

ECONOMIC POLICY AND ITS IMPACT

What Works? Regional Effects of Universities

*Nicolas Bunde, Nina Czernich,
Oliver Falck and
Gabriel Felbermayr*

INSTITUTIONS ACROSS THE WORLD

Institutions – Moving to the Global?

Harold James

BIG-DATA-BASED ECONOMIC INSIGHTS

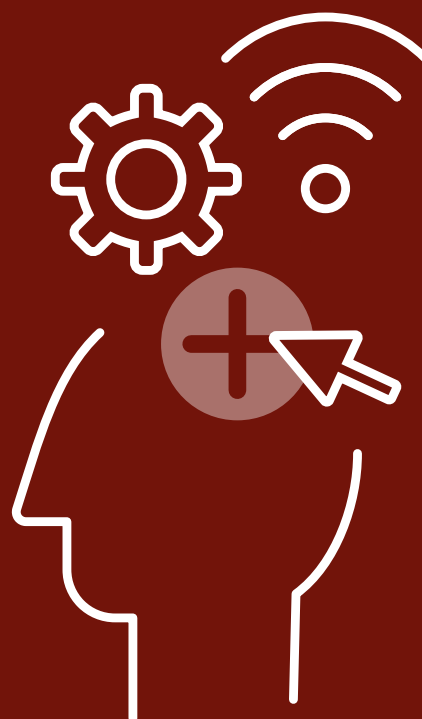
How Do Taxation and Regulation Affect the Real Estate Market?

*Mathias Dolls, David Gstrein,
Carla Krolage and
Florian Neumeier*

POLICY DEBATE OF THE HOUR

European Labor Markets: How Can We Effectively Manage Technological and Structural Change?

*Oliver Falck, Maria Savona, Tommaso Ciarli, Ed Steinmueller,
Simone Vannuccini, Yuchen Guo, Christina Langer, Fabio
Mercorio, Francesco Trentini, Valentin Lindlacher, Simon
Wiederhold, Yvonne Giesing, Britta Rude, Florencia Jaccoud,
Fabien Petit, Ron Boschma, Andreas Baur, Lisandra Flach,
Isabella Gourevich, Filippo Bontadini, Valentina Meliciani,
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The world has *always* been changing, but seldom at such a rapid pace and on so many fronts at the same time as now. The aftermath of the covid pandemic, the need to decarbonize our economies, the Ukraine war and the shifting geopolitical situation, a sudden energy crisis, a spike in fuel prices and inflation, a looming recession, ballooning public debt, technological disruption of labor markets, retrenchment of globalization, ageing societies and workforces, the rise of populism and nationalism and much more present a bewildering array of challenges to European policymakers.

In fact, in the last couple of years the world has *already* changed considerably—and *it is not changing back*.

This calls for creative policymaking and for some institutional redesign which, in turn, calls for sound, evidence-based economic policy analysis and advice on a wide range of fronts.

That was the reasoning behind the decision to bundle our European policy analysis activities under the EconPol brand, CESifo's economic policy platform, which is supported by the ifo Institute. EconPol leverages CESifo's globe-spanning network of 1,800 economists and the ifo Institute's decades-long research and policy advice expertise.

One of the key vehicles to bring our economic analysis and policy advice to a broad range of policymakers, academia and the public at large is this journal, *EconPol Forum* (formerly *CESifo Forum*). It brings together researchers and policymakers from a wide range of countries and institutions to exchange findings and views and thus enrich economic policy debate.

We have structured the EconPol Forum into four sections. The first, "Policy Debate of the Hour", recognizes the constantly evolving nature of policy challenges, focusing on the most pressing issues of the times. Leading experts and researchers working on the cutting edge of the relevant fields share their findings, insights and policy conclusions.

The “Economic Policy and its Impact” section assesses economic policies. Some of its contributors review policies implemented in different countries to guide the optimal design and implementation of similar ones elsewhere, while other authors examine the expected impact of policy proposals through simulations based on relevant economic models.

In the “Institutions Across the World” section, contributors focus on the key role that institutional design plays in shaping socio-economic outcomes, often by comparing institutions across different economic and political systems.

Finally, “Big-Data-Based Economic Insights” presents articles that glean policy advice from the exploitation of large, complex datasets using the latest tools and methods. When it comes to evidence-based policy advice, big data is fast becoming the tool of choice.



And EconPol Forum, we trust, will fast become the journal of choice for making policy sense of our bewildering times.

We hope you enjoy our new

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POLICY DEBATE OF THE HOUR

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Introduction to the Issue on

European Labor Markets: How Can We Effectively Manage Technological and Structural Change?

Oliver Falck

A science worth following must lead. We saw during the covid pandemic what dire consequences the relegation of science to the sidelines can have. With the labor market it is no different. If there is a disconnect between science and policymaking, the ultimate cost will be borne by the economy in general and, much more critically, by many, many individuals.

This is what Pillars is about. Brought to life as part of the European Commission's Horizon 2020 projects, it aims to secure the existence of inclusive labor markets by helping policymakers anticipate disruptive changes, providing them with research-based findings on a timely basis. Pillars' modus operandi is two-pronged. On the one hand, pushing the labor-market science's boundaries. On the other, functioning as a bridge to policymaking.

The science part is tackled by a cadre of mostly young talents hailing from a dozen countries and based in a dozen more, who are not only outstanding in their respective academic disciplines, but happen to speak fluent digital, in any of its many dialects: artificial intelligence, foundational models, machine learning, big data, robotics, automation and much more. When these youngsters have their heads in the cloud, they are not exactly daydreaming.

The bridging part is done through such activities as the pivotal conference held in Brussels this July, which first subjected the research carried out so far by Pillars to a stringent critical analysis, and then discussed findings and strategies with European Commission officials from the labor market policymaking arena.

The other bridging element is this special edition of the EconPol Forum, which devotes its Policy Debate of the Hour section to making Pillars' research findings accessible to policymakers and interested parties in general.

One big area of focus is skills. In the digital era, human skill sets are being challenged by similarly or better-skilled cyber versions. But not all threaten human-performed jobs. As Maria Savona points out, while robots are designed more to substitute workers than to complement them, data-intensive technologies are more complementary to humans. Christina Langer and colleagues explore the skills gaps in European labor markets. They find that while manual workers show skill supply shortages, cognitive work-

ers have skill supply surpluses, and that this has consequences in terms of automation risks.

In this respect, it pays to shore up the working population's digital skills. But, as Oliver Falck and colleagues plead, do not be leave the elderly behind in this endeavor. Fortunately, as they point out, digital skills can be acquired at all ages.

Yvonne Giesing and Britta Rude look at the issue from a somewhat different angle, focusing on the inequality-raising effects of technology between native and immigrant populations: industrial robots and artificial intelligence have beneficial labor market effects on natives, but not migrants.

Tomasso Ciarli and his group of researchers find that high-tech industries adjust employment to ICT penetration faster than do low-tech industries but that, surprisingly, technological penetration of robots is related to higher employment within the industry in low-tech regions—at least in the short run.

Ron Boschma finds that, regionally speaking, smart growth does not always equate inclusive growth. He provides useful pointers for how to bring them closer to each other.

Casting a more global view, Lisandra Flach and her group of colleagues evaluate the effects of robot adoption in OECD countries on exports from Latin America to the OECD along the value chain, to highlight the importance of assessing all supply chain linkages when devising policy.

Maria Savona, this time with a different group, takes a global view of the effects of the recent wave of nearshoring as opposed to those of *farsharing*, a novel but very solid concept that will surely make it into the terminology pantheon. Check it out.

To wrap up this well-rounded Policy Debate section, Zhong Zhao and a colleague give us the Chinese perspective on jobs and migration: a sort of brain drain from Europe to China could start to happen, since in this day and age Europeans can work for Chinese companies without moving from their European homes.

We hope you enjoy this Policy Debate of the Hour section as much as we did preparing it.

Maria Savona, Tommaso Ciarli, Ed Steinmueller and Simone Vannuccini

The Design of Digital Automation Technologies: Implications for the Future of Work*

KEY MESSAGES

- **Automation technologies, including within the same family, are fundamentally heterogeneous in their design and the tasks they can execute**
- **While the number of sectors that are exposed to most digital automation technologies is still relatively limited, it is expanding**
- **Data-intensive technologies are more pervasive in services than in manufacturing sector**
- **This calls for policy to extend its focus from robots to other, more pervasive, forms of automation**
- **Robots are designed more to substitute workers than to complement them, while data-intensive technologies are consistently more complementary to humans**

Contemporary discussions about automation and employment echo a long history of labor-saving technologies. This history has unfolded in waves of disruption to existing labor practices and has been accompanied by anxieties (Mokyr et al. 2015). These used to decline as new occupations were created and economic growth continued to raise the demand for labor, albeit in very different jobs than those that were lost or disrupted. The history of automation anxiety has been constellated by a succession of claims that “this time it will be different.” Digital, following mechanical and electrical automations, is no exception.

However, such a claim requires empirical assessment. First, an assessment of emerging capabilities for technologies such as robotics and AI to automate tasks is needed. The hype of attention that these two technologies, of all others, are attracting seems to be due to the proclivity of humans



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to anthropomorphize such devices – so a robot arm or a decision-making AI algorithm receives greater attention than an automated measuring system for filling containers, though in all these cases there are implications for human labor.

A second consideration is the nature of jobs. Job classifications often reduce the complexity of the tasks that workers do within their activities. In many cases, deploying labor-saving devices results in the reconfiguration of tasks rather than elimination of jobs, so that the net impact on jobs is complex and difficult to ascertain a priori – it often requires ex post assessment and greater precision in identifying emerging capabilities.

The novelty of this study with respect to extant reviews of the literature on the labor impacts of automation is in the purposefully sought classification of different automation technologies, digging in-depth into their technical design and specific capabilities to carry out tasks, and the assessment of these capabilities to substitute or complement workers.

In sum, this study performs a systematic review of the literature from engineering and technology that broadly addresses the following research questions:

- a) Are digital automation technologies designed to substitute, complement, and/or reconfigure specific tasks executed by humans within sectors?
- b) What are these specific tasks across sectors? Are they specific to some sectors? To what extent can they be routinized?

We first glance over the history of technical progress that led to automating labor processes. We offer a (re)designed classification of digital automation technology families. We then systematically review the technical literature focusing on Robotization, Artificial Intelligence, Data Acquisition, and Data Management, and look at how these technologies are designed for different sectors and tasks, to substitute or complement humans while routinizing tasks.

AUTOMATION TECHNOLOGIES AND EMPLOYMENT: A BRIEF HISTORY

The history of labor-saving innovation is constellated by a continuing development of the past waves of automation. Mechanization continues to develop and is influenced by electrification, while digitalization influences both previous waves. The interactive and

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cumulative effects are important. For example, early mechanization was driven by steam power, which dictated that plants would be vertically organized due to the constraints in distributing motive power horizontally. With electrification, the organization of factories, and the nature of jobs, were transformed first by the extension and development of horizontal “assembly lines” and, more recently, by different “work station” and “machine cluster” groupings.

The 20th century is a history of industrial mass production displacing craft production, in which the individual worker executed a variety of operations, from fabricating to finishing a product. More recently, mass production has been extended to operations in service industries such as processing payments in banks, or the surgical operating theatre. In many services, there are residual craft elements that continue to rely on the skill of the “operator,” though in some cases, the logic of mass production has been reversed so that the customer becomes the operator and the service is “co-produced” (Savona and Steinmueller 2013).

Technological history shows that processes of automation involving mechanization and electrification have been underway for an extended time. In many cases, labor-saving innovations have greatly improved individual worker productivity, and most of the job losses in global North manufacturing have already occurred as a result. Digitalization, combined with international logistics and transport, has continued this process. Digital automation has greatly improved the ability to codify designs, communicate about production issues, trace and monitor transport of parts and partially finished goods, and efficiently manage inventories in relation to the flow of production and consumption.

The technological potentials of newer generations of cyber-physical systems have the potential to further transform the mass production paradigm.

A great deal of uncertainty arises regarding the role of emerging digital automation in replacing service-sector jobs. For example, the historical occupation of data entry operator has experienced

dramatic reductions as automation of data acquisition displaces centralized facilities for data entry and filing and replaces them with a “data cloud.” This, in turn, offers opportunities for the application of machine-learning AI to create predictive models and manage data-intensive service provision. In many of these cases, the challenge is to improve the human-computer interface so that opportunities, choices, and services can be customized to the users’ needs. The flexibility and scalability of robotic equipment has major implications for employment in “customer-facing” jobs, with a customer now facing a cyber-physical system rather than a human being. Assessing the potential for the emerging new wave of automation, and whether “this time it will be different,” begins with a careful assessment of the emergence of capabilities in the cyber-physical systems that are the current subjects of research, development, and initial deployment.

EMERGING DIGITAL AUTOMATION TECHNOLOGIES AND EMPLOYMENT: A GRANULAR VIEW

We have identified eight families of digital automation technologies (Ciarli et al. 2022):

- Robots – technologies that sense and (autonomously) act based on data
- Physical data acquisition technologies – technologies that harvest and record information
- Software-based data management – technologies for storing, protecting, managing/handling and acquiring data
- Computing – technologies used to compute/calculate
- AI (not directly as a cloud service) and Intelligent Information Systems – technologies using algorithms and advanced methods to make sense out of the data
- Additive manufacturing (using any material – such as powder metallurgy as well as bioplastic filament) – technologies that produce bottom-up based on digital models

- Networking – technologies for communicating between machines (data transmission) or connecting machines
- User interface – technologies for human interaction with machines or data.

What is relevant in this context is not only the heterogeneity of the emerging digital automation technologies, but also that of the affected aspects of employment. This study reviews the literature from engineering and technology based on a systematic screening and coding (illustrated in Ciarli et al. 2022) and extracts the following information about the technology-employment nexus.¹

Tasks design

- **Routinization:** technologies execute functions at the level of single operations or activities, with different degrees of autonomy. Automation depends on how much tasks or sub-tasks can be routinized (and the relevant knowledge for them to be executed codified), how single operations can be separated or consolidated, and the ability to perform a task without any or different degrees of human intervention (e.g., supervision).
- **Knowledge codification:** technologies can be executed through explicit codified instructions or based on tacit knowledge. Tacit know-how is a cornerstone of the economics of knowledge (Cowan et al. 2000; Foray and Steinmueller 2003) and so far has been exclusively considered a domain of human action.

Employment compensation

Complement or substitute: technologies can complement or replace human labor, having a productivity or substitution effect (Acemoglu and Restrepo 2019). We not only consider automation as complementary or as a substitute for workers, but also how the specific technical design replaces and/or complements segments of tasks (or sub-tasks) across different sectors.

For each of the technology families identified above, we built a query that captures the technology, the tasks carried out, and the applications. We selected the most-cited papers and screened them for relevance, that is whether the paper discusses design, prototypes and early implementation of technologies within the given family, and applications that execute specific tasks and services. Finally, we coded all relevant papers along the technology-employment dimensions described above. Specifically, we used NACE Rev 2 to allocate papers to a sector, and Broad Work Activities from O*NET to categorize tasks. We coded 154 papers for robots, 122 for software-based data

management, 259 for AI, and 192 for physical data acquisition technologies.

DIGITAL AUTOMATION: TASKS, COMPLEMENTARITY AND SECTORAL EXPOSURE

Tasks within Work Activities and Complementarity with Humans

Table 1 shows the shares of papers describing, for each technology family, the tasks they were designed to execute across and within each O*NET broad work activity reported in column 1 (columns 2–5), and the share of papers that describe how they complement rather than substitute human workers (columns 6–9). Work activities are ranked in descending order by Robots, Software-based data management (DM), AI and Physical data acquisition technologies (DA).

The four technologies differ substantially in the tasks they are designed to execute, particularly between robots and the three data technologies. Around 50 percent of the papers mention that robots carry out tasks related to “Handling and moving objects” or “Identifying objects, actions, and events.” Technologies pertaining to the data value chain of DA, DM, and AI are similar to each other with respect to the work activities they carry out, but there are important differences also among those.

For instance, a substantial number of papers in AI refer to “Identifying objects, actions, and events,” and “Estimating the quantifiable characteristics of products, events, or information” (hardly mentioned by papers in DA and DM), but only a few discuss technologies for “Getting information,” which instead are widespread among papers discussing DA and DM technologies. The highest share of sampled papers describes how these technologies carry out tasks of “Processing information” for DM, “Analyzing data” for AI and a less complex or analytic task such as “Monitoring processes and materials” for DA.

None of the digital automation technologies seem (up to 2021) to be executing tasks implying interactions with people from “Coaching and developing others” to the management of human resources (in the bottom part of the columns in red.)

A low share of robot technologies mentioned in at least 5 percent of the coded papers are designed to complement humans. Around 50 percent of the coded papers mention that robots that carry out tasks related to “Handling and moving objects” or “Identifying objects, actions, and events” will complement workers.

Most of the remaining papers discuss activities designed to replace workers, with a small share (approx. 15 percent) designed to both complement and substitute workers – for instance in the case of automation that requires human supervision. Only a small share (20–30 percent) of papers on robots unveils a design that complements human workers for tasks

¹ Ciarli et al. (2022) consider other features, such as exposure, level of adoption, maturity of the technology, time-saving or process innovation, and geographical location of the technology implementation.

Table 1
Share of Papers Describing Sector of Adoption, Process Improvement and Routinization of Working Activities
by Technology Family (Ranked by R)

Tasks	Shares of papers by work activity				Complementing workers			
	Robots	DM	AI	DA	Robots	DM	AI	DA
Handling and moving objects	23%	0%	0%	0%	46%	0%	0%	0%
Identifying objects, actions, and events	18%	2%	18%	9%	58%	100%	84%	73%
Performing general physical activities	9%	1%	0%	0%	30%	100%	0%	0%
Getting information	9%	16%	3%	11%	46%	92%	95%	86%
Assisting and caring for others	6%	0%	0%	0%	58%	0%	0%	0%
Inspecting equipment, structures, or material	6%	1%	1%	6%	20%	100%	100%	64%
Controlling machines and processes	5%	0%	0%	1%	19%	100%	0%	80%
Operating vehicles, mechanized devices, or equipment	4%	0%	0%	0%	21%	0%	0%	0%
Monitor processes, materials, or surroundings	4%	5%	7%	27%	31%	70%	90%	75%
Analyzing data or information	3%	20%	26%	14%	42%	87%	93%	89%
Processing information	2%	29%	15%	17%	25%	91%	85%	80%
Interpreting the meaning of information for others	2%	1%	1%	0%	29%	67%	50%	0%
Training and teaching others	1%	0%	0%	0%	0%	0%	33%	0%
Documenting/recording information	1%	5%	0%	3%	40%	92%	100%	82%
Making decisions and solving problems	1%	3%	3%	1%	40%	69%	68%	43%
Judging the qualities of things, services, or people	1%	2%	5%	0%	25%	100%	67%	50%
Organizing, planning, and prioritizing work	1%	1%	0%	0%	0%	50%	0%	0%
Communicating with supervisors, peers, or subordinates	1%	1%	0%	0%	100%	100%	0%	0%
Developing objectives and strategies	1%	0%	0%	0%	0%	0%	100%	0%
Scheduling work and activities	1%	7%	0%	0%	0%	66%	33%	100%
Interacting with computers	0%	1%	0%	0%	0%	80%	0%	0%
Performing administrative activities	0%	0%	0%	0%	0%	100%	100%	0%
Provide consultation and advice to others	0%	0%	0%	0%	0%	100%	0%	0%
Monitoring and controlling resources	0%	2%	1%	2%	100%	36%	100%	75%
Evaluating information to determine compliance with standards	0%	1%	3%	3%	0%	33%	100%	92%
Estimating the quantifiable characteristics of products, events, or information	0%	0%	14%	5%	100%	100%	95%	72%
Coaching and developing others	0%	0%	0%	0%	100%	0%	100%	0%
Performing for or working directly with the public	0%	0%	0%	0%	0%	0%	0%	0%
Establishing and maintaining interpersonal relationships	0%	0%	0%	0%	100%	0%	0%	0%
Selling or influencing others	0%	0%	0%	0%	0%	100%	100%	0%
Staffing organizational units	0%	0%	0%	0%	0%	0%	0%	0%
Updating and using relevant knowledge	0%	0%	0%	1%	0%	0%	100%	100%
Communicating with persons outside organization	0%	0%	0%	0%	0%	0%	0%	0%
Guiding, directing, and motivating subordinates	0%	0%	0%	0%	0%	0%	0%	0%
Repairing and maintaining mechanical equipment	0%	0%	0%	0%	0%	0%	0%	0%
Resolving conflicts and negotiating with others	0%	0%	0%	0%	0%	0%	0%	0%
Thinking creatively	0%	0%	0%	0%	0%	0%	0%	0%
NA	1%	0%	0%	0%	0%	0%	100%	0%
Total papers	445	441	717	762	178	373	629	597

Notes: The table reports the share of papers that were coded as describing industries related to each NACE sector (column 1), for each of the following families of technologies: Robots (2), Software-based data management (3), AI (not directly as a cloud service) & Intelligent Information Systems (4), and Physical data acquisition technologies (5). Columns 6–9 report the share of papers, for each technology family and sector, which suggest that the technology improves the efficiency in producing the good/service, as opposed to improving their quality. Columns 10–13 report the share of papers, for each technology family and sector, which suggest that the technology allows to routinize the task on which they focus. The final row reports the total number of papers that were coded in relation to each sector: one paper can refer to more than one sector; therefore, the number of work activities is larger than the number of papers.

Source: Authors' compilation.

such as “Controlling machines and processes” or “Performing general physical activities.” In the case of “Controlling machines and processes,” however, 50 percent of the papers mention both complementing and substituting, while in the case of “Performing general physical activities” the combination of complementing and substituting is mentioned in only approximately 15 percent of the papers.

Overall, this suggests that different cohorts of robots with different degrees of capabilities co-exist, with some only improving efficiency and facilitating workers’ operation, while others fully automate processes, for example by opening the way for flexible factory-floors with reconfigurable assembly systems.

