural changes, proposing a universal basic income as a tool to cope with the latter. I build a theoretical agent-based model (ABM) to clarify how these dynamics may unfold under different conditions, simulating the effects of introducing such a policy.

Section 1 recalls the theoretical framework of the debate on technological transition and a proposal about the tools to update welfare systems, also in the light of the economic crisis resulting from the Covid-19 pandemics and of the broader discussion about technological unemployment as a *new normal*. In Section 2, I propose an ABM to simulate an economy where firms and individuals interact both on the goods- and on the labor market. Here endogenous mechanisms defining the agents' ecology take place and agents develop adaptive and learning behaviors. The model is thought to study the effects of technological shocks on the simulated economy and to explore alternative scenarios which may arise from agents' copying strategies. While presenting the possible outcomes that these may lead to, I suggest a universal basic income as a public policy to face the economic transition. Section 3 presents and discusses the results of my model. The simulation aims at verifying the financial feasibility of the proposed policy, but also at testing whether it would be an effective tool to guarantee a larger economic stability during the technological transition.

2. THEORETICAL FRAMEWORK: BETWEEN CRISES, TECHNOLOGICAL ANXIETY AND NEW POSSIBILITIES

2.1 Technological unemployment, the new normal

The Covid-19 recession is only the latest in a long series of crisis impacting the global economy: credit crunch, job-places disruption and drops in incomes, consumptions, and investments levels have become keywords of the modern era, and once again the consequences on the labor market are dramatic (Coates *et al.*, 2020; Fana *et al.*, 2020).

However, the *jobless recovery* phenomenon is not a novelty: starting from the early 1990s all the crises have been followed by periods of output recovery which have not come with a recovery of the employment rate (*e.g.* the 1990-91 crisis, the 2000's Dotcom Bubble, and the Great Recession started in 2007). The Covid-19 crisis is not an exception in this trend: on the contrary, Hodder (2020) highlights the urgence of being retrospective and observing the role played by new technologies in the current crisis. Moreover, Blit (2020) claims that the pandemics accelerated automation and reallocation processes, which may usher in the future of work as more and more jobs have been substituted by machineries. Economists have long tried to explain the search-matching frictions on the labor market, ascribing different causes to the jobless

recovery phenomenon: the sectoral reallocation investing many industries (Aaronson *et al.*, 2004); the increasing job-polarization due to the substitution of middle-skilled jobs (Autor and Dorn, 2013); and the so-called labor hoarding theory (Schwartz and Burger, 2016). Alle these theories share the idea that there is some structural change affecting the labor market, and that the so-called technological unemployment is becoming a *new normal*, which also requires a paradigm shift in the economic theory to look for sustainable solutions.

2.2 The "machinery question" today

Debates about technological unemployment, however, are nothing of new in the human history. Mokyr *et al.* (2015) show how technology is widely considered the main source of economic progress, but it has also generated cultural anxiety throughout history. From generation to generation, literature has often portrayed technology as alien, incomprehensible, increasingly powerful and threatening, and possibly uncontrollable. The "machinery question", discussing the relationship between technological development and (un)employment, has been a hot topic for at least two centuries. First posed by Ricardo, who devoted the chapter 31 of his *Principles* (1821 [2001]) to the topic, it concerns the "influence of machinery on the interests of the different classes of society", and in particular the "opinion entertained by the laboring class, that the employment of machinery is frequently detrimental to their interests". A century later, Keynes (1930 [2010]) in the *Economic Possibilities for our Grandchildren* discusses the acceleration in the technological development experienced between the 18th and the 19th century, defining the consequent technological unemployment of those years as "only a temporary phase of maladjustment".

Predictions of automation making humans redundant have been made before going back to the Industrial Revolution, when textile workers, most famously the Luddites, protested that machines and steam engines would destroy their livelihoods, but also in the 1960s when someone feared at first firms installing computers and robots, or in the 1980s when PCs landed on desks. Analogously, nowadays someone looks at Artificial Intelligence (AI) as a threat to humanity or a "mighty power which has come before we knew how to employ it rightly" (The Economist, 2016). There are many historical examples of how new technology introduced in the productive processes changed them: Bessen (2015) claims how rather than destroying jobs, automation redefines them, changing their nature and the skills required to them – and that it does so in ways that reduce costs and boost demand.

However, a widely note study by Frey and Osborne (2017) examined the probability of computerization for 702 occupations and found that 47% of workers in America had jobs at high risk of potential automation. Moreover, as Autor (2015) warns, this time, many workers will have to switch from routine, unskilled jobs to non-routine, skilled jobs to stay ahead of automation. In previous waves of automation, they could switch from one kind of routine work to another; but now the big data techniques allow companies to train machine-learning systems to perform the jobs of more and more people. The number of jobs lost to more efficient machines is only part of the problem as – as Autor states – automation may prevent the economy from creating enough new jobs. Throughout industry, the trend has been to increase production with a smaller workforce and many of the losses in factory jobs have been countered by an increase in the service industries or in office jobs, but automation is beginning to move in and eliminate office jobs too. In the past, new industries hired far more people than those they put out of business. But this is not true of many of today's new industries. Today's new industries have comparatively few jobs for the unskilled or semiskilled, just the class of workers whose jobs are being eliminated by automation.

Even Ford (2016) agrees that the current technological revolution is different from the earlier one as, in contrast to earlier disruptions, which affected specific sectors of the economy, the effects of today's revolution are "general-purpose": according to him, from janitors to surgeons, virtually no jobs will be immune as the labor-saving technology is whittling their numbers.