Unlike robots, around 80–90 percent of the papers that discuss DM, AI, and DA suggest that these data-intensive technologies complement human workers in all main work activities that they carry out, such as “Analyzing data or information,” “Processing information,” and “Getting information.” There are some exceptions, such as DA technologies related to “Inspecting equipment, structures, or material”: only 60 percent of the papers suggest that DA may complement workers, with the remaining share of the papers suggesting substitution, as in the data filler operator example mentioned above.

In sum, the data value chain technologies (Acquisition, Management, and AI) share a high degree of complementarity with humans, which are the repository of the tacit knowledge needed to complement automated and routinized data acquisition and processing. Human knowledge and activities in these tasks acts as an enabler or, better, as an essential factor – without it, the task cannot be executed at a sufficient level of efficiency granted by automation technologies or is not valuable.

Sectoral Exposure, Process Innovation and Routinization

Table 2 shows the share of papers that discuss technologies related to specific sectors for each technology family (columns 2–5) and, within each sector, the share of papers that discuss technologies that improve efficiency, as opposed to those that improve the quality of the good/service (columns 6–9), or routinize activities (columns 10–13). Sectors are ranked in descending order with respect to the share of papers by robots, DM, AI, and DA.

Considering the sectors mentioned in at least 5 percent of the publications, the academic literature focuses on a few, recurrent sectors across technologies. While different technology families apply to several work activities, they are all relevant only for a small subset of sectors. The most common across technologies is “Professional, scientific, and technical activities (M).” This feeds R&D activities that allow prototypes, technical design, and subsequent deployment. Beyond “Professional, scientific, and technical

activities (M),” there are important differences across technology families. While robots focus on “Manufacturing (C),” tasks related to “Analyzing data or information,” carried out by DM, AI, and DA, are discussed in relation to “Information and communication (J),” “Human health and social work activities (Q),” and to a smaller extent, “Manufacturing (C)” and “Agriculture, forestry, and fishing (A).” The sector focus is similar also for tasks related to “Processing information,” carried out by DM, AI, and DA. Highly intensive and creative services do not seem to be the focus of papers concentrating on DA, DM, and AI.

There are large differences in the technologies: we find a larger focus on improving efficiency in AI and DA papers, while Robots and DM place a stronger focus on improving the product or service. Interestingly, a considerable share of papers describes AI and DA as improving processes and routinizing tasks in most personal services (Accommodation and food (I) Administrative support (N), Real estate (N), and Finance (K)), which are the most pervasively exposed to data-intensive technologies. Despite the differences in relation to complementing labor, it is interesting to note that robots and DM technologies have a lower tendency to mention the routinization of activities than AI and DA. This suggests that, although they do not substitute workers, these technologies are able to make these tasks highly replicable.

POLICY CONCLUSIONS

This study reviewed a large sample of core academic papers from engineering and technology disciplines, which present and discuss four digital automation technologies that execute tasks across different industries. This provides an understanding of how the technical design of digital automation technologies that have been emerging since the early 2000s may affect different aspects of employment, according to the technology developers. We summarize the key messages below.

First, automation technologies, including within the same family, are fundamentally heterogeneous in their design and the tasks they can execute. These tasks tend to be specific to one sector, but often extend to several sectors (such as analyzing data or information).

Second, the number of sectors that attract the development of most digital automation technologies is still relatively limited but expanding. From this type of work, policymakers can form expectations about what occupations and industries are more likely to be affected by digital automation technologies in the future.

Third, data-intensive technologies, particularly DM, but also AI and DA, are more pervasive in services than in manufacturing sectors, which calls for policy to extend its focus from robots to other, more pervasive, forms of automation.

Table 1

Share of Papers Describing Tasks within Work Activities by Technology Family and Degree of Complementarity with Human Workers (Ranked by R)

Group	Labels	Shares of papers by sector				Process improvement				Routinisation of activities			
		Robots	DM	AI	DA	Robots	DM	AI	DA	Robots	DM	AI	DA
M	Professional, scientific and technical activities	24%	35%	20%	41%	40%	34%	95%	92%	33%	42%	89%	90%
C	Manufacturing	34%	15%	11%	14%	61%	42%	95%	87%	71%	33%	98%	80%
A	Agriculture, forestry and fishing	7%	3%	3%	12%	52%	57%	100%	96%	100%	29%	67%	76%
Q	Human health and social work activities	9%	3%	35%	10%	58%	60%	99%	70%	68%	80%	83%	85%
J	Information and communication	1%	22%	7%	8%	0%	48%	83%	91%	50%	76%	96%	87%
F	Construction	2%	5%	6%	4%	9%	27%	100%	74%	46%	50%	95%	87%
T	Activities of households as employers	1%	2%	1%	3%	100%	0%	100%	85%	67%	50%	100%	92%
I	Accommodation and food service activities	2%	0%	0%	2%	38%	0%	100%	86%	100%	0%	100%	86%
N	Administrative and support service activities	5%	3%	1%	2%	46%	0%	100%	85%	64%	77%	100%	85%
E	Water supply, sewerage, waste management and remediation activities	2%	1%	4%	2%	86%	100%	100%	100%	86%	0%	94%	100%
H	Transportation and storage	4%	2%	2%	1%	59%	60%	81%	100%	59%	70%	94%	82%
D	Electricity, gas, steam and air conditioning supply	1%	2%	3%	0%	75%	20%	100%	100%	0%	70%	100%	100%
S	Other service activities	4%	1%	0%	0%	47%	0%	100%	100%	65%	100%	100%	100%
B	Mining and quarrying	2%	1%	2%	0%	90%	100%	100%	100%	60%	0%	100%	100%
L	Real estate activities	0%	0%	0%	0%	0%	100%	100%	100%	0%	100%	100%	100%
K	Financial and insurance activities	0%	2%	2%	0%	0%	22%	100%	0%	0%	22%	87%	0%
P	Education	0%	0%	1%	0%	0%	0%	56%	0%	0%	0%	89%	0%
O	Public administration and defence; compulsory social security	0%	2%	1%	0%	0%	0%	100%	0%	0%	43%	100%	0%
R	Arts, entertainment and recreation	1%	0%	0%	0%	50%	0%	100%	0%	17%	0%	100%	0%
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%
U	Activities of extraterritorial organisations and bodies	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
NA		2%	0%	0%	0%	11%	100%	0%	0%	22%	50%	0%	0%
Total papers		445	441	717	762	230	171	682	671	267	227	640	654

Notes: the table reports the share of papers that were coded as describing tasks related to each of the O*NET broad work activities under column (1), for each of the following families of technologies: Robots (2), Software-based data management (3), AI (not directly as a cloud service) & Intelligent Information System (4) and Physical data acquisition technologies (5). The last four columns report the shares of papers for each technology family and work activity, which suggest that the technology complements workers. The final row reports the total number of papers that were coded in relation to each work activity: one paper can refer to more than one work activity, therefore the number of work activities is larger than the number of papers.

Source: Authors' compilation.

Fourth, the literature on robots shows, however, that they are designed more to substitute workers than to complement them, while so far data-intensive technologies are consistently more complementary to tasks performed by humans. As it turns out, this is driven by the type of service produced, which is an input to other activities, rather than by the inability of routinising tasks, which is also higher for data-intensive technologies.

Fifth, the future of work depends on how technologies will evolve, their idiosyncrasies, their stage of development and adoption, and the specific tasks they complement or replace within the most-exposed sectors (Ciarli et al. 2021). Labor market policies should rely on evidence on digital automation at a greater level of granularity to be properly informed about their heterogeneous effects on task reconfiguration within sectors.

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Yuchen Guo, Christina Langer, Fabio Mercorio and Francesco Trentini

Skills Mismatch, Automation, and Training: Evidence from 17 European Countries Using Survey Data and Online Job Ads^{*}

Labor markets face challenges due to globalization, structural transformation, and advancing technological change. This can lead to skills gaps and skills mismatch between firms' skill demand and employees' skill supply, which can go in two directions: workers having a skill surplus, where skill supply exceeds demand, or workers experiencing skill shortage, where firms' skill demand is greater than the skills workers actually possess. In light of this, the EU's Agenda for New Skills and Jobs (European Commission 2020) states that creating a more skilled workforce "is a considerable challenge given the rapidly-changing skills needed, and the persistent skills mismatches in the EU labor market." In this report, the Commission also "established the anticipation and matching of labor market and skills needs as a top priority for the EU."

However, empirical evidence on the prevalence of skills mismatch between the skills requested by employers and the skills provided by employees across Europe is scarce. We contribute to the understanding of skills mismatch in the EU by presenting novel evidence on skills gaps across countries, occupations, and skill domains using innovative job ad data and survey data for 16 EU countries and the UK.¹ In particular, we leverage two different data sources: online job vacancy data on skills requested by employers and survey data on skills supplied by workers. We document four key findings: first, skill gaps in the European Union exist, but the extent and direction vary across occupation types: workers in cognitive intensive occupations provide more skills than are demanded (skill surplus), whereas workers in manual intensive occupations face higher skill demand compared to the skills they have (skill shortage). Second, this pattern is consistent across almost all 17 countries that are part of our analysis. This suggests that overall patterns of skills mismatch do not reflect country-specific factors but are rather a European-wide phenomenon. Delving deeper into different skill domains (i.e., digital, numeracy, literacy, and social skills), we document similar skills gaps for different occupation types. Thus, the ob-

^{*} This article is based on a larger research project within the scope of PILLARS, which has greatly benefited from contributions by Mario Mezzanzanica, Filippo Pallucchini, and Simon Wiederhold.

¹ These countries are Belgium, Cyprus, Czech Republic, Denmark, France, Germany, Greece, Ireland, Italy, Lithuania, Netherlands, Poland, Slovakia, Slovenia, Spain, Sweden, and the UK.

KEY MESSAGES

- **Linking survey data and online job ads offers new insights into skills gaps in the EU**
- **Matching labor market needs and skill supply remains a Europe-wide challenge**
- **Manual workers have skill supply shortages, cognitive workers have skill supply surpluses**
- **Workers at higher risk of automation experience higher skill shortages, potentially because their job tasks are changing more rapidly**
- **On-the-job training might be a potential measure to meet future skills needs**

served skills gaps are not driven by a lack of specific skill domains such as digital skills. Finally, we investigate potential mechanisms – i.e., an occupation's automation probability and workers' propensity to participate in on-the-job training – that might underlie the observed patterns of skills mismatch.

LINKING SURVEY DATA AND ONLINE JOB ADS OFFERS NEW INSIGHTS INTO SKILLS GAPS IN THE EU

We propose a novel measure of the gap between the skills demanded by employers and the skills supplied by workers. On the demand side, we rely on online job vacancies (OJV) data from the European Center for the Development of Vocational Training (CEDEFOP), collected in 2019, to capture skills de-



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manded by employers.² On the supply side, we use survey data from the Programme for International Assessment of Adult Competencies (PIAAC). PIAAC comprises representative samples of working-age individuals from 17 European countries; data were collected in 2012 and 2014, respectively. Here, respondents working in different occupations were asked about their skill use at work in different skill domains. Among others, these skill domains cover digital, numeracy, literacy, and social skills.

Nonetheless, the two data sources are not directly linked at the skill level. To combine the data, we developed an AI-driven tool using word embeddings that maps skills mentioned in OJV to the skills elicited in PIAAC items. Our final mapping links, for instance, the skills "Coaching young people" and "Instruct others" stated in OJV to the PIAAC skill item "Teaching people."

COMPARING SKILL DEMAND AND SKILL SUPPLY

To quantify the gap between skills on the demand side from OJV data and the skills provided on the supply side in PIAAC, we have developed a measure of skills mismatch based on the importance of each skill for each occupation. Specifically, our measure of skills

² For most countries, PIAAC is only available for 2012. However, the earliest job vacancy data from CEDEFOP stem from 2019. To remedy the issue of temporal misalignment between PIAAC and OJV, we use the skill change in the US, for which the PIAAC survey was conducted in 2012 and 2017, to project skill changes for all other countries. Assuming that changes in the occupational skill content in the US represent changes at the technological frontier (e.g., Caunedo et al. 2021), these changes can be used to project an upper bound of how skills have evolved in other PIAAC countries.

gap is based on differences in the revealed comparative advantage (RCA) of each skill in each occupation between the OJVs and PIAAC. Intuitively, the RCA of a skill is a measure of its prevalence or frequency in each occupation relative to the frequency in all other occupations. For further details on this measure, see the Technical Box.

First, we calculate the RCA of each skill for each occupation in both OJV and PIAAC. Next, for each skill, we compute the rank of the RCA across all occupations on both the demand and supply side. For instance, if the RCA of "Teaching people" is ranked at the top five percent for teaching professionals on the supply side, this means that teachers have a high RCA in this skill among all occupations.

Thus, differences in the RCA ranks of skills between demand and supply reflect potential mismatches in skill relevance. We define the gap in skill ranks as the percentile rank on the demand side minus the percentile rank on the supply side. Thus, a positive value indicates that the RCA of the demand for a skill is larger than the RCA of the skill supplied in a particular occupation. We refer to this case as skill shortage. For instance, the importance of "Reading financial statements" is at the 61st percentile on the demand side for teaching professionals, while it is at the 43rd percentile on the supply side, resulting in a positive skill gap of 18 percentile ranks. Thus, teaching professionals have a skill supply shortage for the skill of "Reading financial statements." Conversely, a negative skill gap indicates a skill surplus. For the skill "Reading e-mails", teaching professionals have a skill surplus: the importance of this skill is at the 68th percentile on the demand side and at the 82nd percentile on the supply side, resulting in a negative skill gap of -14 percentile ranks.

MATCHING LABOR MARKET NEEDS AND SKILL SUPPLY REMAINS A CHALLENGE

The literature often distinguishes between four occupation types: manual routine, manual non-routine,

TECHNICAL BOX: RCA WITH ONLINE JOB ADVERTISEMENTS AND PIAAC

The concept of revealed comparative advantage (RCA) was developed in international trade economics to represent countries' export specialization (e.g., Balassa 1965). The measure, when applied in the context of occupations and skills, can be understood as the relevance of a skill for an occupation, relative to all other occupations. We follow the approach developed by Alabdulkareem et al. (2018), which calculates the RCA using the O*NET dictionary of occupations and skills; O*NET surveys a sample of workers in the US

to assess the relevance of a skill for each occupation. We calculate it using online job ads as proposed in Giabelli et al. (2022). The relevance is computed as the frequency of a skill in the job ads for a specific occupation, relative to the skill's frequency in job ads in all other occupations. Analogously, the RCA of a skill in PIAAC is computed as the frequency of skill use among survey respondents in a given occupation, relative to survey respondents in all other occupations.

cognitive non-routine, and cognitive routine occupations (Autor et al. 2003). These occupations differ in the tasks workers need to perform on the job. For instance, food preparation assistants perform predominantly manual, routine-intensive tasks, such as manual assembling and quality checks. On the other hand, teaching professionals perform predominantly cognitive and non-routine tasks, such as using advanced mathematics and teaching people. At the same time, structural transformation and technological change have different impacts on different types of tasks. Automation technologies have particularly rendered codifiable routine and manual tasks susceptible to substitution by automation. As the task composition and thus the skill requirements of different occupations are affected differently by technological change, this also renders occupations more or less susceptible to changing skills demands and skills mismatch, which we also refer to as skills gaps.

Figure 1 depicts the average skills gap between demand and supply by occupation across all countries in our sample. There is an intriguing difference between manual and cognitive workers in the average skill gap. While cognitive non-routine and cognitive routine workers have a skill supply surplus on average (negative skill gap), manual non-routine and manual routine workers exhibit skill supply shortage (positive skill gap). For instance, business administration professionals exhibit the highest skill surplus: they provide more skills than are required in respective job ads. For this occupation, the relevance of the skills demanded ranks below the skills provided by business administration professionals by 48 percentiles. Cleaners and helpers, on the other hand, show the most pronounced skill shortage: The skill requirements in this occupation exceed their skill supply by 55 percentiles. Health professionals, Electrical workers, ICT professionals, and ICT technicians feature the narrowest skill gaps. Below, we discuss potential mechanisms underlying these patterns across occupations, such as the risk of automation and on-the-job training of employees.

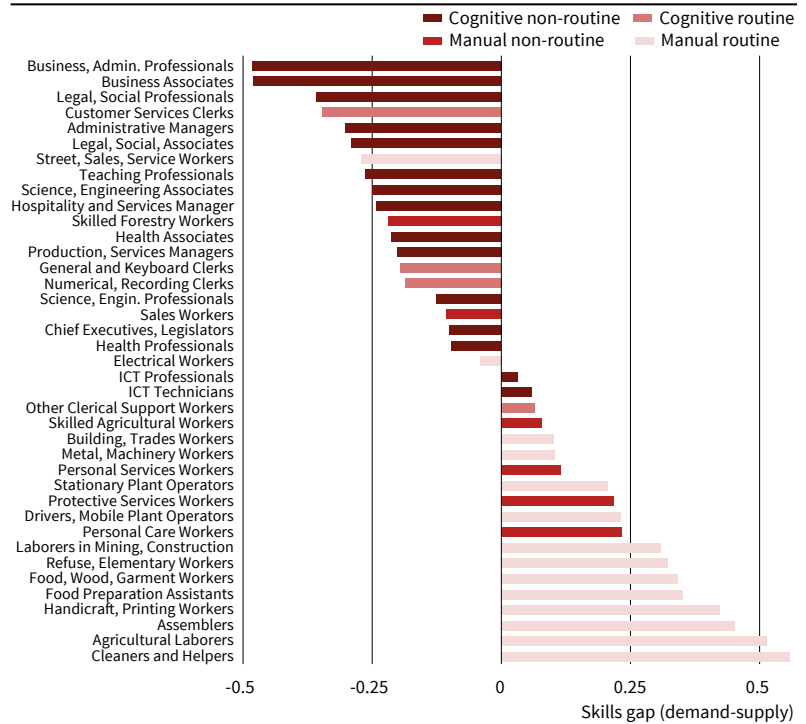
SKILLS GAPS ARE A EUROPE-WIDE CHALLENGE

This pattern of skills mismatch is strikingly consistent across Europe. Figure 2 plots the difference in skills gaps by occupation types for different European countries. Skills gaps by countries for cognitive non-routine, cognitive routine, manual non-routine, and manual routine occupational types are presented in panels 1, 2, 3, and 4, respectively. The dotted line represents the average skills gap over all countries within an occupation type.

We can clearly see that the skill shortage for workers in manual-intensive occupations and the skill surplus for those in cognitive-intensive occupations is persistent across EU countries. For almost all countries, cognitive workers show a skill supply surplus, while manual workers have a skill supply shortage on

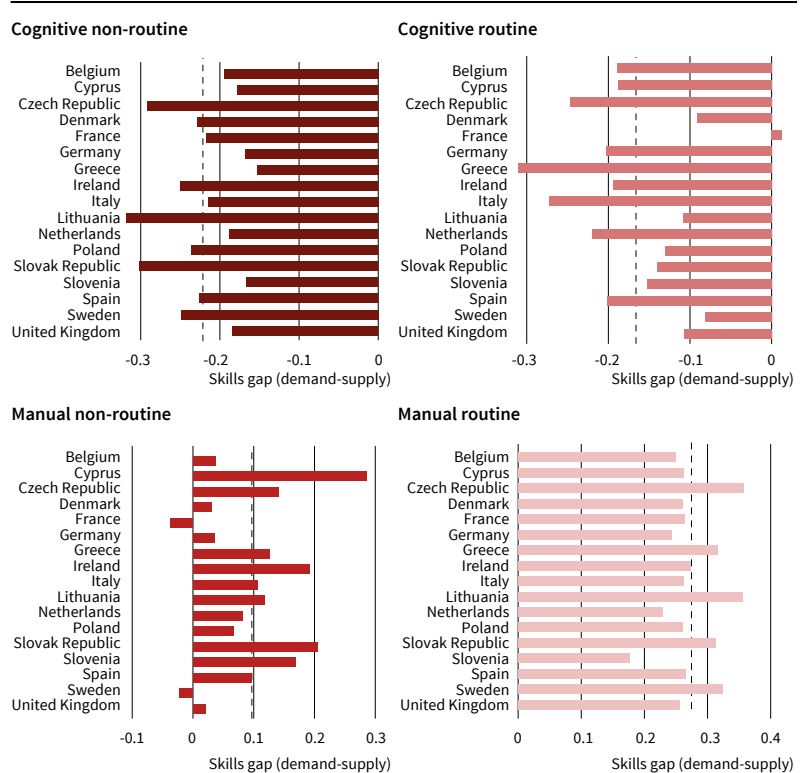
average. The only exceptions are Sweden for manual non-routine workers and France for cognitive routine and manual non-routine workers.

Figure 1 Skills Gaps by Occupation



Note: Pooled for 17 European countries. Source: CEDEFOP; PIAAC. © ifo Institute

Figure 2 Skills Gaps by Country and Occupation Type

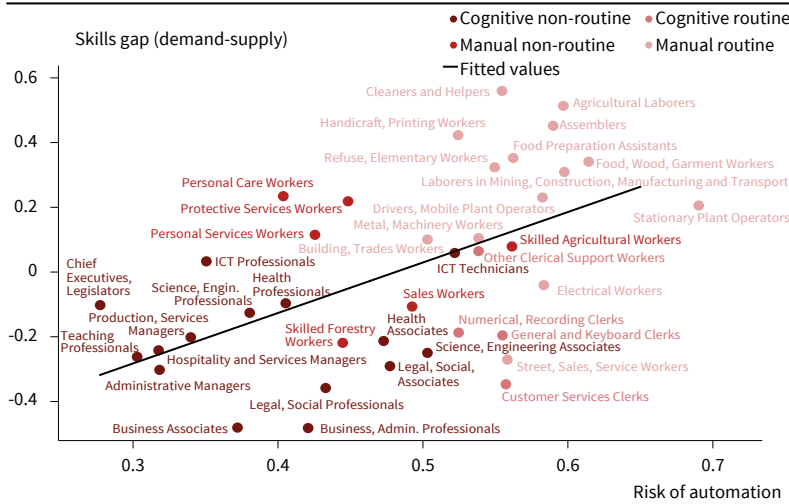


Note: Skills gap by occupation type – cognitive non-routine, cognitive routine, manual non-routine, and manual routine – are shown for 17 European countries. The dotted line shows the occupation-type-specific mean over all countries. Source: CEDEFOP; PIAAC. © ifo Institute

Figure 3
Skill Gaps by Skill Domain and Occupation Type

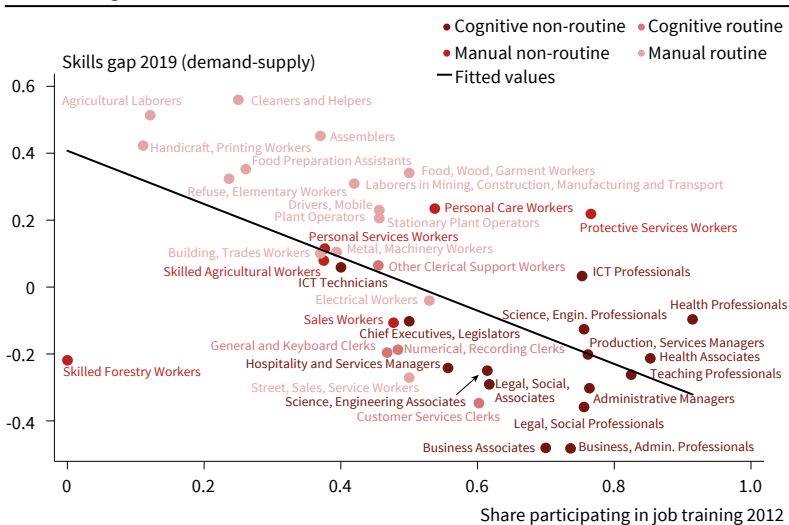


Figure 4
Automation Risk and Skill Gaps



Note: Correlation between automation risk and the skills gap, pooled for 17 European countries. Our measure of automation risk stems from Nedelkoska and Quintini (2018), who constructed the automation probability for all occupations and countries in our sample using PIAAC data. Source: CEDEFOP; PIAAC. © ifo Institute

Figure 5
Job Training and Skill Gaps



Note: Correlation between on-the-job training (measured in 2012) and the skills gap (measured in 2019), pooled for 17 European countries. Source: CEDEFOP; PIAAC. © ifo Institute

SKILL GAPS ARE SIMILAR ACROSS ALL SKILLS DOMAINS

One potential driver of the positive skills gaps of manual workers could be a supply shortage of specific in-demand skills that have gained importance in recent years, such as digital skills. To investigate this, we separate the skills gap for each occupation group by different domains (digital, numeracy, literacy, and social skills) in Figure 3. However, we find similar skills gaps across all skill domains for our four occupation types: cognitive workers show a supply surplus on average, while manual workers exhibit a shortage on average. Further, the supply shortage across all skill domains is largest for manual routine workers, while the surplus is highest among cognitive non-routine workers.

WORKERS AT HIGHER RISK OF AUTOMATION FACE HIGHER SKILL SHORTAGE

Next, we explore potential mechanisms that might underlie our previous results. A large body of literature suggests that routine occupations are particularly exposed to automation risks (e.g., Frey and Osborne 2013; Arntz et al. 2016; Nedelkoska and Quintini 2018). Thus, occupations with higher susceptibility to automation are at larger risk of their tasks being replaced by robots and automation technologies. Accordingly, the skills requirements for these occupations change more rapidly (e.g., Acemoglu and Restrepo 2019; Deming and Noray 2020), and occupations with a higher risk of automation should face larger skills gaps. Our data provide suggestive evidence for this.

Figure 4 depicts the relationship between the skills gap and the risk of automation across occupations. Our measure of automation risk stems from Nedelkoska and Quintini (2018), who constructed the probability of being automated for all occupations and countries in our sample using PIAAC data. For instance, teaching professionals have a probability of 31 percent that their occupation is being substituted by automation, while it is 68 percent for food preparation assistants.

Figure 4 shows a positive relationship between the risk of automation and the average skill shortage of occupations: a higher risk of automation is associated with higher skills gaps (demand-supply). Thus, occupations more exposed to the risk of automation, such as food preparation assistants and plant operators, exhibit skill supply shortages. This is consistent with the notion that as automation technologies become able to perform existing tasks, skill demand for these occupations changes more rapidly and workers face larger challenges to meet these new skill demands. At the same time, occupations at lower risk of automation have skill supply surpluses, indicating that they provide more skills than currently required from employers.

ON-THE-JOB TRAINING AS A POTENTIAL MEASURE TO MEET FUTURE SKILLS NEEDS

We have shown that workers in manual occupations are more exposed to automation risk and face larger skill shortages, which potentially stem from more rapid changes in skills requirements due to the automation of existing tasks.

One measure to mitigate the adverse ramifications of technological change on skills gaps is training to re-educate employees so as to prepare them for changing skill demands. Indeed, Figure 5 shows that workers in occupations with a higher share of workers participating in training in the PIAAC data (measured in 2012) are less likely to exhibit skill shortages in 2019. We use the training intensity in the year 2012, as it is likely that the degree of skills mismatch of employees in an occupation in 2019 depends on the participation in, or missing out on, training in the past. Thus, a potential explanation for this could be that workers in occupations with more training were better at anticipating skills demand changes and investing in on-the-job training to stay on the frontier of what is demanded in their respective job. Conversely, there is a skill supply shortage in 2019 for occupations that showed low rates of training in 2012. At the same time, occupations with lower training intensities in 2012 are also those more exposed to automation risks, such as manual occupations like agricultural laborers and food preparation assistants. This suggests that workers who did not invest in job training were not prepared for changing skill requirements and thus show more pronounced skill shortages.³

POLICY CONCLUSIONS

This article addressed two questions of high relevance for European Union policymakers: (1) how prevalent is skills mismatch in Europe?, and (2) what are the drivers of these skills gaps and how can workers better prepare for the skill demand of employers? Drawing on innovative online job ad data and survey data for 17 European countries, we created novel measures of skills mismatch. We documented that manual workers face skill shortages, while cognitive workers exhibit skill surpluses. This basic pattern holds across all the 16 EU countries, plus the UK, that we analyzed in this report. We further found that this Europe-wide pattern is not driven by single occupations or increased demand for certain skill domains, such as digital skills, but is strikingly consistent across all occupations and skill domains.

Are technological change or differences in training provision important driving or mitigating factors for these patterns? Figure 4 shows that technological change (proxied by an occupation's automation probability) is more prevalent in manual routine and

manual non-routine occupations compared to their cognitive counterparts. Thus, our results suggest that job-specific knowledge of manual workers becomes obsolete more rapidly: the skills that were previously essential for a manual job lose relevance, which leads to skill shortages. In comparison, the skill content of cognitive non-routine and cognitive routine occupations is less exposed to automation. However, cognitive workers might be better able to anticipate the changes in skill content due to automation and invest in on-the-job training early on to guarantee their employability. This, in turn, leads to a skill surplus for these workers. Labor market policies need to ensure that manual workers are not left behind when it comes to training provision.

The EU has given top priority to understanding and mitigating skills gaps (European Commission 2020). Our descriptive evidence points to the fact that skills gaps are prevalent in the European Union and are accompanied by skill depreciation and lower adaptability to technological change. This has adverse impacts on workers in terms of earnings and job satisfaction, but also for firm productivity. Anticipation of future skills needs and providing the opportunity for on-the-job training are thus of fundamental importance for European countries to increase productivity, job satisfaction, and competitiveness of both employers and employees.

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³ See also Falck et al. (2022), who show a positive association between training participation and digital skills for elderly workers.

Oliver Falck, Valentin Lindlacher and Simon Wiederhold

Elderly Left Behind? How Older Workers Can Participate in the Modern Labor Market

KEY MESSAGES

- **Digital skills are positively related to employment prospects and productivity of older workers**
- **They also enable older workers to work in high-paying jobs**
- **Fortunately, digital skills can be acquired and honed at all ages**
- **Policymakers should incentivize employers to offer more training for the elderly and fund training programs in higher-education institutions**
- **At present, the elderly show huge international differences in digital skills, larger than those for younger groups**

In her 2021 State of the Union address, European Commission's President Ursula von der Leyen announced that "[the EU] will invest in 5G and fiber. But equally important is the investment in digital skills." Indeed, the EU Recovery and Resilience Facility, which runs until 2026, has earmarked substantial funds to tackle the digital divide, in acknowledgment of the fact that the EU is not only missing ICT specialists but also that many Europeans do not have sufficient digital skills to thrive in today's society and labor market. Many observers argue that older workers in particular lack digital skills, suffering more often from computer anxiety and showing lower computer self-efficacy (Czaja et al. 2006). This lack of skills hampers their employability and productivity in a technologically fast-changing world. Furthermore, given that societies in the industrialized world are aging, equipping older workers with the necessary skills to remain active

and productive in the labor market has become a key challenge.

In this article, we first document to which extent OECD countries are succeeding in equipping workers of different ages with basic digital skills. Focusing on workers aged 55–65 years, when then show the labor market consequences of insufficient digital skills. While this evidence is based on simple country-level correlations, the strength of the relationships clearly suggests the importance of providing training opportunities in digital skills, especially to older generations. In fact, we show that older workers in countries with more on-the-job training opportunities possess systematically higher digital skills. Our analysis relies on data from the OECD's Programme for the International Assessment of Adult Competencies (PIAAC). The key advantages of these data are that digital skills were assessed in an internationally comparable manner and that a rich background questionnaire provides information on labor market outcomes for adults up to 65 years.

LARGE INEQUALITIES IN DIGITAL SKILLS

PIAAC provides an assessment of adults' proficiency in problem-solving in technology-rich environments, which we refer to as digital skills. We use survey data from the 27 countries that participated in PIAAC's digital skill assessment between 2011 and 2015. All countries participating in PIAAC are developed countries, mostly from the OECD.

In the following, we focus on whether an individual has at least some basic digital skills, that is, whether she was able to participate in PIAAC in a computer-based mode. There are three reasons for why individuals may lack basic digital skills in PIAAC (see Falck et al. 2021): (i) individuals had no prior computer experience; (ii) individuals failed a



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computer core test, which assessed basic digital competencies such as using a keyboard/mouse or scrolling through a web page; (iii) individuals refused to take part in the computer-based assessment. For the sake of exposition, we use the term “individuals with basic digital skills” instead of “individuals with at least basic digital skills” in the remainder of the article.

Figure 1 depicts a country’s share of individuals with basic digital skills for three age groups: 25–44, 45–54, and 55–65 years. We observe a clear age ranking of basic digital skills in all countries: the youngest group always has the highest share of individuals with basic digital skills, while the oldest group always has the lowest share. On average across countries, the digital skill gap between the youngest and oldest age groups amounts to 35 percentage points. While PIAAC only covers adults up to 65 years, it is likely that the gap would be even wider when considering individuals aged over 65.

Figure 2 below shows that countries also differ considerably in the size of the digital-skill gap between the youngest versus the oldest age group. Unsurprisingly, countries that are better able to equip younger workers with digital skills also tend to have higher-skilled workers in the older generation: in the United Kingdom, Norway, the Netherlands, the United States, Sweden, Denmark, and New Zealand, the share of individuals with basic digital skills in the youngest age group exceeds 90 percent, while the gap with the oldest group amounts to only 13 to 20 percentage points. However, a considerable number of countries show large inequality in digital skills by age group. Most striking is South Korea, where almost 90 percent of younger workers but less than 30 percent of older workers have basic digital skills, leading to a skill gap of a whopping 60 percentage points! Other countries in which the youngest and oldest age group are very unequally equipped with basic digital skills are Singapore and Central and Eastern European countries such as Slovenia, Lithuania, and the Czech Republic.

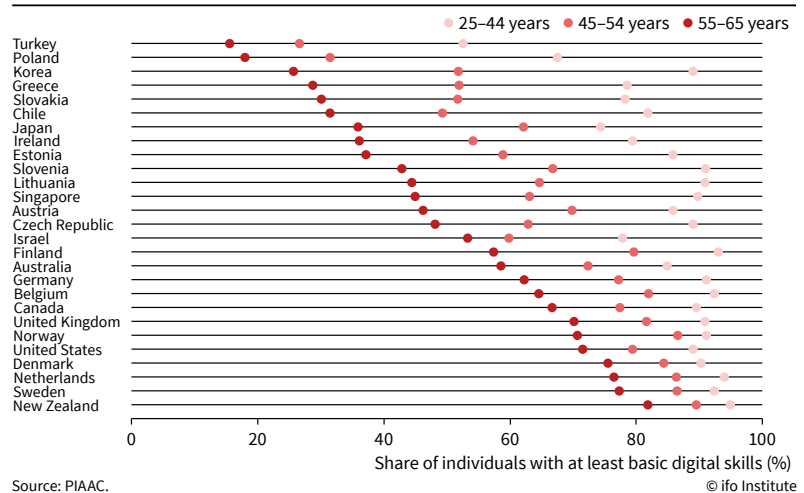
Across the three age groups considered, the cross-country differences in the share of individuals with basic digital skills are by far the largest in the oldest age group. While in Turkey and Poland not even one-fifth of the oldest age group has basic digital skills, the share exceeds 75 percent in New Zealand, Sweden, the Netherlands, and Denmark. Generally, richer countries are better able to equip elderly individuals with basic digital skills. This is not true, however, in very rich Asian countries, particularly South Korea and Japan, where the share of individuals with basic digital skills in the oldest age group is below 40 percent.

DIGITAL SKILLS MATTER FOR LABOR MARKET OUTCOMES OF THE ELDERLY

In the remainder of the article, we focus on individuals aged 55–65 years. Using cross-country variation,

Figure 1

Basic Digital Skills by Country and Age Group



we investigate whether labor market outcomes of the elderly are systematically related to their digital skills, relying on PIAAC’s rich information on employment status, hourly wages, and the abstract-task content of a worker’s occupation.¹

Digital Skills and Employment of the Elderly

We start by assessing the relationship between digital skills and employment of older workers. We find that their employment prospects are systematically higher in countries where such workers are better equipped with basic digital skills (upper panel of Figure 2). A country’s share of older workers with basic digital skills explains as much as 30 percent of the international variation in employment chances for the elderly. Interesting outliers are Chile, Japan, Singapore, and South Korea, where elderly workers have relatively good employment chances despite low basic digital skills. Elderly individuals in countries such as Austria, the Czech Republic, and Belgium have rather low employment opportunities despite reasonable digital skills, while elderly individuals in Southern as well as Central and Eastern European countries, such as Turkey, Greece, and Slovenia, are bleak regardless of their digital skills.

Digital Skills and Hourly Wages of the Elderly

Next, we focus on employed elderly workers and examine the relationship between basic digital skills and (PPP-adjusted) hourly wages as an important measure

¹ Hourly wages are based on purchasing power parities and exclude the self-employed. PIAAC does not report hourly wage information for Singapore and Turkey, so the number of countries shrinks to 25 in the middle panel of Figure 2 - see Hanushek et al. (2015) for further details on the wage data in PIAAC). The abstract task measure is taken from Goos et al. (2014), and incorporates managerial and interactive tasks as well as mathematical and formal reasoning requirements. PIAAC does not provide occupational information at the two-digit ISCO level for Austria, Canada, Estonia, and Finland, so the number of countries shrinks to 23 in the bottom panel of Figure 2.

of individuals' productivity (middle panel of Figure 2). We find a strong positive association: elderly workers earn significantly higher average wages in countries where the share of older workers with basic digital

skills is higher. In fact, a country's proportion of older workers possessing basic digital skills explains almost 44 percent of the international wage variation. Elderly workers in South Korea, Japan, and Ireland are paid relatively well despite having low digital skills, while Central and Eastern European countries (e.g., Slovakia, Estonia, Slovenia, Lithuania, and the Czech Republic) pay their elderly workers relatively little in relation to their digital skills.

Digital Skills and Type of Jobs Performed by the Elderly

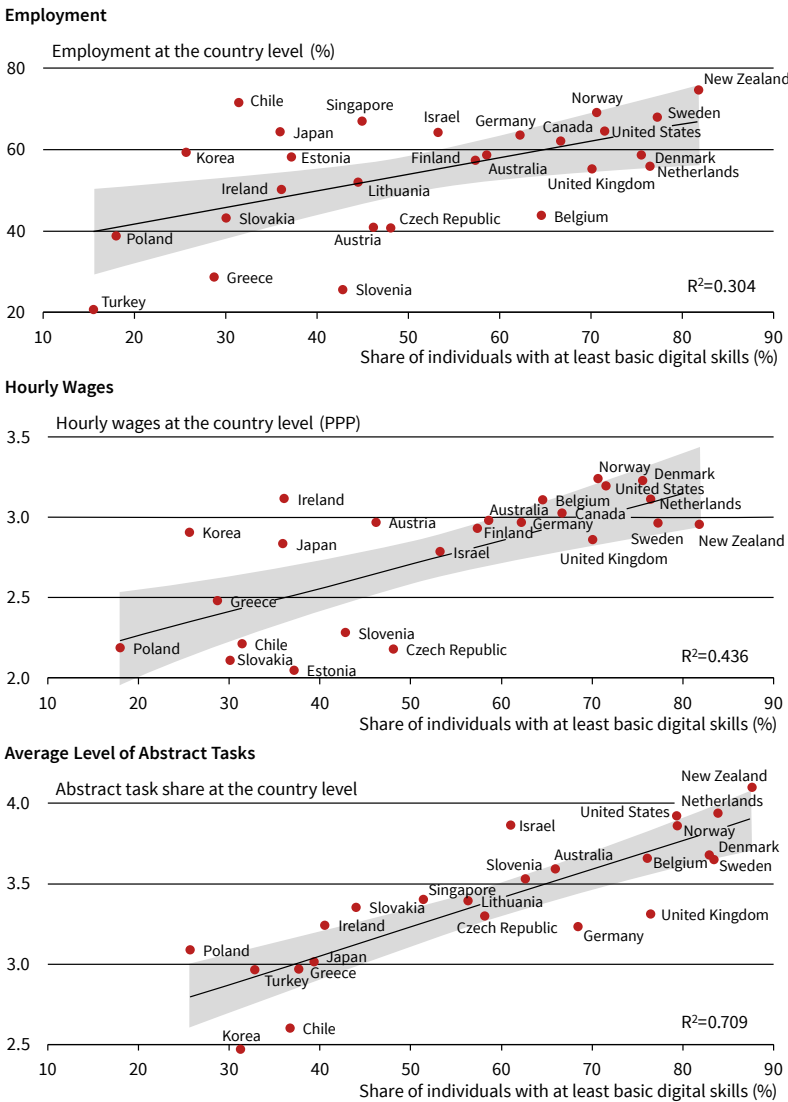
To shed light on why older workers with higher digital skills earn wage premia, we investigate the tasks these workers perform in their jobs. We conjecture that workers need at least some basic digital skills to perform cognitively complex, abstract tasks. This is in line with the idea that recent technological change amplifies the comparative advantage of those workers engaged in abstract tasks. Specifically, Autor et al. (2003 and 2008) show that computers substitute for routine tasks (those that can be accomplished by following explicit rules) and are complementary to nonroutine abstract tasks (such as problem solving, adaptability, and creativity). The underlying reasoning is that routine tasks embody explicit knowledge that can be programmed relatively easily, which is not the case for abstract tasks. Moreover, an increase in the supply of codifiable tasks increases the marginal productivity of employees who engage extensively in abstract tasks.

Our results suggest an important role for occupational selection in explaining the returns to basic digital skills. We find a very strong association between the share of older workers with basic digital skills and the average level of abstract tasks older workers perform in their jobs (bottom panel of Figure 2). In fact, basic digital skills explain more than 70 percent of the international variation in abstract tasks. Thus, having basic digital skills appears to be a prerequisite for benefitting from the wage premia that abstract jobs pay.

POLICY CONCLUSION: BASIC DIGITAL SKILLS CAN BE ACQUIRED AT ANY AGE

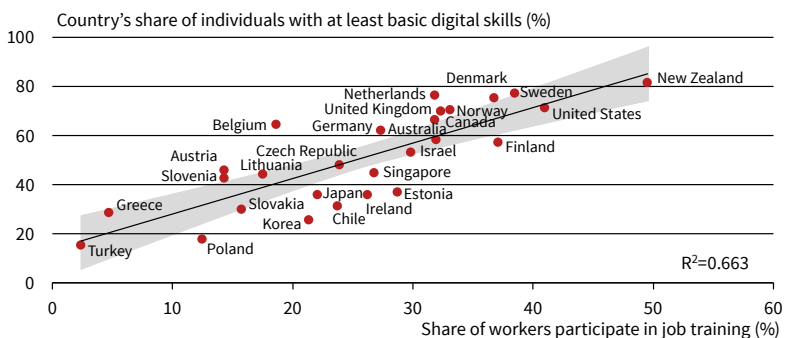
We have shown that an elderly workforce with basic digital skills has substantially better employment chances, earns higher wages, and is less susceptible to being replaced by technology. Thus, fostering the formation of digital skills among the elderly is a key measure for creating inclusive labor markets that can accommodate older workers. Can job training equip older workers with these basic digital skills? To study this question, we again rely on PIAAC, which asked whether individuals had participated in training in the 12 months prior to the survey. Our definition of job training includes both training on the job (i.e.,

Figure 2
Basic Digital Skills and Labor Market Outcomes of Individuals Aged 55–65 Years



Note: The gray-shaded area marks the confidence interval at the 95% level. R² refers to the share of variance in employment, wages, and abstract tasks, respectively, that is explained by the share of individuals with at least basic digital skills. Source: PIAAC. © ifo Institute

Figure 3
Job Training and Basic Digital Skills of Individuals Aged 55–65 Years



Note: The gray-shaded area marks the confidence interval at the 95% level. R² shows how much variation in the share of elderly individuals with digital skills is explained by the share of elderly workers who participated in job training. Source: PIAAC. © ifo Institute

organized sessions for on-the-job training or training by supervisors or co-workers) and any other training measures that were job-related. Figure 3 shows that basic digital skills of workers aged 55–65 years are systematically higher in countries with a higher share of elderly workers participating in job training. The high relevance of job training for developing digital skills of older workers is suggested by the fact that differences in training participation among the elderly explain almost two-thirds of the international variation in the share of older workers with at least basic digital skills.