Hence, there are two basic aspects to be addressed: by one side, this time the transition is likely to be faster, as technologies diffuse more quickly than they did two-hundred years ago; on the other hand, this may cause income inequality to grow further due to the consequent mass unemployment. And without work how will people have enough money to support the mass consumerism on which any remaining jobs might depend? After the Industrial Revolution, governments took a century to respond with new education and welfare systems: nowadays a quicker response is required to allow employers and policymakers to help existing workers acquire new skills and prepare future generations for a workplace stuffed full of AI. Furthermore, the Covid-19 pandemics imposed an acceleration towards the technological transition, but it also pushed the unemployment rates up, with the resulting explosion of poverty that millions of people experienced. For all these

reasons, many scholars support the idea of a universal basic income to deal with this transition, and after the pandemics outbreak, many studies push towards this direction (*e.g.* Nettle *et al.*, 2021; Ståhl and MacEachen, 2021; Johnson and Roberto, 2020).

2.3 A basic income to cope with the technological transition

It was still 1858 when Marx wrote his *Fragment on Machines*: in his view, while the development of machinery led to the oppression of workers under capitalism, it could also offer a prospect for future liberation through what he calls the general intellect, *i.e.* the combination of technological expertise and social knowledge. Finally, today, the structural changes of labor market driven by the technological transition, together with the dramatic consequences of the outbreak of the Covid-19 pandemics on the economic scenario, have made more urgent to think at how updating welfare systems, making at the same time possible to modernize the way at we think at human labor in society. Both economic insecurity conditions experienced by the precariat and concerns about AI and automation have led to calls for a stronger safety net to deal with growing social inequalities and to protect people from labor-market disruption and help them switch to new jobs: hence, both labor market scholars and AI commenters support the idea of a universal basic income as a right.

According to Van Parijs (2004), one of the most distinguished supporters of this idea, a basic income is "an income paid by a political community to all its members on an individual basis, without means test or work requirement". This means that every man, woman, and child should have a monthly basic income, without imposing arbitrary behavioral conditions and not being dependent on marital, sexual, or work status (Standing, 2008). Similar ideas were touted during the Industrial Revolution by Thomas Paine and John Stuart Mill, among others. Its chief merit, say its supporters, is that people who are not working, or are working part-time, are not penalized if they decide to work more, because their welfare payments do not decline as their incomes rise. It gives people more freedom to decide how many hours they wish to work and might also encourage them to retrain by providing them with a small, guaranteed income while they do so. Those who predict apocalyptic job destruction see it as a tool to keep the consumer economy going and support the non-working population. If most jobs are automated away, an alternative mechanism for redistributing wealth will be needed and the Covid-19 crisis has shed further light on the urgence of the topic. Since the idea took hold, there are many pilots and experiments all around the world projecting the implementation of such a measure (see Banerjee *et al.*, 2019;

Hoynes and Rothstein, 2019; Torry, 2019 for a review), and there is some debate around its feasibility (*e.g.* Colombino, 2018; Martinelli, 2017; Browne and Immervoll, 2017). This work aims at contributing to it with a theoretical agent-based model, testing its feasibility, but also discussing whether it would be an effective tool to guarantee economic stability during the technological transition.

3. THE MODEL

3.1 Defining the agents and the starting assumption of the model

I build an agent-based model (ABM)[1] to investigate the linkages between technological innovation and paradigm shifts affecting the structure of the labor market, then I simulate the introduction of a universal basic income as a possible tool to update the welfare system while facing structural changes. As I opt for a concept-driven theoretical model and not for a data-driven one, the parameters applied in the assumptions are arbitrarily chosen, and the model aims at reflecting the dynamics of interaction and at shedding a light on what scenarios could emerge from those, under given conditions.

The model basically relies on two classes of agents – namely individuals and firms – that interact on both the labor and the goods market. Individuals may be employed or unemployed, being all of them assumed to be part of the workforce and displaying different level of skills: the starting population of the model is equally distributed over low-skilled, medium-skilled, and high-skilled individuals. Furthermore, they are provided with a personal endowment, which is randomly assigned at the start of the simulation and is a function of the level of skills if they are employed as the model evolves through its cycles.

Firms are classified according to their main features, being: i) the productivity of capital; ii) the productivity of labor; iii) their capital endowment; iv) their size; and v) the maximum number of workers that they can employ. As far as the productivity of capital and labor are concerned, they are not meant in a traditional manner as

[1] For those who want to explore the model, they can find it at the following repository on GitHub https://github.com/eleonorapriori/basic_income__netlogomodel and play with it using NetLogo 6.1.1.

complements: then, they do not measure how much each of these factors contributes to a unit of product, but rather the efficiency of the investments on capital and labor of each firm compared with that of the other ones. As in Moretti (2013), I define productivity as the amount of output which a worker (or a machine) generates for each worked hour. Each of these two parameters take values between zero and one, and I classify firms according to a semiotic map representing the productivity of K on the abscissa axis and the productivity of L along the ordinate axis. As a result, an equal number of firms is distributed over four clock faces in the graphical interface of the simulation:

- the bottom-left sided quarter represents an area with low productivity of both K and L;
- the bottom-right sided quarter represents an area with low productivity of capital and high productivity of labor;
- the top-left sided quarter represents the opposite situation, *i.e.* an area with high productivity of K and low productivity of L;
- the top-right sided quarter represents an area with high productivity of both K and L.