Hence, it is vital for governments to promote adequate training and lifelong-learning opportunities on labor markets that are rapidly changing (Vona and Consoli 2015). In particular, structural and technological change will likely raise the demand for expertise in digital tasks in the future. On the one hand, training opportunities must be provided on a continuing basis, especially for older workers, as these workers possess lower digital skills than their younger counterparts (see Figure 1). Multivariate evidence from the PIAAC data shows that job training is effective in increasing digital skills for all age groups (Falck et al. 2022). However, elderly workers exhibit a considerably lower training participation rate than their younger peers. Across the 27 PIAAC countries, training participation rates are 47 percent (43 percent) for individuals aged 25–44 years (45–54 years), but only 27 percent for those aged 55–65 years. At the same time, survey evidence from a German follow-up study to PIAAC, PIAAC-L suggests that the share of individuals wishing to have training in information and communications technology (ICT) is by far the largest among the oldest worker generation: while 32 percent of workers aged 55–65 years wish to receive ICT training, only 18 percent (22 percent) of individuals aged 25–44 years (45–54 years) do so.

These findings provide a strong case for policymakers to incentivize employers to offer more training measures for the elderly, who often have lower access to training. Recent programs for developing digital skills at the European level aim at addressing this issue. For instance, the Recovery and Resilience

Facility mandates that all national plans must devote at least 20 percent of resources to foster the digital transition, such as by investing in connectivity, human capital, and digital services.² Likewise, the Digital Europe Programme earmarks EUR 7.4 billion for the deployment of digital technologies and EUR 580 million for courses and training in key digital technologies in higher-education institutions, research centers, and firms.³

Digital skills do not only affect labor market success, but also participation in society more generally. This was shown very starkly during Covid-19, when non-grocery shopping was often only possible online. Other prominent examples are the provision of digital public services and Internet voting. Thus, being unable to master digital skills in an ever more digitalized environment may eventually become a question of social participation.

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² See https://economy-finance.ec.europa.eu/eueconomyexplained/recovery-and-resilience-facility_en.

³ See <https://digital-skills-jobs.europa.eu/en/about/digital-europe-programme>. The Digital Skills & Jobs Platform also provides a collection of training opportunities and best practices from various EU countries.

Yvonne Giesing and Britta Rude

Robots, AI, and Immigration – A Race for Talent or of Displaced Workers

KEY MESSAGES

- **Adoption of new technologies can affect different skill groups differently, potentially increasing inequality between migrant and native populations**
- **New technologies often create skill shortages**
- **Industrial robots and artificial intelligence have important beneficial labor market effects on natives, but not migrants**
- **We observe an increase in the immigrant inflow as a response to AI adoption**
- **Policymakers should pay special attention to the migrant population when designing mitigation policies in response to automation**

Technological change and innovation are not recent phenomena: they have been part of human evolution since the Stone Age. While during the early periods of human development technological change was mainly limited to tools related to hunting, food gathering and preparation, as well as survival, over time there have been many transformative changes driven by technology. Examples are the invention of electricity, airplanes, the telephone and television, and nuclear fission, among many others. More recent examples form part of the digital revolution, which started after the Second World War, and comprises the Internet and personal computers, social media, smartphones, and digital TV.

Technological change can have overall positive welfare effects but might impact certain groups in society more negatively than others.

Economists often define



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technological change as an innovation-driven increase in output using the same amount of inputs (Seo 2018). This can have important benefits for societies undergoing technological change (Callaghan 2021).

Conversely, some studies show that technological change can have adverse impacts on certain groups of society.¹ These adverse effects can occur when some technologies have the potential to replace tasks. One case in point: industrial robots replacing certain manual operations in the production process. Furthermore, artificial intelligence has the potential to replace cognitive tasks, as in the case of automated detection of spam emails. At the same time, technological change can create complementary tasks: an industrial robot needs to be operated and supervised, while an algorithm needs to be updated and verified. Lastly, technological change can result in productivity increases. Employees can use the time saved from no longer having to identify spam emails for more productive purposes. And the employment of industrial robots for industrial production might make it possible for one employee to oversee the manufacturing of more goods than when doing so manually.

The focus of our study is to examine whether and how the impact of technological change differs for migrants and natives. Researchers have mainly focused on different skill groups when studying the differential effects of technological change. This means that they have mainly focused on the low-, middle-, and high-skilled population when analyzing the potentially diverging impact of technologies. We bring a new aspect to these analyses by asking how the impact of technological change differs for the native and migrant population. This is of interest since, as migrants do not have access to the same networks and institutions as the natives (Wang et al. 2018), they tend to experience down-skilling (Borjas 2001), whereby they might be affected more significantly by the potential displacement effects of technological change. Furthermore, technologies can have the potential to raise some of the additional labor market barriers that migrants face. Examples are recruiting software or technologies that automate the translation of different languages. Lastly, there is evidence showing that technological change

¹ The studies by Autor et al. (2003), Graetz and Michaels (2018), Acemoglu and Restrepo (2018), and Dauth et al. (2019) give a good introduction into the literature.

has created skills mismatches.² The resulting scarcity of skills makes it interesting to study whether the adoption of new technologies affects immigration inflows. The underlying rationale is that firms could try to cover potential skill shortages by recruiting suitably skilled workers from abroad.

To shed light on this issue, we have studied the impact of two different automation technologies – industrial robots and artificial intelligence – on labor market outcomes and immigration flows. We first focused on industrial robots, which rank as a form of low-skilled automation technology. Other type of robots has the potential to replace some human tasks, especially at the lower end of the skill distribution (Acemoglu and Restrepo 2018). To measure a labor market's exposure to robots, we used data on the operational stock of robots provided by the Industrial Federation of Robotics, which measures the number of installed robots in different industries in a respective year.

Next, we analyzed the adoption of artificial intelligence. In contrast to industrial robots, artificial intelligence has the potential to perform high-skill tasks (Webb 2019). To this end, we leveraged online job vacancy data provided by the company Burning Glass. We identified the AI-related skill demand through a number of AI-related skills. As soon as one of these skills was mentioned in a job vacancy, we defined it as a job vacancy demanding artificial intelligence. We then followed the demand for AI-related skills as well as the employment of industrial robots over time.

We chose to apply our study to the case of Germany, as it provides the ideal setup for the underlying research question. First, it is one of the main migrant-recipients among OECD countries (see Figure 1). Second, it is one of the leading countries in the adoption of automation technologies (see Figure 2).

We then combined our data on industrial robots and artificial intelligence with labor market data from Germany. We measured our labor market outcomes of interest using matched employer-employee data provided by the Institute of Employment Research (IAB). More concretely, we made use of the Sample of Integrated Labour Market Biographies (SIAB), which is a 2-percent random sample from the Integrated Employment Biographies (IEB). This data represents the German social security data tracking all employees subject to social security contributions, marginal part-time employment, officially registered jobseekers, as well as benefit recipients. We used this data to measure our outcome variables of interest: unemployment rate of migrants and natives, daily wages of migrants and natives, as well as immigrant inflow. We applied state-of-the-art econometric methods to investigate the impact of technological change on our outcome

² As an example, firms in Germany spent on average six months filling tech positions.

Figure 1
Immigrant Inflow

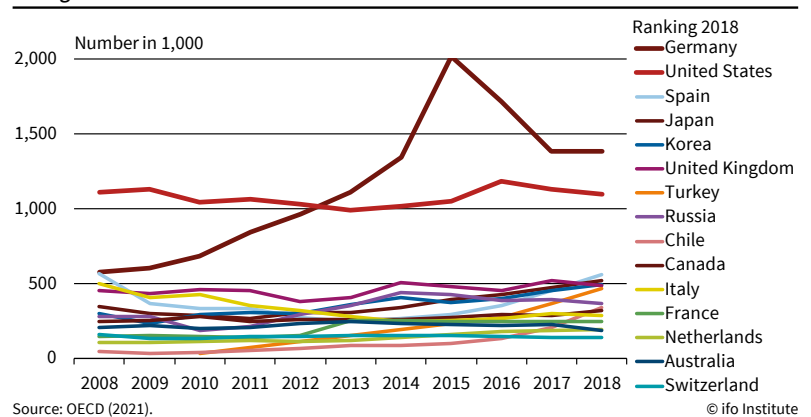
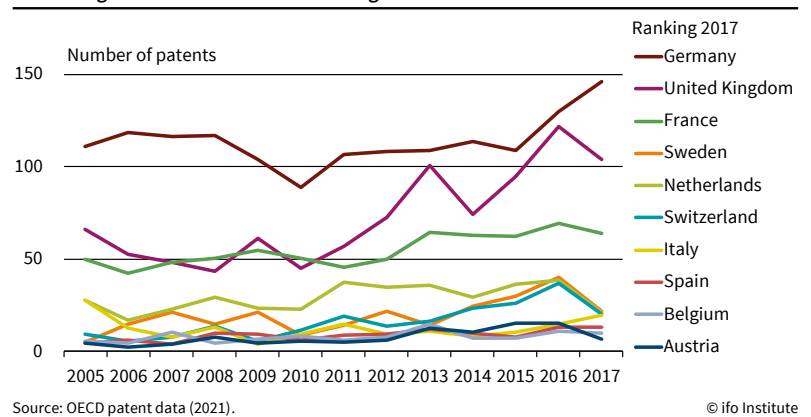


Figure 2
Technologies Related to Artificial Intelligence



variables of interest.³ Importantly, we conducted our analysis at the county level. Figures 3 and 4 show that there has been significant variation in the adoption of these two technologies over time.

DIVERGING EFFECTS OF TECHNOLOGICAL CHANGE ON MIGRANTS AND NATIVES

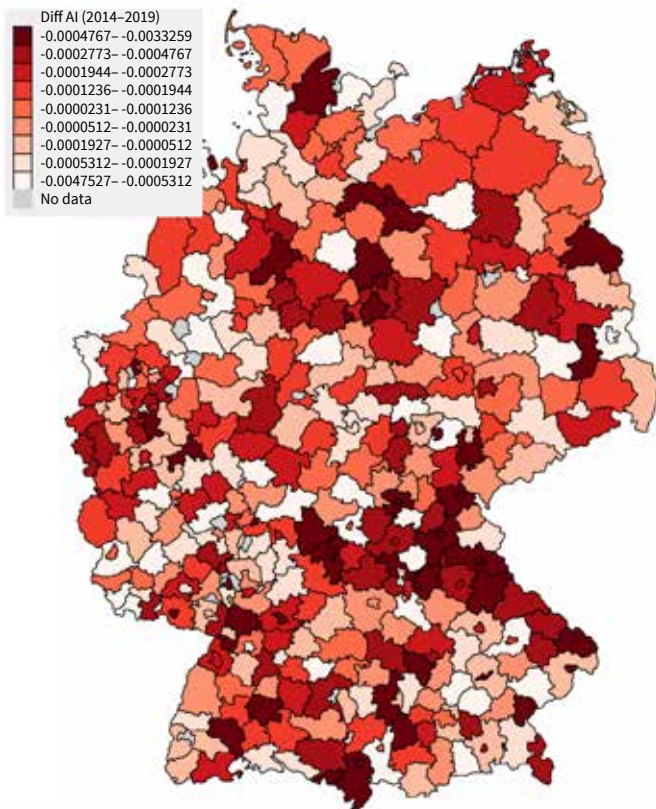
The Impact of Industrial Robots

We find that robot adoption did not result in a significant increase or decrease of immigrant inflows in Germany during the 2005–2018 period, but they did have adverse effects on migrants who were already in Germany. While no displacement effects were observed for either migrants or natives, there was a significant impact on daily wages. While natives experienced a wage increase – a clear indication of productivity increases – this was not the case for migrants. On the contrary, they experienced wage declines as a result of robot adoption. Additionally, differently from natives, migrants do not seem to benefit from productivity increases. Possible reasons for this are that migrants might have less access to information on the need to

³ We applied a shift-share instrumental variable strategy. For an overview of the shift-share instrument, see Goldsmith-Pinkham et al. (2020).

Figure 3

Artificial Intelligence

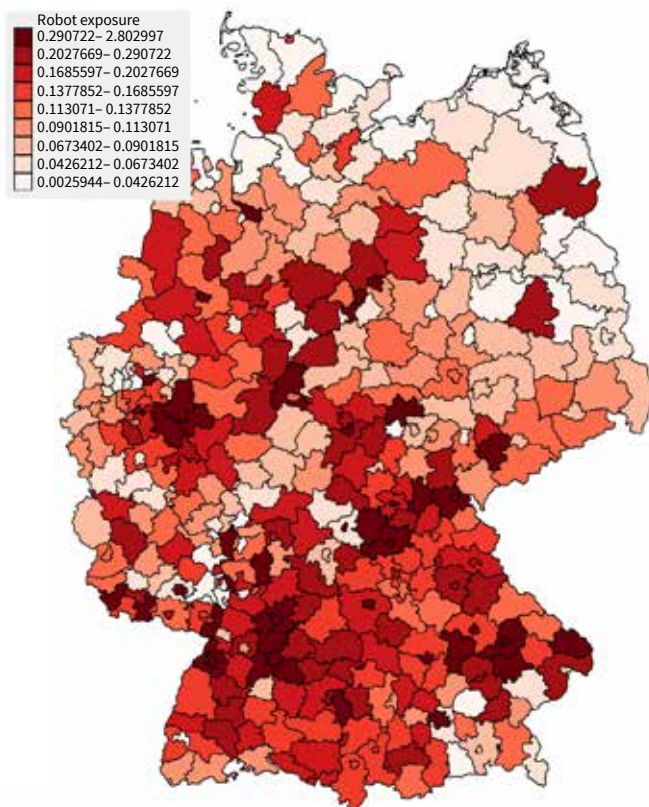


Source: OECD.

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Figure 4

Robot Adoption



Source: OECD.

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adapt their skill set or to switch jobs; language barriers; or discriminatory labor market structures. When splitting the analysis by economic sectors, we find evidence of a migrant share decrease in the manufacturing sector, which is where robots are mostly installed. A decrease in the migrant share could result from migrants leaving the most exposed sector as a response to robot adoption or leaving Germany altogether.

Artificial Intelligence

Differently from robots, exposure to an increase in AI demands during the period 2014–2019 results in an increase in immigrant inflows, while also having adverse effects on natives and migrants. This could mean that firms face skill shortages due to AI, which they cover from abroad. Surprisingly, this effect is only significant for the medium- and low-skilled, pointing towards complementarity effects. Next, we find adverse effects on the labor market outcomes – namely the unemployment rate and daily wages – of migrants versus natives. This applies to all skill groups investigated. These findings indicate that – in line with our results on the impact of robot adoption – AI leads to productivity increases for natives, while negatively affecting migrants. Similarly to what we showed for robot adoption, potential drivers could lie with migrants having less access to labor market institutions, to information on how to adapt their skill set as well as to local networks.

POLICY CONCLUSIONS

Our findings show that automation has diverging effects on migrants and natives, likely driven by the fact that natives benefit from complementary and productivity effects of technological change, while migrants start competing with technological change. Consequently, inequalities between natives and migrants could increase as a consequence of technological change.

We also found a significant increase in the immigrant inflow as a response to AI adoption, which could be due to firms facing skill shortages that they cannot cover through the local labor supply, prompting them to tap the global labor market for the skills they require.

The key policy implications resulting from the above are:

- (1) Policymakers interested in equity between migrants and natives should pay special attention to the migrant population when designing mitigation measures in response to technological change.
- (2) It is advisable to introduce policies to ensure that migrants enjoy equal access to labor market institutions and networks as the natives. Mentoring programs could be a useful way to achieve this (Weiss and Tulin 2021).

- (3) Policymakers should also make sure that migrants have equal access to relevant information about how to adapt their skill sets, as well as securing their access to retraining programs.
- (4) In general, measures that target the enforcement of the “Equal Pay for Equal Work” principle between migrants and natives are recommended.
- (5) The development of sound migration policies, which make it easy for firms to recruit the best talent abroad, is desirable.

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Tommaso Ciarli, Florencia Jaccoud and Fabien Petit

Heterogeneous Adjustments of Employment to Automation Technologies: Evidence from Manufacturing Industries in European Regions^{*}

KEY MESSAGES

- Employment adjustments to automation vary across industries, regions, technologies, and time
- Technological penetration of robots is related to higher employment within the industry in low-tech regions in the short run
- Robots are negatively correlated to employment in knowledge-intensive regions
- Regional heterogeneity in employment adjustment to robots is not driven by industry composition
- High-tech industries adjust employment to ICT penetration faster than low-tech industries

Automation of activities changes the demand for labor across industries, regions, and occupations (Acemoglu and Restrepo 2019). However, the net effect of investment in different digital and automation technologies on employment in local labor markets remains unclear (see Aghion et al. 2022 for a survey), especially among European regions that differ in their industry composition, labor force characteristics, and technological endowments. These differences raise questions for policymakers about how to best deal with the varying effects of automation technologies across regions and industries, and over time. How do employment adjustments differ in structurally diverse regions such as Inner London (a knowledge- and service-intensive region), Stuttgart (a high-tech and manufacturing-intensive region), and Calabria (a low-tech tourist-driven

region) in the wake of increased investment in a given automation technology?

This paper provides evidence on the relation between investment in digital and automation technologies and employment in different manufacturing industries in Europe and the extent to which this relation varies over time across technologies, industries, and regions. We find that in the short run the technological penetration of robots is associated with higher employment in low-tech regions, while service-intensive regions and cities experience decreased employment. Our heterogeneous results suggest the need for different but coordinated policies at the European, national, and sub-national levels.

We distinguish four digital and automation technologies: robots, communication technology, information technology, and software-database (see Box below for definitions). By combining data from several sources, we build a measure of the penetration of these technologies at the industry-region level. We include 144 NUTS-2 regions from seven European countries between 1996 and 2017. Our three-step analysis includes, first, estimation of the employment adjustments in a given region and industry to a change in technology penetration in the same year, and up to 15 years later. Second, we cluster regions into knowl-

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edge-intensive, high-tech, and low-tech, and cluster industries into high-tech and low-tech. Third, we examine heterogeneity in employment changes across region and industry clusters.

We obtain two main empirical results. First, the relation between investment in digital and automation technologies and employment differs in the short (less than 5 years) and medium (between 6 and 15 years) runs, adopting a pattern specific to each technology. Second, the adjustment of employment to technological penetration differs substantially across industries and regions.

Our paper contributes to several literature strands. We extend the literature on the effects of digital technologies on labor markets (e.g. Autor et al. 2003; Goos et al. 2009; Michaels et al. 2014) by showing the existence of large differences across regions and industries in regarding the consequences of information and communication technology (ICT) for employment.

Our work is also related to work on the impact of robots on employment, which despite using similar data and methods provides mixed evidence. Some suggest that robots have a negative impact on local or regional labor markets (Acemoglu and Restrepo 2020; Benmelech and Zator 2022), while others find no impact or even a positive association at the country and industry levels (Graetz and Michaels 2018; Dauth et al. 2021). We show that these differences are related to how employment adjusts in regions and industries. The heterogeneity in the relationship between robots and employment might be due to different occupational structures, investment patterns, and technological features of different regions and industries.

DATA AND METHODOLOGY

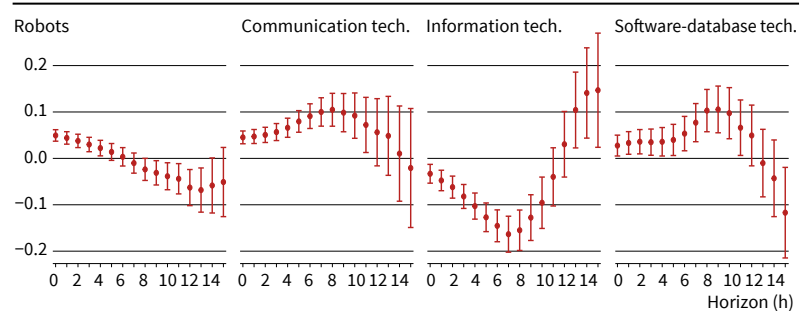
We observe data for 144 NUTS-2 regions from seven European countries (Austria, France, Germany, Italy, Netherlands, Spain, and the UK) between 1996 and 2017. Since more than 90 percent of industrial robots are used in manufacturing (Klenert et al. 2022), we focus on industries within this sector (International Standard Industrial Classification (ISIC Rev. 4) divisions 10-33). Since our data come from several sources which employ different industrial classifications, we aggregate divisions into eight groups that we define as industries (see Box on next page).

For each technology, we build a measure of its region-industry level penetration. First, we measure region-industry level of capital for each technology as the product of three components: (i) the national level of capital in a given industry; (ii) the within-country share of the gross fixed capital formation in manufacturing at the regional level assuming that in all industries more capital-intensive regions are likely to attract more digital and automation capital; and (iii) regional share of employment in the industry, rela-

Figure 1

Employment Adjustments over Time

Change in employment (in %)



Note: Employment adjustments over time are expressed as the percentage changes to employment following a 1%-change in technology penetration. Each panel represents an individual technology. Point estimates and their confidence levels are depicted for each period up to 15 years.

Source: EU-LFS for employment; technology penetration based on authors' calculations using IFR, EU-KLEMS, ARDECO, and IPUMS data.

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tive to the national share of employment in this same industry (before the period of analysis), assuming that in all regions some industries are more exposed than others to digital and automation technologies. We then obtain a measure of penetration by dividing the level of capital by the number of employees in the region-industry before the period of analysis. We smooth our measure of technology penetration with a five-year moving average to account for investment cycles.

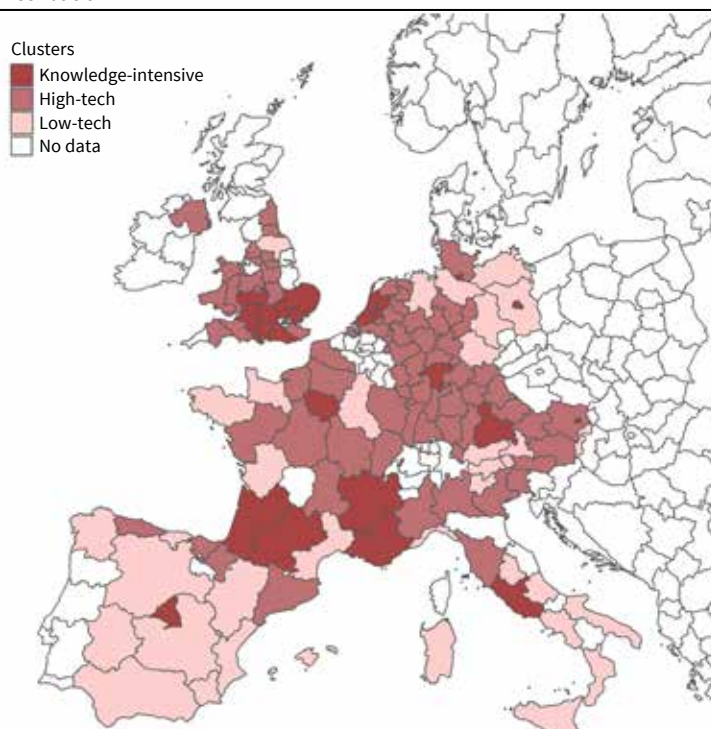
DIGITAL AND AUTOMATION TECHNOLOGIES

We consider four different but related automation technologies:

1. Robot: programmed actuated mechanism with a degree of autonomy to perform locomotion, manipulation, or positioning (ISO 8373:2021).
2. Communication technology: specific tools, systems, computer programs, etc., used to transfer information (ISO 24765:2017).
3. Information technology: resources required to acquire, process, store, and disseminate information (ISO 24765:2017).
- 4a. Software: computer programs, procedures, and possibly associated documentation and data pertaining to the operation of a computer system (ISO 24765:2017).
- 4b. Database: collection of interrelated data stored together in one or more computerized files (ISO 24765:2017).

For reasons of data availability, we consider Software (4a) and Database (4b) to be a unique software-database technology.

Figure 2
Cluster Distribution



Source: EU-LFS for employment; technology penetration based on authors' calculations using IFR, EU-KLEMS, ARDECO, and IPUMS data. © ifo Institute

DATA SOURCES AND INDUSTRY CLASSIFICATION

For robots, we use the number of industrial robots reported by the International Federation of Robots (IFR). For ICT and software-database, we use the capital stock in constant 2010 USD from the EU-KLEMS database. Employment data are from the European Labour Force Survey (EU-LFS), which measure annual employment. Census data from IPUMS International or national statistical offices are used to build our measure of technology penetration (see also below). Data on gross fixed capital formation in manufacturing are from the ARDECO database. Imports from China and the consumption index are taken, respectively, from the OECD Trade in Value Added (TiVA) 2021 and Inter-Country Input-Output (ICIO) tables.

Division	Description of industry
10-12	Food products, beverages, tobacco products
13-15	Textiles, wearing apparel, leather products
16-18	Wood, wood products, paper, paper products, publishing, printing
19-23	Chemicals, pharmaceuticals, plastic, non-metallic mineral products
24-25	Basic metals, metal products
26-27	Computer, electronic, optical products, electrical equipment
28	Machinery and equipment not elsewhere classified
29-30	Motor vehicles, trailers, transport equipment
31-33	Furniture, other manufacturing, repair, and installation (not included)

In our baseline specification, we regress level of employment in year $t + h$ on the four technology penetration levels in year t , where h corresponds to the horizon, which we allow to vary between 0 and 15 years. Both variables are expressed in indices with respect to 1996. For short horizons, we examine the short-run technology penetration and employment co-movements. For long horizons, we estimate medium-term adjustments to employment in the region-industry. Both variables of interest are expressed as logarithms, so the coefficients can be interpreted as elasticities.

We include relevant control variables and fixed effects. The former includes imports from China (in billion USD) and the regional-level consumption index to account for the influence of foreign competition and demand cycles on employment. We consider region-industry and year-fixed effects.

EMPLOYMENT ADJUSTMENT OVER TIME

The baseline results suggest that increased penetration of different digital and automation technologies is related to different adjustments to employment in the short and medium terms (Figure 1). The panels correspond to individual technologies and show the average employment change for a 1 percent change in the penetration of the focal technology at the region-industry level. We provide confidence intervals for these employment responses over a 0 to 15-year horizon after the technology's penetration. A longer time horizon leads to wider confidence intervals as the sample shrinks.

Figure 1 provides two main results. First, an increase in the penetration of robots in the average European region-industry is associated with a short-run increase but a medium-run decrease in employment. On average, a 10 percent increase in robot penetration is associated with a 0.5 percent increase in employment in the same year, slowing down to a 0.1 percent increase after five years. This short-run relation may reflect co-movement of investments in capital and labor. However, the elasticity becomes negative for the average European region-industry over the medium run, with a 10 percent increase in robot penetration in a given region-industry being associated with a -0.7 percent decline in employment after 13 years. This implies that region-industries that invest more in robots do not absorb the workers replaced by robots.

Second, adjustment of employment to ICT and software-database penetration shows a hump-shaped relation over the time horizon analyzed. On the one hand, investment in communication and software-database technologies is associated with increased employment, whereby a 10 percent increase in the penetration of such investments is linked to a respective 0.5 percent and 0.3 percent increase in employment in the same year, on average across in-

dustries and regions. The highest elasticities (about 1 percent increase in employment for a 10 percent increase in penetration) are achieved between eight and nine years later. Although this positive relation with employment disappears in the medium run, in contrast to penetration by robots we found no evidence that investment in communication and software-database technologies reduces employment in the same region-industry over the same period. On the other hand, a 10 percent increase in the penetration of information technology dampens employment by -0.3 percent in the same year and by -1.6 percent after seven years. This relation is reversed in the medium run.

HETEROGENEITY ACROSS REGIONS AND INDUSTRIES

Despite the results identified above having important implications, heterogeneity in technologies and employment across European regions (Wirkierman et al. 2021) and industries (Dosi et al. 2021) raises questions for policy about the relevance of average region-industry employment behavior. For instance, it might be expected that a 10 percent change in use of robots in Inner London and Andalucía would be associated with different employment adjustment patterns. To investigate this, we used cluster analysis to examine both sources of heterogeneity by distinguishing regions and industries within more homogeneous groups.

REGIONAL CLUSTERS

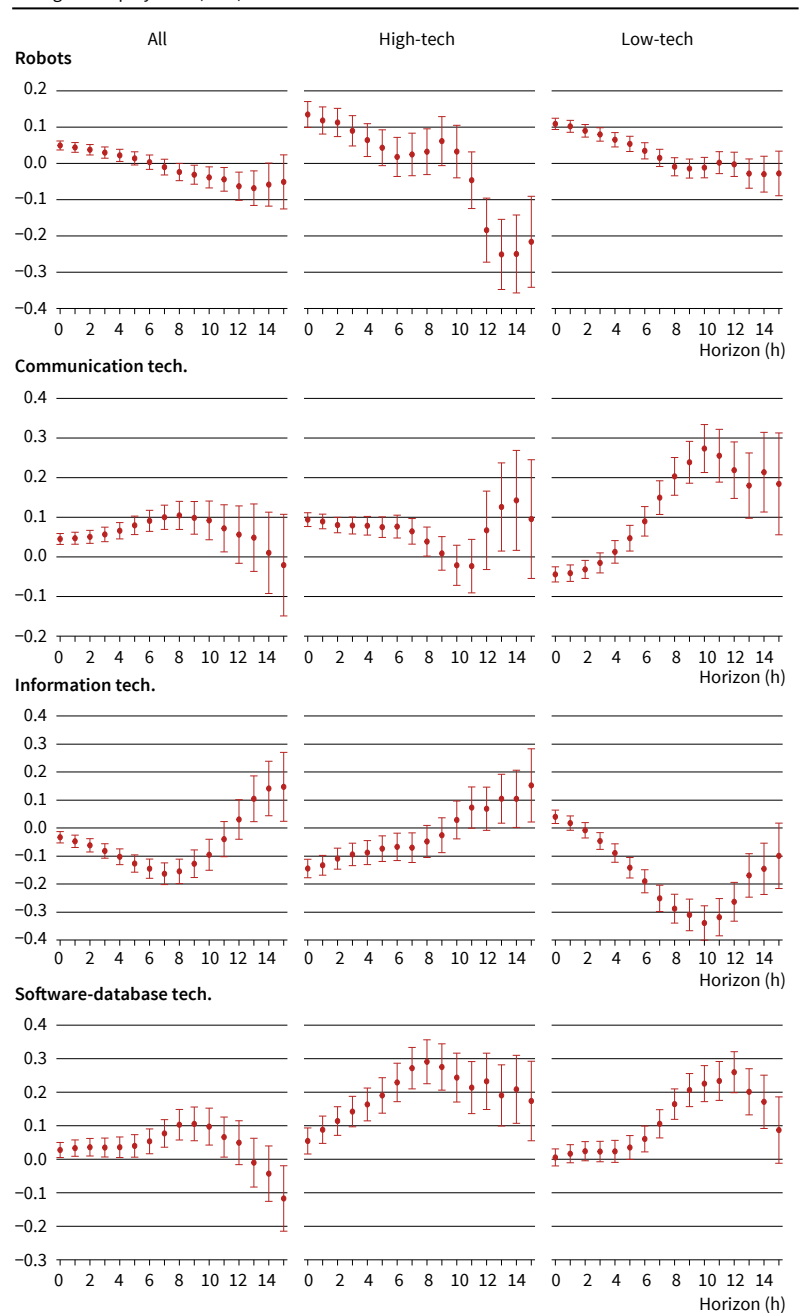
We identified three regional clusters, based on information on the share of highly educated workers, employment in knowledge-intensive activities, and gross value added (GVA) in manufacturing. The first (knowledge-intensive cluster) includes regions with the highest shares of employment in knowledge-intensive sectors and highly educated workers but the lowest share of GVA in manufacturing, as well as low levels of technology penetration in 1996, except for software-database. The second and third clusters are both less service-intensive but differ in the share of the manufacturing sector in the regions' value-added. The high-tech cluster includes regions with high shares of GVA and highly educated workers in high-tech industries, and high levels of technology penetration; the low-tech cluster includes all the remaining regions.

Figure 2 depicts the geographical distribution of regions across the three clusters. Regions that include capital cities (e.g., Berlin, London, Paris, Vienna) and service-intensive regions (e.g., Essex, Hamburg, Provence-Alpes-Côte d'Azur, Utrecht) are in the knowledge-intensive cluster. The high-tech cluster includes traditional manufacturing core regions. The low-tech cluster (most of Spain, South Italy, East Germany) are

Figure 3

Employment Adjustments over Time across Industries

Change in employment (in %)



Note: Employment adjustment over time are expressed as the percentage changes to employment following a 1%-change in technology penetration. Each row of panels represents an individual technology. The first panels in each row refer to the baseline estimates; the second and third panels report the results for each industry cluster. Point estimates and their confidence intervals are presented for each period up to 15 years. Source: EU-LFS for employment; technology penetration based on authors' calculations based on IFR, EU-KLEMS, ARDECO, and IPUMS data.

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areas where manufacturing and knowledge-intensive services are less prominent.

Adjustment of employment to technological penetration differs among the three clusters for all technologies. For instance, in the regions in the knowledge-intensive cluster, robots are associated with lower employment levels over the whole-time horizon. The pattern of employment in high-tech regions is similar to the average in Figure 1, i.e., positive in the short run and then turning negative. Low-tech

regions exhibit large and stable positive employment adjustments following the penetration of robots, with elasticities stable at around 2 percent for a 10 percent increase in penetration up to year 6.

INDUSTRY CLUSTERS

Industries are clustered into a high-tech and low-tech cluster based on average technology penetration (across regions) for the four digital and automation technologies at the beginning of the period in 1996.

The high-tech cluster includes three industries: plastic, chemical products, glass, ceramic (19–23), electrical/electronics (26–27), and automobile and transport equipment (29–30). These industries are characterized by wide penetration of at least two of the four technologies considered. In the case of the automobile and transport equipment sector it is mainly robots and communications technologies; for the electrical/electronics sector it is information technologies and software-database, and all four technologies for the plastics/chemicals sector.

The low-tech cluster contains the five remaining industries (see list in the second Box). These industries have much lower initial levels of technology penetration compared to high-tech industries and differ less in terms of technology investments.

Figure 3 shows the employment response over time to technology penetration for the two industry clusters. The patterns differ significantly for different types of industries.

On average, high-tech industries experience earlier adjustments to employment in the same industry-region than low-tech industries following an increase in penetration of digital technologies. The last three panels show significant changes in employment in high-tech industries in the same year as the investment in the technology occurred, with this changed employment re-absorbed by the industry-region in the medium term. In low-tech industries, employment adjustments emerge only after the fourth year following increased technology penetration and persist in the medium term. These differences might be due to the different ability of workers in the industry to master the new technologies, positive impacts of the new technologies on final demand, or market competition. However, more research is needed on these aspects.

The top panel of Figure 3 emphasizes that the observed heterogeneity in short-term employment adjustments to robot penetration among the three clusters discussed above is not driven by industry composition. It also confirms that high-tech industries do not re-absorb employment in the medium run.

POLICY CONCLUSIONS

The findings suggest that employment adjustments within manufacturing industries in relation to increased investment in different digital and automa-

tion technologies differs across European regions, industries, and time horizons. This suggests the need for different policy instruments for regions with different labor force characteristics, technological endowments, and product specialization.

In terms of time, our findings indicate that in the short to medium run, policies should take account of different time horizons depending on the industries and regions. For instance, employment adjusts more rapidly in high-tech than in low-tech industries. In the medium to long run, compensation mechanisms seem to be in place for most technologies, regions, and industries, although robots in a high-tech region and industry context seem to be an exception, with employment separation persistent in the medium to long run. However, our analysis does not consider reallocation of jobs across industries or regions where more compensation mechanisms may be available.

With respect to regions, compared to low-tech and high-tech regions, knowledge-intensive regions are the least resilient to increased robot penetration. This result requires further scrutiny since it might affect regional industrialization and leveling-up policies. Note that this result is not driven by industry composition.

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Ron Boschma

Regional Diversification and Inequality between and within Regions

Regional inequality is on the rise again (Terzidis et al. 2017). Income inequality across NUTS-2 regions in the EU has risen substantially in the last decades. The same applies to the US, where inequality in income per capita between metropolitan areas has increased. Scholars often attribute rising regional income disparities to technological change and globalization (Moretti 2012; Iammarino et al. 2019). Technological change has decreased trade costs, which makes knowledge-intensive activities concentrate in large cities where the highly paid high-skill jobs are found to an increasing extent. Other (often manufacturing) regions are stagnating economically, due to trade and automation of routine tasks (Autor 2019).

Besides affecting inter-regional inequality, concentration of innovation in certain cities also goes hand in hand with intra-regional inequalities. A prime example is Silicon Valley, whose huge innovative success has been accompanied by crowding out of low-income people due to lack of affordable housing. Florida (2006) claimed that the most innovative cities in the US are also the most unequal. Lee (2011), and Lee and Rodríguez-Pose (2013) found a positive relationship between innovation and wage inequality in European regions. Large cities draw in relatively high amounts of both high- and low-skilled workers (Eeckhout et al. 2014) where the high-skilled workers increase the demand for local services, resulting in an employment multiplier for low-wage jobs (Moretti 2010; Lee and Clarke 2019).

REGIONAL DIVERSIFICATION

However, there is little understanding of the extent to which the entry of new industries in regions affects inequality between and within regions. There is a large body of literature on regional diversification that has focused on the development of industries in regions and how they build on local capabilities from related industries. This literature claims that regions diversify into new activities that are related or close to what they have been doing in the past (Neffke et al. 2011). Many studies have shown that this so-called principle of relatedness (Hidalgo et al. 2018) indeed holds when explaining the entry of new technologies, industries, products, occupations, and scientific fields in regions (Boschma 2017).

Besides showing that regions tend to diversify in related rather than unrelated activities, this literature claims that regions should move into activities

that are more complex. Complex activities are of high value and are considered to bring high economic returns to a region because they combine many capabilities that are very hard to master by other regions (Hidalgo and Hausmann 2009). Balland et al. (2019) found that many regions have the ambition to diversify into complex activities, but only some of them have the capabilities to do so.

REGIONAL INEQUALITY

The regional diversification literature suggests that related diversification in complex industries is likely to increase inter-regional inequality. This is not because high-income regions necessarily diversify more than low-income regions, but because high-income regions have a stronger capacity to diversify into complex activities (Pinheiro et al. 2022) that also bring higher economic benefits to the region (Rigby et al. 2022).

There is a significant amount of evidence that complex activities concentrate in high-income cities, and there is a positive association with their economic performance (Balland and Rigby 2017; Balland et al. 2020; Rigby et al. 2022). This implies that inter-regional inequality is likely to increase, as high-income regions have a greater capacity (i.e., a wide range of relevant capabilities) to

KEY MESSAGES

- **The relationship between diversification and wage inequality in regions is still poorly understood**
- **Related diversification is crucial for economic growth of regions**
- **Related diversification in more complex industries tends to increase wage inequality between regions**
- **Related diversification in less complex industries tends to reduce wage inequality**
- **It remains a policy challenge to combine smart and inclusive growth in regions**

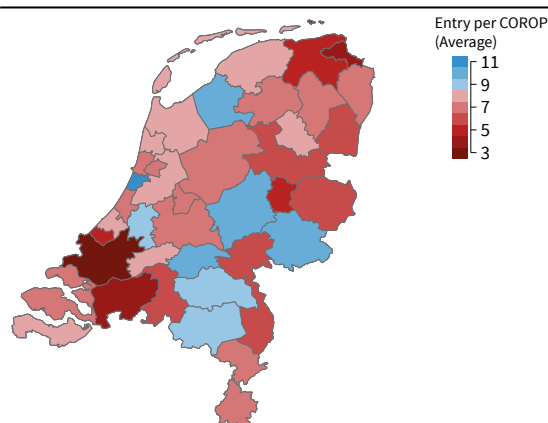


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Figure 1

Map of the Average Number of Entries in Dutch Regions

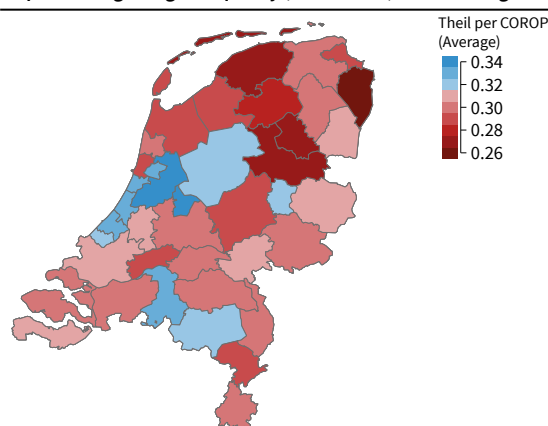


Source: Cortinovis et al. (2022).

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Figure 2

Map of Average Wage Inequality (Theil Index) in Dutch Regions



Source: Cortinovis et al. (2022).

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diversify into complex activities that bring higher economic benefits. Pinheiro et al. (2022) found that advanced regions in Europe have the best opportunity to diversify into high-complex activities, while lagging regions focus mainly on the development of low-complex activities. Their study showed that high-income regions (with a high GDP per capita) not only enter more complex technologies and industries, but also have the highest potential to continue to do so in the years to come, given their strong local capabilities.

The complexity literature (Hidalgo and Hausmann 2009) has investigated the relationship between economic complexity and intra-regional inequality. At the country level, studies have shown that the higher the complexity of an economy, the lower the wage inequality (Hartmann et al. 2017). This finding at the national scale stands in contrast with studies done at the regional scale that show there is instead a positive relationship between economic complexity and inequality at the sub-national scale (Marco et al. 2022; Hartmann and Pinheiro 2022). New York and San Francisco are examples of complex cities that show the highest inequalities. According to Hartmann and Pinheiro (2022), the positive relationship may be attributed to the co-existence of simple and

complex activities in large cities, where relatively little job opportunities exist for middle-income people in semi-complex activities.

However, no study yet exists that has examined the relationship between industrial diversification on intra-regional wage inequality, let alone what such a relationship looks like in case of complex entries. It is also not that straightforward what relationship to expect. Entries in more complex industries are likely to pay higher average wages than entries in less complex industries. Entries in related industries share similar skill requirements with other related industries in the region. Therefore, related entries need to compete for labor with other related local industries, so they might have to offer higher wages to their employees. This may also increase wage levels in the other related industries in the region. This may imply that we can also expect a positive relationship between related complex entries and intra-regional inequality, as complex entries are expected to pay higher wages on average.

Examining the relationship between regional diversification and intra-regional wage inequality requires detailed data on the entry of industries in regions and linking them to wages of individuals within those regions. At the European level, these regional data are very hard to get, which makes it almost impossible to investigate this relationship for all European regions.

Cortinovis et al. (2022) did such an analysis in one single country (the Netherlands) using linked employer-employee micro-data from the Central Bureau of Statistics. These data link industry categories to wages of individuals and their work location in 40 NUTS-3 regions. Figure 1 presents the distribution of the average number of entries across 40 regions in the Netherlands. An industry enters a region when the region becomes specialized in that industry, based on location quotients and applying a bootstrapping technique (Cortinovis et al. 2022). Figure 1 shows that the highest number of entries occur outside the most urbanized regions. The lowest number of entries are recorded in regions like Groot-Rijnmond, West Noord-Brabant, Delft and Westland, Delfzijl en Omgeving, and Overig Groningen.

Figure 2 shows a map of the Theil-index in the 40 NUTS-3 regions in the Netherlands. The Theil index is an entropy measure of inequality widely used in research on regional inequality. Wage inequality levels are highest in the northern part of the Randstad area: Groot-Amsterdam and its neighboring regions such as Gooi en Vechtstreek show the highest scores. Relatively high levels of inequality are found also in Midden Noord-Brabant (in the south). Low levels of wage-inequality can be found in the northern part of the Netherlands in particular.