This distribution allows to reflect four situations occurring in the global labor market: i) areas with low levels of technological development and low levels of employment rates; ii) areas with low levels of technological development and high levels of employment rates; iii) areas with high levels of technological development and low levels of employment rates; and iv) areas with high levels of technological development and high levels of employment rates.

Capital endowment then is a proxy of firms' savings: at the start of the simulation it assumes random values, then it evolves over time depending on the results which firms earn on the market. Firms are also classified according to their size distinguishing between small-sized firms, middle-sized firms, and big firms. The size of the firms, combined with the capital endowment *CE* and the productivity of labor *L*, determines their capacity in terms of job-places, *i.e.* the maximum number of workers *NW* they can employ. Then the equation defining the firms' capacity of creating job places is given by:

$$NW = (\alpha + \beta CE) * (1 - L)$$

where the parameters α and β depend on the firm's size. Hence, the maximum number of workers is an endogenous variable, which depends positively on the capital endowment and negatively on the productivity of labor, as the more productive the workers are, the lower is the number of individuals that firms will hire.

Once that the number of workers that each firm can employ is set, the model computes which workers each firm needs according to their level of skills. To do so, I assume that all the workers are employed in job positions reflecting their level of skills and that firms' labor demand depends on their productivity mix between capital and labor as follows:

- firms with low levels of productivity of both K and L distribute their workers in a 50% of low-skilled workers, a 40% of middle-skilled workers and a 10% of high skilled workers since they mainly require low-skilled and middle-skilled workers due to the low level of technological development;
- firms with low productivity of K and high productivity of L require the 50% of low-skilled workers, the 30% of middle-skilled workers and the 20% of high skilled workers;
- firms with high productivity of K and low productivity of L distribute their workers in a 25% of low-skilled workers, a 15% of middle-skilled workers and a 60% of high skilled workers since the labor-force demand shifts from low-skilled to high-skilled workers to deal with the increased technological level of the tools used by the firm;
- firms with high productivity of K and high productivity of L employ a 20% of low-skilled workers, a 15% of middle-skilled workers and a 65% of high skilled workers since the labor-force demand is focused on high-skilled workers.

As the model considers search-matching frictions, it may be the case that firms do not fill all their job places, with some workers remaining unemployed due to an informational asymmetry, preventing demand and supply to meet each other. According to these rules, firms employ only the unemployed workers following a random process, then workers cannot choose the firm where to work, but only accept the first offer they get. Once that the hiring process is done, employees perceive a wage accordingly to their level of skills; unemployed individuals do not receive a wage but only an unemployment benefit and firms with no workers are ruled out from the market.

3.2 The baseline dynamics: the goods- and the labor market

Upon this framework, I build the model over 100 subsequent cycles representing each one year of the simulation. In each cycle individuals and firms interact on the goods market and firms update their labor demand according to the results they perform on the latter.

Individuals are provided with a consumption function extracting random values from a normal distribution, whereas firms' production decisions are defined setting a minimum produced quantity according to their size, plus a random value extracted from a normal distribution to provide heterogeneity to the model. Then, firms' cost function is given by the sum of the wages of its workers and by a fixed parameter multiplying their productivity of capital, which defines the firms' fixed costs. In this way, the model computes the price level as the relation between the total quantity of goods demanded and produced (assuming the market selling a unique good), and the price is applied to the exchanges on the market. Hence, individuals' personal endowment is updated adding the annual wage (or an unemployment benefit lower than the minimum wage if they do not work, which is built by equally taxing all the firms operating on the market) and subtracting their consumption quantity multiplied by the price level. Analogously, firms update their capital endowment according to the profit/loss performed on the market. Furthermore, agents observe prices in the two previous periods, and adjust their production and consumption choices according to them (*i.e.,* consumers demand smaller quantities and firms produce more if prices grow over time, and vice versa).

Similarly, firms adapt their choices on the labor market according to their results on the goods market and decide whether to fire some of their employees or hire some new. Then, if they perform some loss or if their capital endowment becomes lower than a given threshold, they fire a share of their workers, selecting which ones according to their productive mix. Specifically, the level of productivity of L determines the number of workers to be fired: low-labor productivity firms will fire higher amounts of workers rather than high-labor productivity ones due to efficiency reasons. Instead, the level of productivity of K determines which kind of workers to fire, as firms with higher levels of productivity of K will prefer to fire low- and middle-skilled workers and keep those with higher level of skills, since they enhance the technological endowment of the firm, whereas firms with low productivity of K are more in need of low labor. With a specular logic, firms that perform profits above average or whose capital endowment is greater than an arbitrary threshold will

demand more labor to keep on growing. Again, the productivity of L determines the quantity of demanded labor, whereas that of K impacts on the quality of demand. Hence, firms with lower productivity of L will require higher numbers of new workers to compete with their high productivity of labor rivals, which being more efficient can demand lower numbers of new employees. Firms with higher levels of productivity of K will invest on hiring high-skilled workers, whereas those with lower productivities of K will ask for low- and middle-skilled work.

3.3 A policy to manage the technological transition

Once that the baseline of the model is set, I introduce a technological shock affecting the system at a given time. This represents the impact of innovation on the model and is assumed to be exogenous and to affect firms with different probabilities, reflecting their heterogeneity in the aptitude at embracing changes. Then, if the aptitude of a firm in exploiting innovation is higher than a given threshold, the shock invests the firm. When the technological shock hits a firm, this enlarges its productivity of capital by a given size, which is exogenously defined with a parameter. Now, firms may react to the shock adopting one of two opposite behaviors: they can either implement the production of goods keeping or choose to replace workers with machineries. To do so, firms would fire a consistent share of their workers as the increase in productivity of K allows them to keep the production levels stable by significantly reducing their cost function cutting the cost of labor. I explore which scenarios will arise by each of these cases in the *Results* section.