Cortinovis et al. (2022) regressed the Theil index on the number of entries in each region for 7 overlapping 3-year periods during 2010–2019 and differentiated between different types of entries in terms

of relatedness and complexity. Related entries were defined as entries in industries that are skill-related to other industries (with whom they share similar skill requirements) in which the region is specialized. Complex entries were defined as entries in industries that are complex, using the eigenvector method to compute complexity (Balland and Rigby 2017). Cortinovis et al. (2022) found a negative relationship between entry and levels of inequality: the higher the number of entries in a region, the lower the wage inequality. This was true for related but not for unrelated entries. They also found that less complex entries reduce the level of wage inequality, especially when it concerns related entries. However, the Dutch study did not find a positive relationship between related complex entries and intra-regional inequality, in contrast to expectation, which was based on the assumption that complex entries pay higher wages on average, especially when they have to compete with other related industries in the region. Overall, their findings suggest that related diversification in low-complex industries enhances inclusive growth at the regional level.

POLICY CONCLUSIONS

Many regions have the ambition to combine smart growth and inclusive growth. The smart growth objective means that regions aim to develop new activities that build on local capabilities, as promoted by Smart Specialization policy in the European Union (Foray 2015). However, not every region has the same capacity to diversify into new industries (Neffke et al. 2011; Balland et al. 2019). McCann and Ortega-Argiles (2015), among others, have raised concerns more than once that the more advanced regions have a strong capacity to do so, while backward and peripheral regions lag behind in this respect. If so, smart growth could lead to increasing regional income disparities, at the expense of inclusive growth.

Recent studies on European regions show that this indeed might be a likely scenario. Related diversification seems to favor both high-income and low-income regions, but high-income regions will tend to do that in more complex activities, as opposed to low-income regions that have a stronger capacity to develop low-complex activities (Pinheiro et al. 2022). Because more complex activities on average pay higher wages and bring higher economic benefits to regions in terms of GDP growth (Rigby et al. 2022), this is likely to contribute to widening disparities between regions. This is not easy to correct by policy (see Boschma 2022). At the same time, it might actually be very good that some complex activities (like artificial intelligence) are heavily concentrated in the European space, because this might enable Europe to acquire leadership and compete globally. Having said that, the challenge remains of how to develop more complex activities in peripheral regions and how policy can make a difference in terms of promoting investment

from elsewhere, lifting the research and innovation capacity of local firms, and establishing collaborations with other regions, among other policy actions.

While such concerns about these possible effects have been acknowledged and discussed in Smart Specialization policy in the European Union, this is far less the case for intra-regional inequality. The findings of the Dutch study indicate that entry in low-complex industries that are skill-related to existing local industries tends to reduce wage inequality in a region. In other words, related diversification in low-complex industries might be good for inclusive growth in regions, while Rigby et al. (2022) showed that related diversification in high-complex industries is best for smart growth in European regions. This implies that the challenge remains of how to combine and align the two objectives of smart growth (as addressed by Smart Specialization policy) and inclusive growth (the main focus of the Cohesion policy). However, we must be cautious not to draw strong conclusions concerning policy implications at this stage, which is based on few studies so far, and also because many of the unresolved issues are still poorly understood, such as the role of (national and regional) institutions.

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Andreas Baur, Lisandra Flach and Isabella Gourevich

The Effect of Robotization in OECD Countries on Latin American Exports

In the past decades we have observed rising use of industrial robots, which has been especially pronounced in high-income countries. According to the International Federation of Robotics (IFR), more than 3 million industrial robots were operating in factories around the world in 2020 (IFR 2021); the stock of industrial robots rose by a factor of 5 between 1993 and 2015 in North America, Europe, and Asia (Dauth et al. 2021). Automation has primarily taken place in manufacturing, but also in other sectors, such as agriculture or services. These trends have had disruptive effects on domestic markets, which spurred research on the economic effects of automation. In particular, scholars have focused on the impact of robots on productivity and labor market outcomes.

However, the impact of robotization is not constrained to the domestic market and can spill over globally through supply chains and affect firms in developing countries through different mechanisms. There are two main channels through which automation might affect trade flows. The first channel focuses on the shift in relative production costs. Automation might reduce production costs in high-income countries, such that low-income, labor-abundant countries may lose their relative cost advantage in producing formerly labor-intensive goods. This could lead to the reallocation of production sites back from the global South to the global North (i.e., reshoring). In this case, products from developing countries might face a decline in global demand, adversely impacting local economic development (Rodrik 2018). The second channel operates through the increase in efficiency of robot-adopting firms in the North, such that these firms expand their pro-

duction. In this case, their demand for intermediates might increase, which could benefit developing countries (Artuc et al. 2020).

This policy brief investigates the effect of robotization in the global North on firm-level exports from Latin America across sectors. Importantly, we evaluate the impact of robotization in the North on firm-level North-South trade along the entire supply chain. This allows us to take into account inter-country input-output linkages that channel the effects of automation in the global North to firms in the global South. The results from our empirical analysis indicate

KEY MESSAGES

- **The effects of automation in high-income countries are not limited to domestic economies, but might spill over via global supply chains**
- **We evaluate the effects of robot adoption in OECD countries on exports from Latin America to the OECD along the value chain**
- **We combine detailed firm-level data for four Latin American countries with data on robot adoption and input-output linkages**
- **In response to robot adoption, exports in the same industry decrease, but exports increase for products along the value chain**
- **Our results indicate the importance of evaluating supply chain linkages when drawing policy conclusions about the effects of robotization**



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the importance of evaluating supply chain linkages when drawing policy conclusions about the effects of robotization.

TAKING STOCK OF THE ACADEMIC LITERATURE

Robotization is often discussed as the third big economic transformation in modern times.¹ The adoption of robots has caused a reorganization of production in many industries, spurring academic research on the economic impact of automation.

Firms have in general profited from technological advances in robotics. Adoption of robots has reduced production and operational costs for firms, which has led to sizable productivity gains (Koch et al. 2021). Multiple studies have shown both at the aggregate and at the firm level how automation augments labor productivity (Graetz and Michaels 2018), increases value-added (Acemoglu and Restrepo 2020), and boosts competitiveness (Bonfiglioli et al. 2020). While the literature agrees on the overall gains of robotization for firms, the impact on the workforce is still disputed.

In a recent literature survey, Aghion et al. (2022) show two contrary views on the impact of robots on labor demand. The optimistic view posits that through increases in productivity and competitiveness firms can expand their market shares, lower the price of goods, and increase the overall size of the market. This potentially leads to an increase in both employment and wages. The pessimistic view highlights that the increase in labor demand as a result of productivity gains only applies to the labor force that performs complementary tasks. At the same time, automation might lead to a displacement of workers from labor-intensive tasks, which are then performed by robots. Acemoglu and Restrepo (2020) provide evidence for the US labor market that the latter effect dominates. They find that automation leads on aggregate to a decline in employment and wages in local US labor markets. Based on Spanish firm-level data, however, Koch et al. (2021) found evidence for positive employment effects in robot-adopting firms and negative employment effects for firms which do not adopt robots. For the German labor market, Dauth et al. (2021) show a nuanced picture. Here, the displacement effect of automation in manufacturing is fully offset by re-allocation effects towards service industries.

Taking stock of these findings, the jury seems still to be out on the question whether automation leads on aggregate to positive or negative employment effects at home. However, in the age of global value chains (GVCs), automation also has an impact on the (international) sourcing decision of firms and can thereby affect the economies of trading partners abroad. Echoing the views on the domestic employ-

ment effects of automation, two different channels for the effect of automation on international trade are conceivable. First, automation might put low-skilled and replaceable jobs at risk not only at home, but also abroad due to a change in relative production costs. This could especially affect trade flows between the global North and South. If robots can take over tasks at lower costs which were originally performed by low-skilled workers in the South, the current pattern of relative cost advantages might change and production sites might increasingly be relocated to the North (i.e., production reshoring). On the other hand, productivity gains for robot-adopting firms in the North might also translate into increasing demand for intermediate goods coming from the South, with positive implications for trade and growth.

The empirical findings on the impact of automation in the global North on trading partners in the global South are relatively scarce and to some extent inconclusive. There is limited evidence for automation-induced reshoring from South to North. Krenz et al. (2021) show, based on a cross-country framework, a strong association between automation and reshoring at the macro-level. For the case of Spain, Stapleton and Webb (2021) find that robot adoption had no impact on the offshoring activity of firms in the case that they were already offshoring to low-income countries, but robot adoption increased offshoring activities of firms that had not yet offshored to such countries. In total, they cannot detect a clear effect on the value of imports from developing countries. Taking the perspective of a country from the global South, Faber (2020) finds evidence that robot adoption in the US had a negative effect on local employment and exports in Mexico. Similar findings are reported by Stemmler (2019) for Brazil and Kugler et al. (2020) for Colombia. On the other hand, Artuc et al. (2022) provide support for a strong efficiency channel of automation and argue that in the long run, developing countries will profit from robot adoption in the Global North through an increase in global demand for intermediate and final goods.

EFFECT OF ROBOT ADOPTION ON FIRM EXPORTS ALONG THE SUPPLY CHAIN

The objective of our analysis is to provide empirical evidence on the effect of robot adoption in high-income countries on firm-level exports of Latin American countries.² For this purpose, we use detailed firm-level data for four Latin American countries (Mexico, Brazil, Peru, and Uruguay), which accounted for 68.5% of Latin American exports in the year 2019.³ The data covers the universe of exports by firm, HS

² The results presented in this article are based on Baur et al. (2022).

³ Numbers are based on Inter-American Development Bank data on goods exports of Latin American countries, which in turn are based on official data from national sources.

¹ The first transformation being industrialization in the 18th century and the second being the service transformation during the middle of the last century.

6-digit product, destination country of exports, and year over the period 2001–2007.⁴ From Figure 1 we can observe that the OECD is an important destination region for Latin America, with an export share of 60% for the countries covered in our analysis. This provides support for our assumption that changes in the robot stock of the selected destination countries will impact exports. Interestingly, the share of exports to other Latin American (neighbor) countries⁵ is low in comparison to exports to other world regions. This is quite surprising, as gravity trade theory predicts high trade shares with neighbors, but it reinforces the importance of shocks outside Latin America on exports.

We combine our firm-level data with data on industrial robot adoption from the International Federation of Robotics (IFR), which are available for most OECD countries by industry and year of robot adoption. One challenge for our project is to account for the proper automation shock that exporters face in the destination country of exports. To our knowledge, the literature accounts for robot adoption in the same industry, meaning that textile exporters are affected by robot adoption in the textile industry.⁶ However, this analysis disregards value-chain linkages, which account for a great part of the shock faced by developing countries. For instance, a textile producer is not only affected by automation in the textile industry in the North (due to an increase in competition), but also by shocks in all other industries that use textile products as inputs. Hence, we construct a novel dataset using input-output linkages from the Bureau of

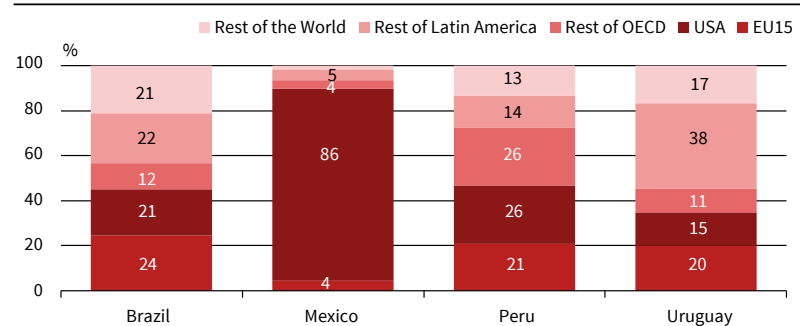
⁴ Firm-level data for Mexico, Peru, and Uruguay come from the World Bank Exporter Dynamics Database. Firm-level data for Brazilian firms come from SECEX (Brazilian Foreign Trade Secretariat).

⁵ Latin American Members of the OECD (Chile, Costa Rica, Colombia, and Mexico) are categorized as Rest of Latin America and are excluded from the OECD group for this analysis.

⁶ One exception is Stemmler (2019), who distinguishes between final product and intermediate exports based on the World Input Output Database (WIOD).

Figure 1

Exports from Latin America by Destination Regions



^a The graph depicts the distribution of exports from Brazil, Mexico, Peru and Uruguay across different destination regions in 2001. OECD countries are the main destinations of exports for products from Brazil, Mexico, Peru and Uruguay.

Quelle: World Bank Exporter Dynamics Database; SECEX; authors' calculations.

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Economic Analysis (BEA-US) to map exported products to all industries in which they are used as inputs. In this way, automation shocks in the destination are mapped to trade flows using same-industry linkages as well as value-chain linkages.

In terms of our empirical strategy, we estimate the effect using long differences between 2001 and 2007 to account for lagged effects in the adoption of robots.⁷ Table 1 shows our main results. Columns 1 and 2 provide evidence on same-industry effects, whereas columns 3 and 4 show the effects along the value chain. Robot adoption in OECD countries is associated with a reduction in exports of Latin American countries, when solely considering effects in the same industry (see columns 1 and 2). However, once we account for input-output linkages and trade along the value chain, the opposite holds: we find a positive effect of robot adoption on firm-level exports to OECD countries (see columns 3 to 5). This positive export effect also remains significant when accounting

⁷ To account for selection effect due to entry and exit of firms, we estimate the effect of robot adoption on trade using a Pseudo-Maximum-Likelihood estimator.

Table 1

Effect of Robotization in OECD Countries on Latin American Exports: Same-industry Effects vs. Effect along the Value Chain

Outcome variable:	Direct linkages			Indirect linkages	
	(1)	(2)	(3)	(4)	(5)
Firm-level exports to OECD					
Robots stock	-0.0135* (0.00763)	-0.0126** (0.00496)	0.252* (0.129)	0.0770 (0.0600)	0.313*** (0.0574)
Total imp of destination	0.0621*** (0.0178)	0.0581*** (0.0173)	0.754*** (0.0965)	0.810*** (0.0884)	0.850*** (0.101)
Observations	100,142	100,140	86,332	86,332	86,272
Firm-product-destination	Yes	Yes	Yes	Yes	Yes
Origin-destination-time	Yes	Yes	Yes	Yes	Yes
Product-time	Yes	Yes	Yes	Yes	Yes
Sector-origin-time		Yes		Yes	Yes
Sector-destination-time					Yes

Note: All results include interacted firm (in the origin country), HS 6-digit product, and destination-fixed effects to account for unobserved heterogeneity of firm-product pairs by destination. As we want to rule out the effect of changes in trade policy and country-specific policies, we also include importer-exporter-time fixed effects to absorb any time-varying changes by country pair. In addition, we include product-time fixed effects, which help mitigate endogeneity concerns related to changes in demand for specific products, such as commodities over this period. Note that we also include imports from the rest of the world as a control variable to account for changes in demand by product in the destination country. Standard errors are clustered two-way by importer-product and year.

Source: Authors' own calculation.

for unobserved shocks specific to an industry in the destination country.⁸

POLICY CONCLUSIONS

Our empirical analysis shows that robot adoption in the global North does not necessarily pose a threat to export-led growth in developing countries. On the contrary, advanced economies might increase their demand for goods and services from developing countries thanks to productivity gains related to automation. This could open new opportunities for firms in the global South to benefit from participation in global value chains. Domestic government policies can play an important role in facilitating integration of developing countries into GVCs (World Bank 2020).

A central policy priority in this context should be the lowering of trade costs and better access to trade infrastructure. Lowering tariffs and other nontariff barriers gives firms better access to foreign intermediate inputs, which improves their GVC integration. Additionally, the adoption of new trade agreements makes serving foreign markets less costly for domestic firms and, as a result, it might increase integration into international production networks. For the same reason, policy measures to streamline border procedures and to improve domestic infrastructure are essential to reap the benefits of exporting and of participating in GVCs.

Another set of policies relates to foreign direct investment (FDI). By attracting multinational corporations (MNCs), domestic firms can more easily enter global production networks and benefit from knowledge and technology spillovers. Not only firms acquired through FDI, but also domestic firms that become a supplier to an MNC might observe substantial productivity growth.⁹ To make FDI more attractive, governments should focus on improving domestic institutions and engage in proactive investment policies. For example, investment promotion agencies (IPA) can successfully reduce information asymmetries that often impede the first investment of MNCs in a foreign country (Carballo et al. 2021). Moreover, government programs targeted at increasing linkages between MNCs and domestic suppliers can also play an important role in sharing the benefits of GVC participation more broadly and enhancing the transfer of foreign knowledge and technology.

It is also important that policymakers take into account that the positive effects of automation on North-South trade might come with important distri-

butional consequences within developing countries, which could lead to disruptions in local labor markets. For this reason, investments in the training of workers and sound distributive policies are crucial to mitigate the adverse effects of both domestic and foreign automation and to share the gains from trade more equally.

Finally, the functioning of complex GVCs crucially depends on the rule-based multilateral trade order, especially when it comes to the GVC participation of firms in developing countries (World Bank 2020). A revival of multilateral trade cooperation and an ambitious reform of the WTO should therefore figure prominently on the priority list of policymakers around the world.

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⁸ This is an important advantage of exploiting input-output linkages in comparison to same-industry linkages. In the second case, we cannot account for shocks that are specific to an industry-country pair, whereas in the case of input-output linkages we control for all shocks that affect an industry-country pair over the period.

⁹ Using data for Indonesian firms, Arnold and Javorcik (2009) provide evidence of productivity increases from being acquired by an MNC. Alfaro-Urena et al (2022) show positive productivity effects of becoming a supplier to an MNC using firm-to-firm data for Costa Rica.

Filippo Bontadini, Valentina Meliciani, Maria Savona and Ariel Wirkierman

Nearshoring and Farsharing in Europe within the Global Economy*

Has the world economy really entered a phase of de-globalization or deceleration in globalization after the Great Recession of 2008–2009? Or, rather, are we experiencing a phase of reorganization of value chains with a shift from global to more regional configurations? Is the increasingly popular term “nearshoring” indicative of a significant trend similarly affecting Europe, Asia-Pacific, and the Americas on both the sourcing and destination sides of value chains, or are there regionally distinctive trends?

Recent studies addressing some of these questions find no conclusive evidence of de-globalization, but rather a slowing down of the pace of globalization relative to the “hyper-globalization” era (1986–2008) (Piatanesi and Arauzo-Carod 2019; Antràs 2020). Despite the extensive literature on globalization trends and the revived interest in the topic due to the emergence of the Covid-19 pandemic (Baldwin and Evenett 2020) and the war in Ukraine, empirical evidence on the reconfiguration of global value chains (GVCs) that takes into account both the sourcing (production) and destination (consumption) of value added within and across regional areas is still missing.

Taking into account both the source and destination sides of GVCs is essential for envisaging possible strategies and avenues to follow in Europe in line with the concept of open strategic autonomy.

This policy brief applies (and further refines) the well-established input-output methodology (Foster-McGregor and Stehrer 2013; Timmer et al. 2014; Los et al. 2015) to the recently released OECD Inter-Country Input-Output (ICIO) 2021 dataset to shed light on these issues.

We find very clear-cut results for Europe, suggesting two opposite trends on the source and destination sides of GVCs: Europe is increasingly sourcing value added from within the region (which we refer to as “nearshoring”) but exporting value added globally (a so-far understudied phenomenon which we term “farsharing”).

These two trends raise new questions on Europe’s GVC participation. On the one hand, there is the degree to which it is driven by innovation and international competitiveness and, on the other, there is the role played by the contraction of domestic demand, partially brought about by fiscal consolidation policies in Europe over the past decade.

In light of this, our evidence suggests that policies aiming at strategic autonomy in Europe should take into account Europe’s increasing dependence

- KEY MESSAGES**
- **We distinguish the geographical source and destination of value added contributed by each country-industry to each country-global-value-chain (GVC) from both input sourcing and output destination perspectives**
 - **We define indicators that capture the relative intensity of regional vis-à-vis global (i.e., extra-regional) components of foreign value added and employment**
 - **Europe is increasingly sourcing value added from within the region (“nearshoring”) but exporting value added globally (“farsharing”)**
 - **European GVCs mostly generate foreign employment outside Europe. In contrast, most of European employment is activated by European GVCs: an important labor market policy implication arguing for more intensive intra-EU trade and integration**
 - **Europe and its economic policy should not only focus on the sourcing of value added across production processes, but also on the final demand that generates economic activity in Europe**

on foreign demand, especially in relation to the long-standing effects of fiscal consolidation policies on its own countries’ domestic final output. In sum, Europe should not only focus on the sourcing of value added across production processes, but also on the final demand that generates economic activity in Europe.

MEASURING REGIONAL AND GLOBAL VALUE-ADDED CONTENT OF TRADE

The starting point to devise nearshoring and farsharing indicators is the world’s gross value added (GVA). Each monetary unit of gross output embod-

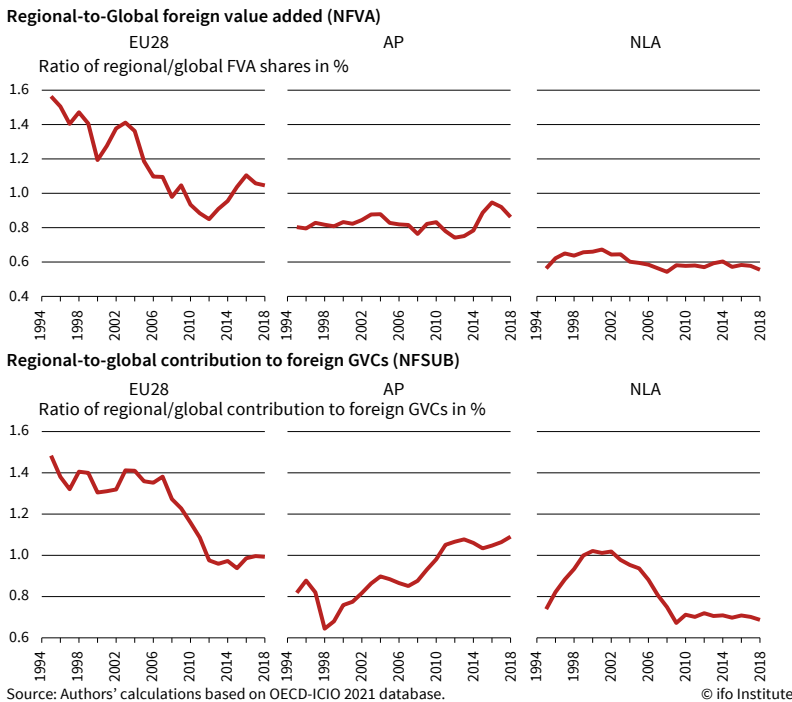
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Figure 1
Regional-to-global Foreign Value Added, and Regional-to-Global Contribution to Foreign GVCs



ies an amount of value added. But gross output is itself induced by demand for final products through direct and indirect inter-country, inter-industry input requirements. Hence, the value-added content of output can be distributed across and linked to each generating source of final demand, adding up to total value added in the world economy.

Using matrix algebra (for details, please refer to Bontadini et. al. 2022), it is possible to distinguish the geographical source and destination of value added contributed by each country-industry to each country-global-value-chain (GVC).¹ In technical terms, a country-GVC represents an international subsystem (Sraffa 1960) or vertically integrated sector (Pasinetti 1973), in the sense that it is a unit of analysis comprising all direct and indirect input (and value added) requirements to produce a given element of final output in the world economy.

To pursue our analysis, we formulate indicators capturing two aspects of the redistribution of global income through GVCs. First, we adopt an input sourcing perspective: we look at where value chains

¹ It is important to stress the difference between country-industry and country-GVC. The former refers to a given industry in a given country – much like in standard statistics – which produces both final and intermediate goods. The latter, instead, refers to the production of final goods that reaches completion in a given country-industry but also includes the value-added contributions of all other countries and industries across the world. For example, the production of the textile industry in Italy includes both cloth that is used for production by other industries and dresses that are sold as final products. The Italian GVC instead only includes dresses sold as final goods but it includes the value added of design, yarn, dyes, and cotton (and other intermediates) coming from outside the Italian textile industry.

in each region draw value-added contributions from and whether this comes from within (i.e., the Regional Foreign Value Added Share, RFVAS) or outside (i.e., the Global Foreign Value Added Share, GFVAS) a country's region.

Second, we adopt an output destination perspective: we look at the final destination of domestic value added and whether it contributes to value chains articulated within (i.e., Regional Foreign Subsystem Share, RFSUBS) or outside (i.e., Global Foreign Subsystem Share, GFSUBS) a country's region.

We then define regional-to-global ratios:

$$(1) \quad NFVA = \frac{RFVAS}{GFVAS} \quad \text{and} \quad NFSUB = \frac{RFSUBS}{GFSUBS}$$

capturing the degree of regionalization of value chains or industries, respectively. Hence, if NFVA is increasing (decreasing), the country (or region) is nearshoring (farshoring), whereas if NFSUB is increasing (decreasing), the country (or region) is nearsharing (farsharing).

In order to capture the employment dimension of international production fragmentation, besides computing the redistribution of global income through GVCs, we also formulate all previous indicators in terms of the employment content of final output.

Hence, on the one hand, from an input sourcing perspective, we will have the Regional Foreign Employment Share (RFEMS) and the Global Foreign Employment Share (GFEMS), quantifying the proportion of total GVC employment coming from within or outside a country's region. On the other hand, from an output destination perspective, we compute the domestic employment contributions to foreign regional (RFSEMS) and global (GFSEMS) GVCs. In this case we also define regional-to-global ratios:

$$(2) \quad NFEM = \frac{RFEMS}{GFEMS} \quad \text{and} \quad NFSEM = \frac{RFSEMS}{GFSEMS}$$

Thus, we use the indicators devised to quantify the extent of far/nearshoring and far/nearsharing in the global economy from both income and employment perspectives.

RESULTS

Computations require a set of global input-output tables. We use the OECD Inter-Country Input-Output (ICIO) dataset – published in November 2021 – providing data for 45 industries (based on ISIC Rev. 4) across 66 countries, covering the 1995–2018 period.² We consider three macro-regions: the European Union (EU28), Asia-Pacific (AP), and North and Latin America (NLA).³

² Data can be accessed at <http://oe.cd/icio>.

³ EU28 considers 28 European countries, including Croatia and the UK; AP considers 18 countries: ASEAN Plus Six (i.e., including China, Japan, South Korea, India, Australia, and New Zealand), together with Hong Kong and Chinese Taipei; NLA considers 9 countries: US-CA, together with Argentina, Brazil, Chile, Colombia, Costa Rica, and Peru.



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We focus on GVCs articulated around manufacturing final outputs to compute foreign value-added shares,⁴ and on manufacturing industries to compute domestic value-added contributions to foreign GVCs.⁵

The upper panel of Figure 1 reports the ratio between RFBAS and GFBAS, while the lower panel depicts the ratio between RFSUBS and GFSUBS. These correspond to NFVA and NFSUB in equation (1), respectively. Increases in these ratios reflect nearshoring of the sourcing of FVA and its homologue on the destination side, which we term as “nearsharing,” respectively.

We can see starkly different patterns for each region, with three key findings emerging.

NEARSHORING IN EUROPE AND ASIA-PACIFIC

First, Europe has a much higher level of intra-regional integration than both Asia-Pacific and the Americas; this is true when looking at either NFVA or NFSUB in Figure 1.

The upward trend for NFVA since 2012 in Europe and Asia-Pacific suggests that nearshoring is taking place in both regions. For Europe, this comes after a long decline in the sourcing of regional *vis-à-vis* extra-European value added. In contrast, Asia-Pacific shows a rather stable trend until 2012.

Looking at the upper panel of Figure 2, we can see that this common nearshoring trend since 2012 actually has different drivers. In Asia-Pacific, it is the result of a sharp decline in global sourcing *vis-à-vis* a stagnant regional share, implying an increase in domestic value-added content.⁶ In contrast, nearshoring in Europe is linked to a steady increase in the regional

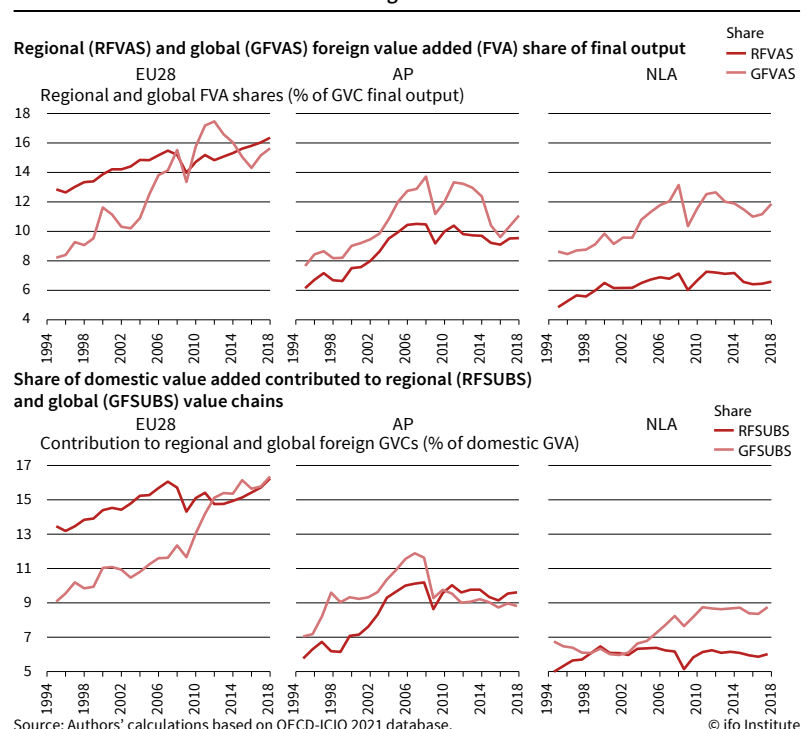
value-added share coupled with a declining (though later rebounding) global share. Finally, the Americas show a slowly declining trend for NFVA, with regional FVA remaining at relatively lower levels than for the other two regions.

COMMODITY PRICE SUPER-CYCLE AND GLOBAL BACKWARD LINKAGES

Looking at the upper panel of Figure 2, the synchronized rise (2002–2012), decline (2012–2016), and rebound (2016–2018) of the global FVA component (GFBAS) across regions – though with different intensity – suggests the influence of a common driver, namely, the commodity price super-cycle (Reinhart et al. 2016).

Figure 2

Regional and Global Foreign Value Added Share of Final Output, and Share of Domestic Value Added Contributed to Regional and Global Value Chains

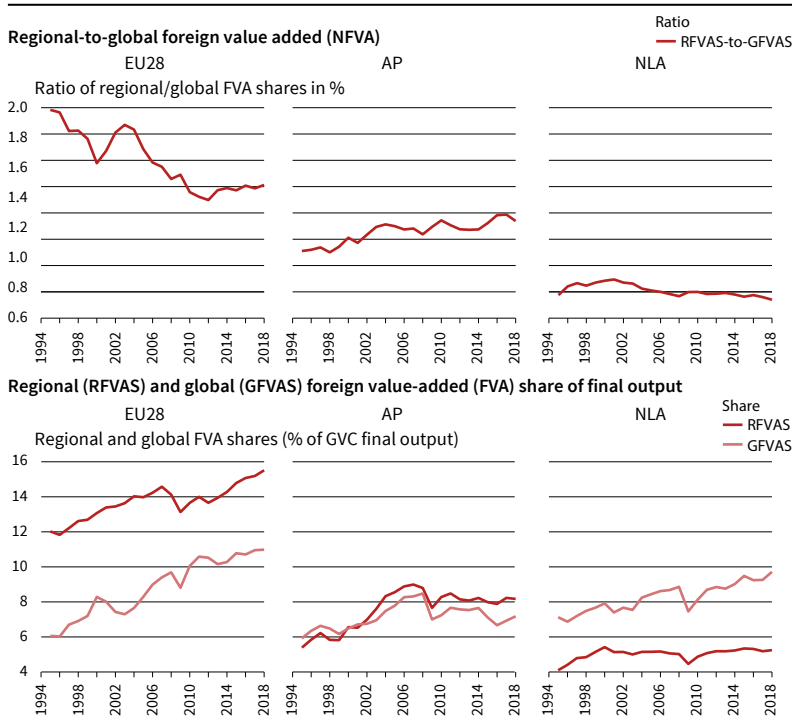


⁴ This means that we only consider the production of final manufacturing goods. Recall, however, that a manufacturing GVC requires – directly and/or indirectly – inputs from all industries of an economy (primary sectors and services included).

⁵ A manufacturing industry contributes to foreign GVCs for all final products (primary sectors and services included).

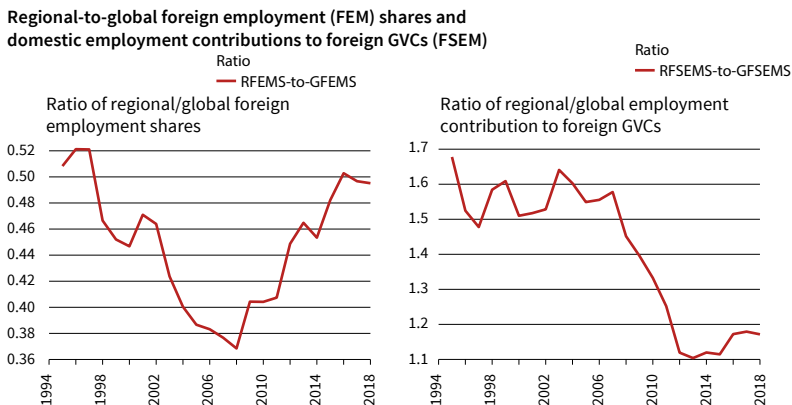
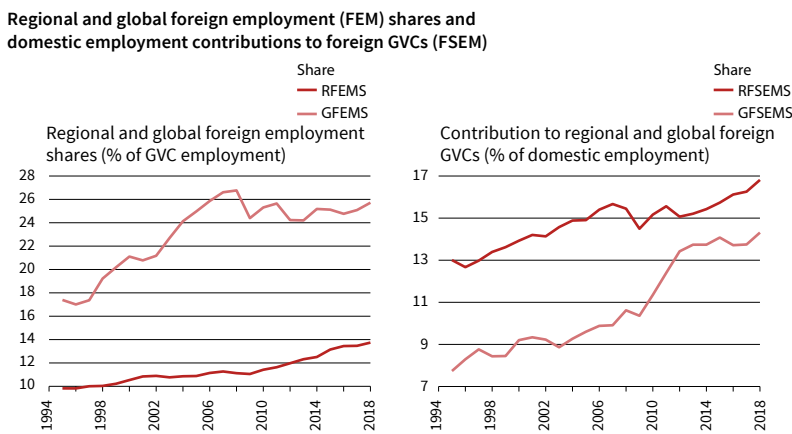
⁶ This is because RFBAS and GFBAS are shares of value added and together with the domestic share of value they add up to 100 Percent.

Figure 3
Regional-to-Global Foreign Value Added, and Regional and Global Foreign Value-added Share of Final Output



Note: All value added corresponding to primary industries has been excluded from the computations. The upper panel of the figure replicates the upper panel from Figure 1, while the lower panel does the same for the upper panel from Figure 2.
Source: Authors' calculations based on OECD-ICIO 2021 database. © ifo Institute

Figure 4
Regional and Global Foreign Employment Shares and Domestic Employment Contributions to Foreign GVCs, and Regional-to-Global Foreign Employment Shares and Domestic Employment Contributions to Foreign GVCs



Note: All value added and employment corresponding to primary industries has been excluded from the computation. Source: Authors' calculations based on OECD-ICIO 2021 database. © ifo Institute

As a robustness exercise, we recalculate regional and global FVA shares but exclude all value-added contributions by primary industries from our computations, reporting results in Figure 3.⁷

Notably, now the regional FVA share appears always above the global FVA component for Europe and Asia-Pacific (lower panel of Figure 3). This suggests that their relative dependence on extra-regional input sourcing fluctuates with commodity prices and, more importantly, signals a limited input substitutability capacity as prices increase. Hence, global backward linkages in value-added terms are considerably affected by primary commodity prices.⁸ This notwithstanding, the upper panel of Figure 3 suggests that the nearshoring trend in Europe since 2012 persists, with no sign of it slowing down after 2016, even when the commodity price super-cycle is accounted for.

FARSHARING IN EUROPE

Third, when it comes to the (regional/global) destination of domestic value added – in lower panels of Figure 1 – NFSUB in the Americas first increased starkly when NAFTA came into effect, but steadily decreased as China joined the WTO (2001) and became a major player in the global economy, absorbing growing shares of American-produced GVA. Instead, nearshoring in Asia-Pacific is complemented by a relative increase in the regional destination of its domestic value added. This is mainly driven by a declining global share in combination with a stagnant regional share (GFSUBS and RFSUBS in Figure 2, respectively), reflecting the fact that this region has been able to rely on its countries' own domestic demand to absorb value added.

Europe shows yet a different pattern. On the one hand, non-European value chains have been absorbing an increasing share of value added produced within the continent (GFSUBS in the bottom-left panel of Figure 2). On the other hand, it took almost a decade for the share of European value added absorbed by European value chains (RFSUBS) to recover its pre-crisis level (2007). The combination of these two trends leads to what we refer to as “farsharing.”

NEARSHORING OF EMPLOYMENT IN EUROPE

Trends in the employment content of final output in Europe reflect trends in value added but also differences in productivity across geographical areas.

⁷ The inter-country input-output database used is only available in current prices, making it impossible to disentangle price from volume effects. We therefore exploit the fact that price effects from primary commodities originate from a clear subset of industries to exclude these from our calculations. Please note that, by focusing on the industry of origin, rather than the final product around which a GVC is articulated, indicators RFSUBS and GFSUBS are unaffected by these recalculations, given that we already focus on manufacturing industries of origin contributing to all GVCs.

⁸ While this is well beyond the scope of this work, our results do suggest that it may prove to be a challenge for Europe to quickly end its dependence on Russian gas.

Figure 4 (upper left panel) shows that, from an input sourcing perspective, the Regional Foreign Employment Share lies always below the Global Foreign Employment Share (GFEMS), despite the opposite being true for the foreign value-added shares (Figure 3, lower panel). Although Europe is sourcing the majority of value added from within the region, the employment contribution from within the region is below the global employment contribution. This means that the GVC activities carried out outside Europe are more labor intensive than those performed within Europe.

Looking at trends in the ratios, we also find evidence of nearshoring in the case of employment (Figure 4, lower left panel). The phenomenon is more pronounced than value added nearshoring and starts in 2008 with the financial crisis. This is probably due to both a stagnant global component of foreign value-added contribution to European value chains and to a decrease in global labor requirements.

From an output destination perspective, the domestic employment contributions to foreign regional GVCs (RFSEMS) are always larger than the global (GFSEMS) ones (Figure 4 upper right panel). This occurs also after 2011, when non-European value chains started absorbing more global than regional value added (see lower panel Figure 2). Overall, we find from 2008 to 2012 a clear phenomenon of farshoring also in the case of employment (Figure 4 lower right panel), with foreign non-European GVCs generating an increasing share of employment in European industries.

DISCUSSION AND POLICY CONCLUSIONS

In conclusion, our analysis identifies three distinct GVC integration patterns. First, a European model, characterized by an increasing regionalization of its foreign value-added sourcing (nearshoring) and a globalization of EU domestic value-added contributions (farshoring). Second, and in contrast to Europe, the Asia-Pacific area has experienced a relative regionalization of input sourcing and a consolidation of its own countries' domestic final demand for value-added absorption after the global financial crisis (2008–2009). Finally, the Americas have, by far, the lowest level of GVC regionalization, both in terms of input sourcing and of domestic value-added destinations, in stark contrast with the other regions.

The evidence of nearshoring in Europe seems to be the effect of a faster increase in the regional share than the global share of sourcing. However, it remains to be seen whether such trends will hold in the future.

At the moment, both the pandemic and the war in Ukraine suggest that, at least in some strategic areas, there are political reasons for geographically shortening global value chains. To fully grasp the evidence of farshoring, note that domestic value added contributes to either foreign (regional/global) or domesti-

cally articulated GVCs.⁹ It follows that a stable share of value added absorbed by European value chains – coupled with a sharp increase in the share of value added absorbed by extra-regional ones (gradually replaced by intra-regional demand since 2012) – suggests that final demand from domestically articulated value chains has been particularly weak.

This has two key implications that warrant further research and policy discussion. First, it appears that, following the global financial crisis (2008–2009) and sovereign debt crisis in some European countries (2011), fiscal consolidation policy in Europe has contributed to shrinking demand from domestically articulated value chains. The extent to which this has happened may have been underestimated by policymakers across the continent. Second, in response to this, European industries have re-directed output towards extra-European value chains (Polyak 2021).¹⁰

The nearshoring and farshoring trends suggest the consolidation of a European export-led growth model involving an increase in intra-regional backward linkages and a diversification towards extra-regional markets. While the perception of the fragility of GVCs to external shocks after the pandemic and the war in Ukraine has shifted the debate on the trade-off between efficiency and security in the direction of reshoring or nearshoring (Javorcik, 2020; Posen 2022; World Bank 2022), little attention has been paid to the destination of European value added.

Differently from Asia, where nearshoring is accompanied by an increasing domestic absorption of value added, Europe has become increasingly dependent on foreign demand. This requires a deeper analysis of the gains and losses for Europe of a process of further fragmentation of value chains into regional blocks. While Europe should be aware of the economic and political risks of a deceleration of globalization and should defend multilateralism and resist a new wave of protectionism, its capacity to play a geo-economic role requires a step forward in both common industrial and macroeconomic policies.

This implies that a deeper reflection should be made on the future of European economic governance and on the necessity to reconcile the EU domestic and global agendas (Buti and Messori 2022). Open strategic autonomy requires an adequate European fiscal stance, which can be achieved only through a central fiscal capacity allowing European common investments that are necessary not only for ensuring the supply of strategic inputs, but also to sustain European demand.

Finally, from an employment perspective, our results show that European GVCs mostly generate employment outside Europe, suggesting that these are

⁹ This is because RFSUBS and GFSUBS are shares of value added and, together with the share of value added absorbed by domestic value chains, they add up to 100 Percent.

¹⁰ The evidence we present in this study is aggregated at the European level, masking, no doubt, a great deal of heterogeneity at the country and industry level. In our ongoing research, we apply the methods outlined here to provide insights at a more granular level.

low-value-added jobs. In contrast, most of European employment is generated by European GVCs. In this respect, our results suggest caution in considering the benefits of nearshoring from an employment perspective. With regard to sourcing, it is mostly low-wage and low-productivity jobs that are likely to be reshored; from the destination perspective, it seems that most EU jobs are already dependent on European value chains and that there is therefore little potential to increase this further.

Overall, these results highlight that value added and employment are not always distributed in the same way along GVCs and that both aspects should be at the forefront of policy discussions on the future of GVCs.

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Chao Ma and Zhong Zhao

Brain Drain from Europe to China in a Digital Economy Era?

Over the past several decades, China has significantly affected the European labor market through trade in commodities, via channels discussed in Autor et al. (2013). The same authors (2021) found that these effects can be persistent. For example, Dauth et al. (2021) found that trade exposure benefits highly skilled workers but hurts low-skilled workers in the German manufacturing sector. Kiyota et al. (2021) show that the import penetration of final goods from China has negative effects, but that the import penetration of intermediate inputs could have positive effects on manufacturing employment in six advanced countries and that such positive effects could more than offset the negative effects in some of them.

China is the biggest emerging economy and is quickly evolving from a developing into a developed economy. Several key features will weigh in China's future development: labor costs in China are rising, and the manufacturing sector is moving from labor-intensive to capital- and technology-intensive. China is not only a manufacturing powerhouse, but it is also becoming a leading service provider: the tertiary industry accounted for 54.5 percent of Chinese GDP in 2020.