However, under the latter hypothesis, I test different universal basic income proposals to face the technological unemployment scenario that emerges. A basic income provision being equal to the maximum wage is distributed to all the individuals in the model some cycles after that the technological shock hits the economic system. As the agent-based model I represent is a closed system, where all the economic flows come from the interaction between the agents and no external resources are introduced, the basic income proposal is financed through firms' taxation. Different criteria of taxation may be selected, and here I investigate four scenarios: i) a taxation equally divided among all the firms; ii) a redistributive model where firms are taxed according to the profits they gain; iii) a "robot tax" based on the productivity of capital (*i.e.* the higher the productivity of capital of a given firm is, the higher is the taxation it will bear); iv) a taxation based on stimulating firms in investing even more in technologies, with higher contributions for firms displaying

lower productivities of capital, being the opposite principle of the "robot tax". However, the model does not highlight crucial differences among different financing criteria.

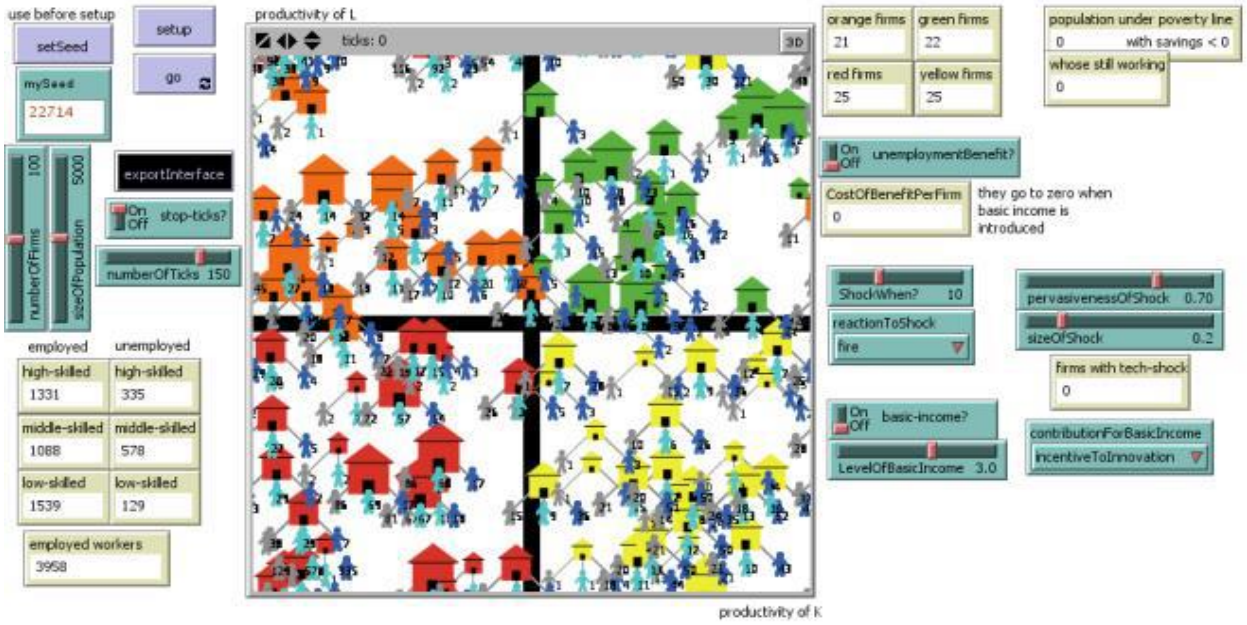
4. RESULTS

4.1 Calibration of the model

In this section I present the results emerging by running the simulation for 100 subsequent cycles (*i.e.* one-hundred years), and I explore the different scenarios arising under different input conditions of the model.

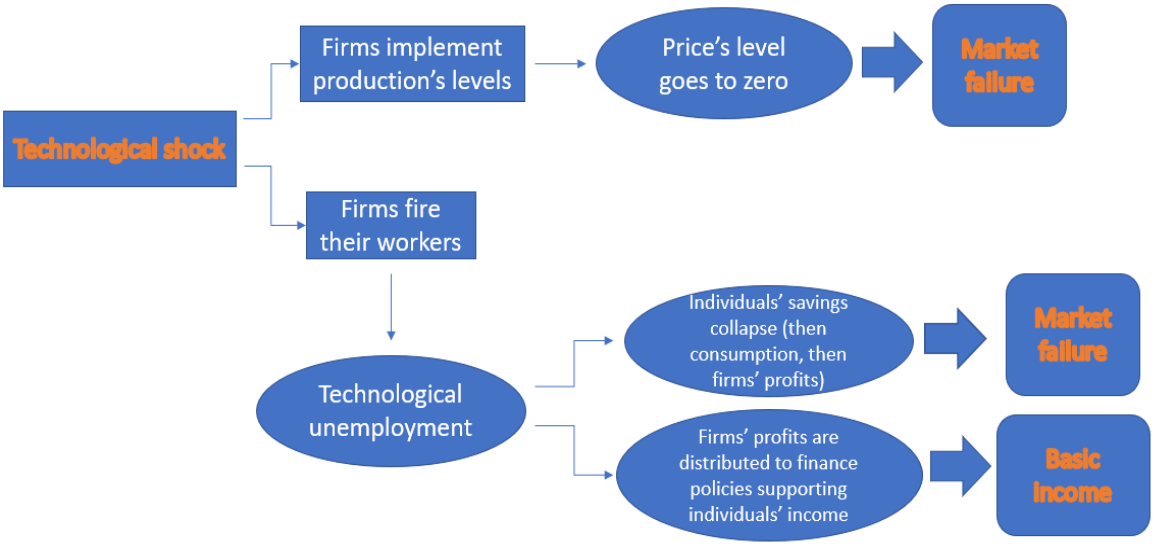
Before focusing on them, let me recall some items on the calibration of the model, being them equal for all the scenarios. Population is split according to their level of skills in three groups of equal size and the same holds for the four classes of firms; the population size is 5000, and the number of firms is 100. As this parametrization choice is arbitrary, one can explore different starting settings by modifying the parameters of the model, which is available at: https://github.com/eleonorapriori/basic_income__netlogomodel. According to the starting setting I defined above, one can easily observe that one agent out of five is unemployed in the model, as firms absorb 3958 workers over a population of 5000. Furthermore, the rules defined while modelling the process of matching between demand and supply on the labor market leads to a strong job-polarization scenario, where firms are more incline to employ low-skilled workers (the 92% are employed) and high-skilled workers (the 80% are employed) rather than middle-skilled ones (where only the 65% have a job). This scenario reflects the tendency of the job-market to employ either low labor or highly specialized workers, whereas middle-skilled job-places are progressively disappearing as they are those with higher probability of being substituted by machineries. Moreover, it is interesting to notice that firms with high productivity of labor are more likely to be ruled out from the market because they do not employ workers, meaning that they find it harder to find the match with the workers they require.

FIGURE 1 • THE GRAPHIC INTERFACE OF THE MODEL AFTER THE INITIAL SETUP OF THE MODEL.



Once that I discussed the starting setting of the model, let me now introduce the scenarios that I focus on. In any case, the model considers that after a given number of cycles a technological shock affects the market, and this implies a structural change in the traditional trends that emerge from the events occurring at any cycle on both the goods- and the labor market. Now, two different scenarios may emerge depending on how firms react to this shock. They can react either by implementing their production levels; or by firing most of their workers. Under this second hypothesis, there are two further possible scenarios: no policy measure to face the situation is implemented; otherwise, a basic income measure is introduced. Figure 2 sums up the flow chart of the outcome scenarios which arise under the different hypotheses of the model.

FIGURE 2 • FLOW CHART OF THE POSSIBLE OUTCOME SCENARIOS OF THE MODEL

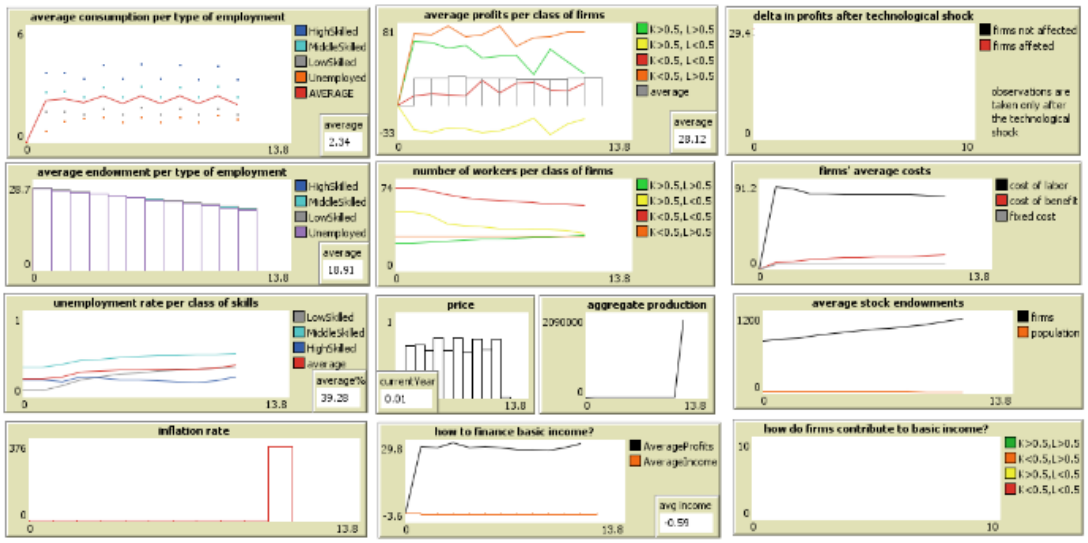


The model aims at investigating the effects of a technological shock that affects the market by augmenting firms' productivity of capital under different conditions. As far as concerns with the calibration of the model, I set the pervasiveness of the technological shock at the 75%, meaning that it affects three out of four firms with high productivity of capital, and the half of those with low productivity of K. This implies that the shock observed is sufficiently deep to modify the structure of our economic system: vice versa, an isolated shock hitting only a small portion of the market would affect only choices – and, therefore, the results – of a limited number of firms with no significant impact on the global outcomes of the model. Moreover, the model is robust to different values of the size of the shock, meaning that different values of the parameter affect the intensity of the observed results, but the general outcome is always the same. For the results described hereafter, I assume that the size of the shock, *i.e.* the increment in firms' productivity of K, is of 0.2.

4.2 Can a technological innovation lead to market failure? Two unexpected scenarios

Figure 3 shows the general outcome when firms implement the production to react to the shock.

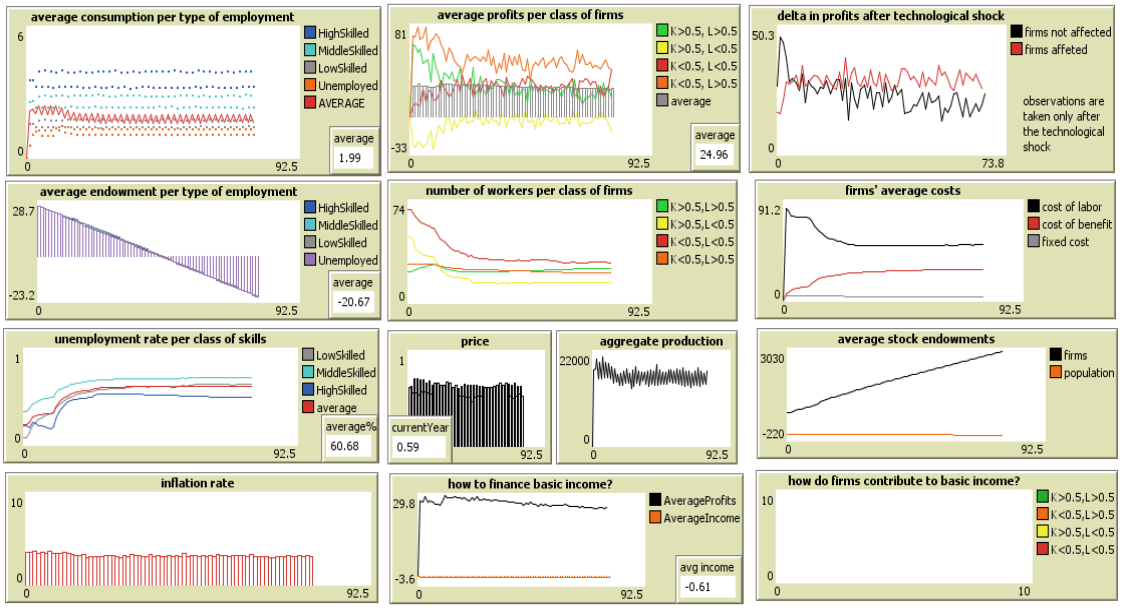
FIGURE 3 • GENERAL OUTCOMES WHEN FIRMS REACT IMPLEMENTING THE PRODUCTION'S LEVELS



Under this scenario, firms implement the quantity of the goods that they produce (and hence supply) as they experience an increase in the productivity of capital and keep the number of workers that they employ stable. This hypothesis drives to an unexpected outcome as the huge rise experienced by the production level yields a supply excess, which pushes the price level to zero. In fact, if the consumption levels (*i.e.* the demand for goods) keeps constant and the supply of goods that firms produce suddenly increases, the price level collapses as its formation mechanism is given by the ratio between the total quantity of goods produced in the system and the total quantity of goods demanded. To put it with the math, when the denominator of this fraction tends to infinite, the result goes to zero, and this clearly emerges by observing the details of aggregate production and of price in Figure 3. This result recalls the famous contribution of Robbins (1932), who defined economics as the science studying the relationship between ends and scarce means which have alternative uses. This specification of my model drives to the disappearance of the notion of scarcity itself in economics, and hence it determines a market failure as prices become meaningless since they do not measure anymore some relationship between production and value coming from the interaction between the agents. When prices become irrelevant, also profits and incomes are meaningless because individuals can catch the goods on the market for free. All of this shows that such a specification of the model drives to highly instable outcomes, which turn out to be unsustainable in the long run: for this reason, the model cannot be run for all the 100 cycles.

After observing that this scenario turned into an unsustainable market failure, let me introduce the next one, whose general outcomes are summed up in Figure 4.

FIGURE 4 • GENERAL OUTCOME WHEN FIRMS REACT TO THE SHOCK FIRING THEIR WORKERS AND NO POLICY IS IMPLEMENTED



In the case that firms opt for firing a vast majority of their workers to react to the shock, a technological unemployment scenario emerges: the 60% of the population in the model are not employed under these conditions. This represents a long-run change in the structure of the environment that I simulate: since the model is a closed system where no external resources are introduced, when a permanent high unemployment rate arises, this rapidly turns into a drop in the average consumption as the agents do not perceive an income to be reinvested on the goods market, and this in turns drives to an economic crisis scenario due to the collapse in firms' profits. When workers switch from employed to unemployed, they change their budget constraints to face the loss of their wages. Since their consumption functions allow for expenditures higher than the in-flows that they gain from working or from perceiving an unemployment benefit, they continue purchasing goods on the market, even if lowering their consumption. Looking at firms' aggregate production, it is possible to observe a drop, which is due to the reduction in the consumption level. All this implies a twofold effect: the first one is the collapse in firms' profits; the second one is that since individuals purchase more than their budget constraint, they reduce their personal endowment cycle by cycle until it gets negative. Hence, also

under these conditions the emerging outcome is an unsustainable scenario: all the individuals end under the poverty line after just eighty cycles and their savings assumes negative values, meaning that they should get into debt to buy their consumption goods. Then, also this hypothesis drives to a market failure as it yields a scenario where the agents can no longer keep the cycles of production and consumption self-sustaining due to the structural change on the labor market that the technological shock provoked.

4.3 Introducing basic income

Hence, when a technological unemployment scenario emerges, this drives to the unsustainability of the simulated model as it triggers an economic crisis which propagates through the consumption-production cycle. To prevent this from happening, I simulate what would be the effects of introducing a public policy managing with the paradigm shift: the model proposes a universal basic income supporting all the individuals in facing this transition. The role of this measure is to provide all the population with an income to support their consumption, hence stimulating the demand on the goods market and allowing firms to keep their production's level.

FIGURE 5 • GENERAL OUTCOME WHEN A UNIVERSAL BASIC INCOME IS INTRODUCED TO FACE TECHNOLOGICAL UNEMPLOYMENT

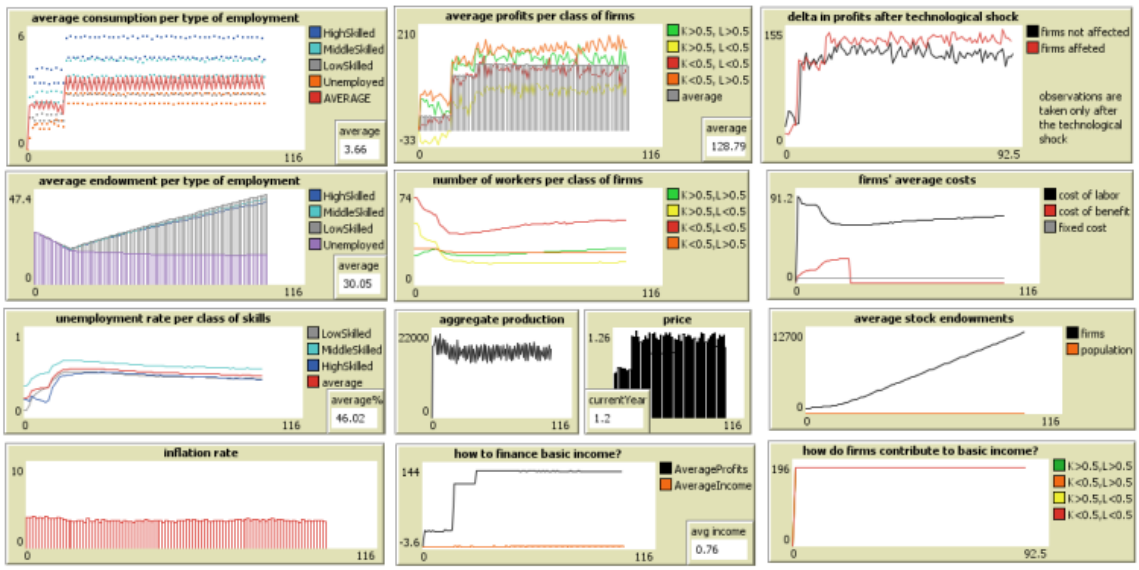


Figure 5 reports the general outcome observed when a universal basic income policy is introduced. The simulation aims at studying different aspects of the measure: i) to show its feasibility displaying that it led to a stable macro-economic pattern; ii) to verify its impact on individuals' savings, and then their consumption trend; iii) to analyze the effects on the labor market; iv) to observe whether it affects firms' profits and production levels; v) to discuss how these interact with prices, showing whether there is some effects on the inflation rate.

The first aim is satisfied, as the model achieves a stable long-run macroeconomic pattern where the dynamics of interaction between the agents self-sustain the model itself, meaning that the economy is sustainable and the economic flows driving the economic cycles are in balance.

The introduction of the basic income policy brings stability to the model, but also to the agents themselves: individuals' endowment levels decrease cycle by cycle until cycle 15, which is the moment individuals start to perceive their basic income. Hereafter, they increase their savings if they work (and therefore perceive a further wage plus the basic income) or keep them constant around the same level of endowment if they do not, and only the 8.2% of the individuals lie under the poverty line: a great result if compared with the previous scenario, where the whole population ended under the poverty line (and even in shorter times). Clearly this implies positive consequences for the consumption levels, boosting a virtuous circle since higher consumption levels sustain higher firms' profits.

As far as the dynamics of the labor market are concerned, there is a sensitive drop in the unemployment rate, which reaches the 47% with respect to the 60% of the previous scenario. This happens because the market is more efficient and then the number of firms disappearing is lower. Moreover, it is suggested in the literature that individuals perceiving income supporting measures tend to invest this amount to train and enter the productive process again obtaining higher-qualified job positions: the model does not account for this hypothesis, but it should be considered in a further development. However, observing the distribution of job-places in the simulation, it again displays a high level of job-polarization, but high-skilled workers turn out to be those with higher probabilities to be employed. This can easily be explained by considering the increment in firms' levels of innovation (*i.e.* productivity of capital), which pushes the demand for highly-qualified workers up, whereas middle-skilled workers are again those suffering more from the job places disruption. Low-skilled workers instead are still required on the labor market, since there are no incentives to

invest in machines substituting their tasks as they work at low cost. Workers are distributed over the four types of firms according to patterns noticeable: firms with high productivity of capital do not decrease the number of their employees, rather they experience a slight constant increase. Firms with low productivity of capital experience a significant drop in the number of workers they employ, but those with also low productivity of labor are still the firms with the highest number of employees, whereas those with high productivity of labor end the simulation with the smallest number of workers.

The overall effect of the basic income on firms' profits is positive as supporting consumption levels it supports firms' supply, and then their profits. Let me look at the increment in firms' profits observing how they are distributed for each typology of firms. Firms with low productivity of capital and high productivity of labor are those with the highest profits as their cost function is the slimmest one, even if it is also interesting to notice how the distance with the firms with high productivity of both K and L is thinner after the shock, displaying that the latter have gained some comparative advantages from the technological shock. Moreover, it is shown the delta between the firms affected by the technological shock and those which did not receive it: this clearly displays the comparative advantages that the shock produces as it allows to reduce the costs of production. However, it seems clear that the productivity of capital and labor are the determinants of the profits' level as they enter the cost function equation.

The technological shock yields a slight reduction in the aggregate production level, which is due to several firms quitting the market as they remain with no workers: this together with the boost in the consumption levels coming from the income-supporting measure determines a huge increase in price's level. However, looking at the consumption levels expressed in terms of units of goods purchased it is possible to observe that its value keeps constant over time, meaning that some inflation occurred, and it is reasonable to reconduct it to the measure, but that this should not worry as the real consumption level keeps constant and satisfies all the agents yielding to a stable pattern of the model.

To conclude, my model provides different proposals on the ways to distribute taxation among firms to finance the public policy. Being the model a closed system, the only way to achieve the financial affordability to implement the measure is to raise money by taxing firms' profits. To do so, I identify four possible criteria: a) by dividing

the total amount equally among all the firms; b) by dividing the total amount according to the levels of profits (*i.e.* asking the firms with more profits to contribute more); c) by applying a "robot tax" (*i.e.* taxing the firms with the highest levels of productivity of capital); d) by incentivizing firms to invest in innovation and technology (*i.e.* taxing firms displaying lower levels of productivity of capital).

It is interesting to notice that when the tax levy is equally distributed among all the firms, there are no firms quitting the market after the introduction of the basic income measure. As far as the profits-based taxation case, there is a high variability depending on the fact that firms' profits levels hugely vary from one cycle to the other one. While applying the robot tax and the incentive to innovation, the tax levy keeps a value constant over time since I simulate only one technological shock, and after its occurrence, the productivity of capital – being the parameter upon which these measures are built – keeps a constant over time.

As I yet mentioned before, firms experience a huge increase in their profits' levels due to the introduction of the basic income. Clearly, average values of profits do not change in the different financing hypotheses, what changes is the distribution across different typology of firms, even if also the latter seems to be restrained. In each of the four cases, firms with high productivity of labor and low productivity of capital are those performing highest profits, and those with high productivity of capital and low productivity of labor are those more in trouble; and this depends on how the productivity of K and L impacts on the firms' cost function determining their profits.

Hence, switching from one policy to the other does not affect considerably firms' results, but the measure has an important redistributive effect, shifting financial flows from firms to population. Moreover, it seems to bring large benefits both for population and firms, since it provides stability and robustness to the whole economic system by sustaining the demand for goods. Broadly speaking, the impact of universal basic income on the economy of the model seems to be pretty positive: simulated trends show an increment in individuals' economic stability through the increment in savings - and made sure that consumption levels are not decreased – and a consistent increment in firms' profits. Furthermore, the stability of the economic pushed down the unemployment.

5. Conclusions

Moving from the Covid-19 pandemic crisis, I analyze some recurring patterns in the recessions over the latest twenty years. I focus on the impact of technological innovation on the labor market, discussing whether the technological unemployment observed in these trends could be considered as a structural change. After presenting the outlines of the historical debate on the so-called "machinery question", I suggest that the current technological revolution may represent a *new normal*, which hence requires an update of the welfare system to cope with the economic transition. Arguing in favor of a universal basic income proposal to do so, my contribution presents a theoretical agent-based model to discuss both its feasibility and the benefits it would yield. The model simulates a simple economy where individuals and firms interact both on the goods- and on the labor market, developing adapting behaviors and with some endogenous mechanisms defining the features of their ecology: among this there is the price formation mechanism, turning out to be crucial in determining the system' dynamics. The model is thought to study the effects of a technological shock on the system, exploring alternative outcome scenarios which may arise from agents' choices and testing the impact of introducing basic income as a public policy, also comparing different criteria to finance the measure. Results show that with no public intervention technological shocks may lead the model to a market failure in the case of both firms implementing a coping strategy of hyper-production and under a technological unemployment hypothesis of firms' reaction. On the contrary, a redistribution scheme obtained taxing firms' profits and providing individuals with a basic income would prevent this outcome, guaranteeing a larger stability of the model during the technological transition and supporting the long-run sustainability of the system.

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La decima edizione del Premio Giorgio Rota Best Paper Award for Young Researchers*, sul tema* Labour, Value, Robots*, vede come vincitori Filippo Passerini, Ana Sofia Pessoa ed Eleonora Priori. I paper sono stati presentati il 18 maggio 2022 alla Conferenza Giorgio Rota che si è tenuta al Campus Luigi Einaudi. Gli autori sono introdotti nel volume da un contributo di Elisabetta Ottoz, direttrice del Dipartimento di Economia e Statistica "Cognetti de Martiis".*
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The tenth edition of the Giorgio Rota Best Paper Award for Young Researchers*, on* Labor, Value, Robots*, has Filippo Passerini, Ana Sofia Pessoa and Eleonora Priori as winners. The papers were presented on May 18, 2022 at the Giorgio Rota Conference held at the Campus Luigi Einaudi. The authors are introduced in the volume by a contribution from Elisabetta Ottoz, director of the Department of Economics and Statistics "Cognetti de Martiis". The Prize, established by the Centro Einaudi in memory of the economist Giorgio Rota, is supported by Fondazione CRT.*

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