In the future, the composition of trade will change, and other channels will become more important as emerging technologies and industrial transformation take hold. In this article, we investigate how China's development, such as industrial upgrading, will affect the European labor market, keeping in mind that in the digital economy era the organization of labor is no longer limited by physical space or restricted by borders. Our key contribution is to build a model to allow European high-skilled workers to provide services to Chinese domestic firms remotely, without international migration, and examine how the digital transformation in China might differ in its effect on the European labor market compared with a standard model with international migration. Our results suggest that in a digital economy, the possibility of online international job search, matching, and working remotely will raise the demand and competition for high-skilled workers resulting from China's industrial upgrading and economic development, increasing the tightness of high-skilled but not of low-skilled labor markets in Europe. These results are in sharp contrast with the ones from a traditional model where a European worker can take a job in China through international migration.

KEY MESSAGES

- **In the digital economy era, the organization of labor is no longer restricted by borders**
- **China's development has increased its demand for high-skilled workers**
- **We build a model where European high-skilled workers can provide services to Chinese domestic firms remotely**
- **High-skilled labor demand from China increases the tightness of the high-skilled but not the low-skilled labor markets in Europe**
- **Sharp contrast with traditional model where a European worker migrates to China to take a job there**

BEYOND TRADE EFFECTS

Development of China

China has been undergoing massive macroeconomic transformation, industrial upgrading, and technological progress. For the 2010–2019 period, China's GDP averaged 7.7 percent annual growth, while secondary and tertiary industry growth rates clocked 7.6 percent and 8.4 percent, respectively. In 2019, the tertiary industry accounted for 54.3 percent of Chinese GDP, a significant increase of 10.1 percentage points since 2010. Meanwhile, the secondary industry dropped from 46.5 percent to 38.6 percent over the same period. At the same time, the composition of GDP in European countries remained quite stable.

Technology in China has been advancing rapidly. As reported by the International Federation of Robotics (IFR), China in 2016 was the world's biggest robot market in terms of annual sales and operational stock.



Chao Ma

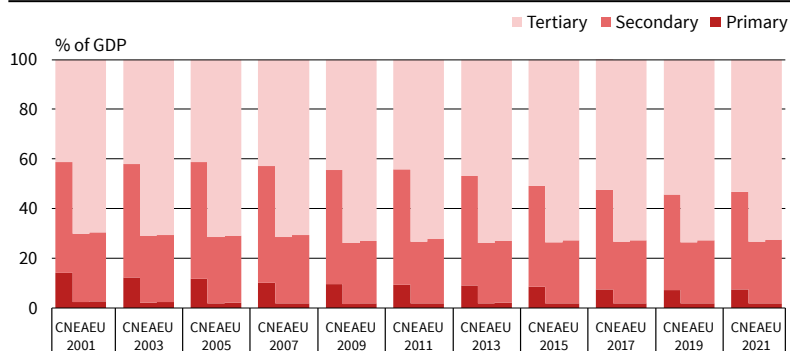
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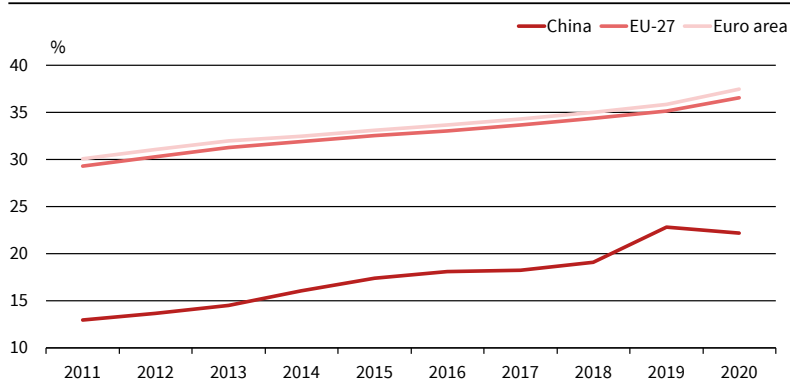
is a full professor of economics at the School of Labor and Human Resources, Renmin University of China.

Figure 1
Share of GDP by Sectors



Note: CN - China; EU - European Union, 27 countries; EA - Euro area, 19 countries.
Source: National Bureau of Statistics of China; Eurostat; authors' calculations. © ifo Institute

Figure 2
Share of Employees having Tertiary Education



Source: National Bureau of Statistics of China; Eurostat; authors' calculations. © ifo Institute

By 2017, the robot density in the manufacturing industry (number of multipurpose industrial robots per 10,000 people employed) in China exceeded the world average. At the same time, China is a leading player in the digital and platform economies.

Reverse Brain Drain?

China is one of the EU's most important trading partners. In 2021, it was the third-largest partner for EU exports of goods and the largest partner for EU imports of goods. This has given rise to concerns regarding Chinese import competition and its consequences on employment and wage inequality in local labor markets.

However, on the one hand, new patterns are emerging in the EU-China trade which should be considered. The first is that the manufacturing sector in China is shifting from labor-intensive to capital- and technology-intensive. For example, in 2021, office and telecommunication equipment accounted for 29.3 percent of EU import flows, and transport equipment for 19.8 percent of EU export flows with China. On the other hand, most studies that examine the impact on employment of trade with China only find negative effects on the manufacturing sector. As Coricelli and

Ravasan (2017) point out, the shrinking of employment in manufacturing could be due to competition from international trade or to faster productivity growth in manufacturing relative to services, i.e., the Baumol effect.

Globalization not only affects labor markets indirectly through international trade, but also directly through migration. The flow of high-skilled labor or young talent from emerging to developed economies is commonly known as "brain drain." However, the rapid development of emerging economies has turned them into active competitors for talent, an aspect that had previously been dominated by advanced economies.

Europe and China have both seen an increasing share of employed workers with tertiary education (levels 5–8 in ISCED 2011) during the 2011–2020 period. Data from Eurostat shows that the share of employed workers aged 20 to 64 steadily increased, from about 30 percent in 2011 to around 37 percent in 2020, for the EU (27 countries) and euro area (19 countries). Statistics of China reveals a relatively larger increase, from 12.9 percent in 2011 to 22.2 percent in 2020 (Figure 2). Even though the gap was moderately reduced, by 2.3 percent for the last decades, persistent difference still exists in the skill composition of labor markets between Europe and China. In an era when China is experiencing dramatic demographic and economic transitions, the skills shortage will be a prevalent phenomenon in the country's labor market and could have potential consequences for European labor markets if China's high-skilled labor migration policies are designed to attract more foreign talents.

Several factors are driving the booming demand for high-skilled labor in China. First, China is experiencing a profound demographic change, whereby the working population is shrinking. According to census data, the share of working population (aged 15 to 64) in China decreased from 74.5 percent in 2010 to 68.6 percent in 2020. Working population shrinkage directly reduces the supply of both high- and low-skilled workers. Additionally, population aging will negatively impact individuals' skill acquisition decisions through lower public and private educational investment, which ultimately will affect the skill composition of the general population. Second, the increased robot density led by automation-based technology progress in China is leading to the destruction of traditional routine jobs and creation of skill-intensive routine jobs and non-routine jobs. Third, the growth of modern service industries and manufacturing with higher value added results in greater demand for professionals with specific talents. China is in the process of transitioning from "world factory" for low-end products to an exporter of high-end technology and services. All of the factors mentioned above are contributing to the skills shortage in China.

BRAIN DRAIN FROM EUROPE TO CHINA: THEORETICAL FRAMEWORK AND NUMERICAL ILLUSTRATION

As discussed above, the Chinese economy's transition to high-value-added manufacturing and modern service industries results in a widening supply-demand gap for high-skilled labor. In this section, we present two benchmark models which incorporate labor market search frictions.

The first one is a standard migration model: high-skilled workers in Europe consider working abroad in China through international migration. The increased probability of working abroad for high-skilled workers will affect the willingness of local firms to create high-skilled positions and will probably also affect other labor market conditions.

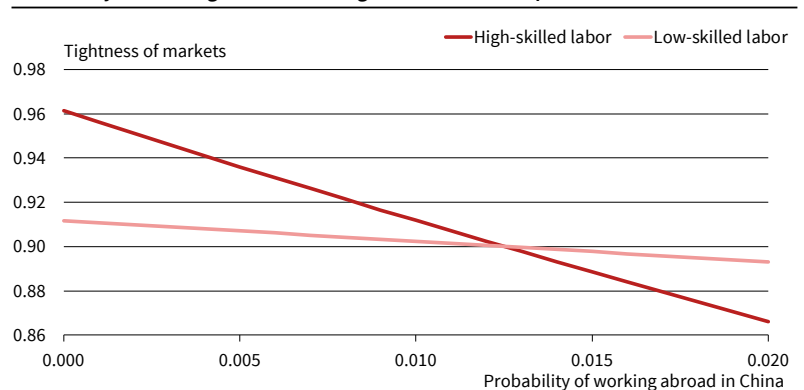
In the digital economy era, online labor markets facilitate international search and matching between high-skilled labor in Europe and high-skilled jobs in China, making it possible for high-skilled workers in Europe to provide services to Chinese firms without physically migrating to China. Thus, in the second model, we assume that high-skilled workers are potentially matched with two sources of high-skilled jobs offered by European and Chinese firms with equal probability. The booming demand for high-end talents by Chinese firms results in an exogenous shift of the demand curve of high-skilled workers in the European labor market, which directly increases the tightness of the high-skilled market.

Standard Model

We develop a simple migration model based on Mortensen's and Pissarides's labor search-matching framework (Mortensen 1982; Pissarides 1984). Our model emphasizes two features: first, that the transformation of China from a low-skilled, labor-intensive economy to a capital-intensive, innovation-based economy spurs rapid growth in the demand for high-end talents. We capture this feature by assuming that high-skilled jobseekers (both employed and unemployed) in Europe have an increased probability of migrating abroad to work for a Chinese firm. Second, the stronger demand for high-skilled labor led by skilled-based technology change in China exerts a heterogeneous influence on European labor markets. Accordingly, we consider two types of workers in the European labor market: high- and low-skilled workers. High-skilled workers, defined as workers with tertiary education, can look for jobs in both the European and the Chinese labor markets, performing such jobs through international migration, while low-skilled workers could only be employed by European firms. We further assume that each migrating high-skilled worker is replaced by an identical unemployed one such that the skill pool of European labor market is unchanged by international migration.

Figure 3

Probability of Working in China and Tightness of the European Labor Market

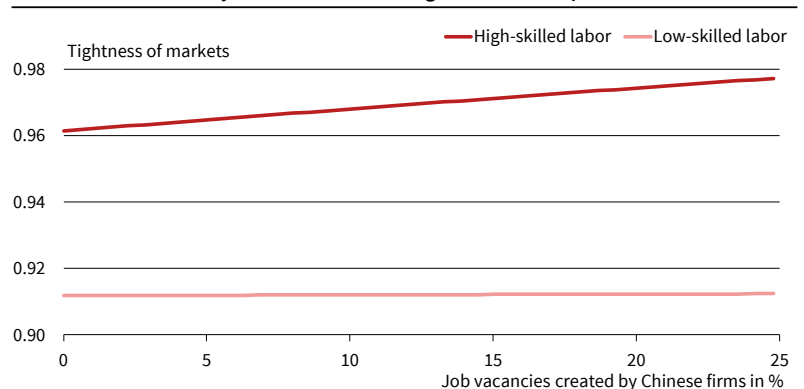


Source: National Bureau of Statistics of China; Eurostat; authors' calculations.

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Figure 4

Online Job Vacancies by Chinese Firms and Tightness of European Labor Market



Source: National Bureau of Statistics of China; Eurostat; authors' calculations.

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On the production side, a homogeneous final good is sold in a competitive market by a representative firm exhibiting constant returns-to-scale with high- and low-skilled labor being intermediate inputs. The complementarity between high- and low-skilled workers is governed by the elasticity of substitution in the production function. We assume that high- and low-skilled workers are imperfect substitutes in the production of a final good, which implies that the marginal product of high-skilled input depends positively on the amount of low-skilled labor employed but negatively on the amount of high-skilled labor employed.

The search-and-matching and wage determination processes follow the standard search-and-matching model. We do not allow cross-skill matching and on-the-job search, which means that our model does not allow high-skilled workers who are initially mismatched with low-skilled jobs to conduct an on-the-job search for high-skilled jobs. Additionally, the labor market's skill structure in our model is exogenously given.

There are two channels through which an increase in the probability of a successful match between European high-skilled workers and Chinese firms affects wages and unemployment rates. The interaction of these two channels determines the end results. First, an increase in the probability of working abroad in China results in a greater gap between

high-skilled workers and high-skilled jobs in Europe, putting a downward pressure on firms' expected profits from creating a high-skilled position. The prospect of working abroad in China also discourages entry of high-skilled jobs and decreases the tightness of the high-skilled labor market in Europe. Consequently, the outside option of finding a high-skilled job for high-skilled workers goes down, which reduces their wages and raises the unemployment rate.

Second, a reduction in the tightness of the high-skilled labor market due to an increase in the probability of international migration decreases the amount of high-skilled inputs in the production of final goods, which raises the marginal product of high-skilled labor and lowers that of low-skilled labor. This complementarity-substitutability channel raises the potential profits of opening high-skilled job positions, which induces entry of high-skilled jobs and brings up labor market tightness. For the low-skilled workers, the opposite is true. Wages and unemployment rates, as a result, adjust in accordance with changes in market tightness.

Modified Model

In the modified model, we highlight the interaction between the digital economy and international migration. The rise of the digital economy partially removes the physical boundaries of nations and provides an online international labor market platform, which facilitates international hiring and outsourcing (Goldfarb and Tucker 2019). It is also possible for workers to provide services remotely. Consequently, in the modified model two kinds of jobs are created in the high-skilled labor market: one by European firms in the traditional offline labor market, which is endogenously determined, and one by Chinese firms through an online labor market that is exogenously given. High-skilled workers conduct their search in both the offline and online high-skilled labor markets and seek potential matches with both sources of jobs. If the European high-skilled workers find matches with a Chinese firm, they can supply their labor to the Chinese firm without migrating to China. China's digital transformation and industrial upgrading increase the demand for high-skilled labor, create more job vacancies in the online labor market, and offer the possibility of providing services to Chinese firms without migration. As a result, the tightness of both the high- and low-skilled labor market benefits from the exogenous rise of the digital international labor market induced by China's development.

Numerical Illustration

To quantitatively gauge the effects of China's digital transformation on the European labor market, we calibrate our model to match European data for the period 2012–2021 and simulate the effects of the in-

crease in the probability of working abroad in China in the traditional model, and the increase in the job vacancies of online high-skilled labor market in the modified digital economy model.

As shown in Figure 3, in the traditional migration model an increase of migration probability from 0 to 0.02 significantly reduces the tightness of the high-skilled labor market by around 0.1 and moderately decreases that of low-skilled labor market by about 0.02. This indicates that for a high-skilled labor market the negative job-separation effects more than offset the positive diminishing-marginal-productivity effects of the option of working abroad. As a result, the wage rate and employment rate of the high- and low-skilled labor market decrease as the probability of working abroad in China rises.

In Figure 4, we present the simulation exercises for the effects of an exogenous increase in job vacancies created by Chinese firms through an online labor market and the possibility for high-skilled worker to work remotely. We show that high-skilled vacancies posted by Chinese firms is positively correlated with tightness and wage rate, while negatively correlated with the unemployment rate of the high-skilled in Europe. An increase of vacancy-unemployment ratio from 0 to 25 percent results in a rise of tightness in the high-skilled market about 0.015. The low-skilled labor market, on the other hand, responds moderately to the exogenous expansion of unfilled high-skilled vacancies through a complementarity-substitutability channel. Thus, the entry of Chinese firms into the high-skilled labor market directly raises market tightness even though a higher outside option for high-skilled workers discourages the creation of high-skilled positions by European firms, which indirectly reduces market tightness.

The numerical exercises quantitatively demonstrate that the labor market consequences of a rise in China's demand for high-skilled labor could be quite different under different scenarios. In a traditional economy, a high-skilled worker can only take a position in China through international migration, and our results suggest that with the development of the Chinese economy and the associated increase in the demand for high-skilled work, the tightness of high- and low-skilled labor markets both decrease, but the decrease in the high-skilled labor market is more significant. A digital economy, in contrast, offers the possibility of an online international job search and matching as well as working without having to migrate. In this case, the demand and competition for high-skilled workers from China increases the tightness of the high-skilled but not the low-skilled labor markets.

DISCUSSION AND POLICY CONCLUSION

Ever since the paper by Autor et al. (2013) on how international trade affects local labor markets, the

topic has become an important one in both academic and policy circles. Though a large number of studies find that the exposure to international trade has negative effects on employment opportunities for the low-skilled workers in the manufacturing sector of advanced economies, the effects could be quite heterogeneous depending on whether the interest group is low-skilled or high-skilled workers, and whether the trade commodity is final goods or intermediate inputs. Few studies distinguish trade effects from the Baumol effect.

Besides international trade, globalization also directly affects local labor markets through international migration. Along with the development of China, the demand and competition for high-skilled workers will inevitably affect the European labor market, especially for the high-skilled segment. With technological progress and the digital transformation, the labor market itself is changing. Online job search and matching is becoming more and more important: the organization of labor into production processes is no longer limited by physical space or restricted by borders.

Our model, which allows workers to supply their labor remotely, suggests that the demand and competition for high-skilled workers from China resulting from its industrial upgrading and economic development increases the tightness of the high-skilled but not the low-skilled labor markets in Europe.

The implication of our finding is that in the digital economy era, international mobility of labor is becoming less necessary since workers can provide their services remotely. This change can create win-win situations for both the EU and China. On the one hand, China is able to benefit from EU high-skilled workers; on the other, the European labor market is not negatively affected by the shock on the demand curve of its high-skilled workers. These results are in sharp contrast with the ones from a traditional model where a European worker can take a job in China through international migration.

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Nicolas Bunde, Nina Czernich, Oliver Falck and Gabriel Felbermayr

What Works? Regional Effects of Universities*

KEY MESSAGES

- Universities exert a positive impact on the development of a region
- They increase employment in high-tech and knowledge-intensive industries and raise long-term wages
- Research results from universities are the basis for technological progress, new products, and start-ups
- Framework conditions and institutional characteristics play an important role for such effects
- Innovation ecosystems grow over years and decades. Therefore, higher-education policy must be long-term

Economic research has always emphasized the importance of a well-educated population for the level and dynamics of per capita income and other key economic variables. Hanushek and Woessmann (2022) provide a current overview. Foreseeable demographic changes – especially the stagnation or even decline of the active labor force – make investments in the quality of human capital particularly necessary.

The literature attributes a significant role to universities for the development of a region. Their research and education activities generate qualified graduates, spawn innovative companies, and spur stronger economic and employment growth. Universities may particularly have an impact on their immediate surroundings. Stanford University is an often-cited example of universities spawning significant technology clusters in their vicinity, such as Silicon Valley. They are considered a major cause of high-quality employment and prosperity in their regions. But de-

spite the theoretically well-founded positive effects of universities, many channels are not easy to prove empirically and are more likely to be classified as anecdotal evidence, which is why a critical examination of the postulated effects is needed.

The challenge for empirical scrutiny of the effects of universities on their environment is that causal effects are difficult to separate from pure correlations. For example, the presence of a university regularly correlates with high regional per capita income. But it is likely that completely different factors, such as a central or urban location, can explain the presence of a university on the one hand and high per capita incomes on the other, without the former necessarily causing the latter. In addition, it is quite possible that the causality (also) runs in the opposite direction: where per capita incomes are high, there are more resources for universities. Similar problems arise when researching the effect of tertiary education and research institutions on other variables such as start-up dynamics, innovation activity, unemployment, and much more.

The associated methodological challenges have been amply discussed in various studies and addressed by different means. To better assess which regional effects can be expected from universities, this article summarizes the results of selected impact studies from different countries on the effects of universities on their region. The report was preceded by a comprehensive literature study, with only those studies being considered that could demonstrate a particularly high internal validity, i.e., a methodically convincing implementation.

EFFECT CHANNELS

Universities exert direct and indirect investment and employment effects through their establishment and maintenance and the demand for services necessary for their operation. Indirect effects stem from university employees and students, who usually live in the region, increasing demand for housing, consumer goods, and services. Beyond this, universities may exert other effects on their location that go beyond the mere generation of purchasing power.



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* Based on the study "What Works? Regionale Auswirkungen von Hochschulgründungen und der Fall der neuen TU Oberösterreich" commissioned by the Federation of Upper Austrian Industry.

Universities are also important drivers of innovation through their research activities and cooperation with companies. Their creation and dissemination of new knowledge is not limited to the publication of research papers or patents: the importance of further channels such as consulting services, master's theses and doctoral dissertations, conferences, internships, and informal exchange between university researchers and company representatives should not be underestimated. The literature also attributes a significant role to personal exchange between innovation actors (see Agrawal and Henderson 2002, on knowledge transfer). It is therefore not surprising that spatial proximity is relevant for the diffusion of innovation. This explains, among other things, why innovation activities often occur in clusters.

Universities, through their research activities and the infrastructure they provide (e.g., laboratories), can ideally represent anchor points for innovation networks and attract companies seeking proximity to science and a qualified workforce. There is also evidence that such companies produce more valuable patents, which again shows the importance of networks between universities and local business (on cooperation between universities and economic actors, see Fritsch et al. 2008).

In addition to economic effects, universities are also associated with a strengthening of the institutional fabric. As platforms for democratic dialogue, they contribute to the exchange of ideas through events, publications, and reports for policymakers. They bring together people of different cultures, mindsets, and disciplines and are also often associated with strengthening the cultural and creative scene. Universities, for example, are often involved in the work of museums, galleries, or theaters, and staff and students also act as consumers of culture. Influences of this kind are not always precisely quantifiable, but are nevertheless important.

METHODOLOGICAL CHALLENGES

Many studies on the impact of higher education institutions on their environment have identified a whole range of possible impact channels. However, not every study can be generalized, for example because some correlations only apply to certain types of higher-education institutions or were investigated in specific country contexts. The methods used and the data sources also differ from study to study, which can result in differences in the validity of the findings. In addition, many findings are not proven causal relationships, but merely correlations. For example, a positive correlation between the presence of a university and business start-ups could simply be due to the fact that universities are often found in conurbations that favor the establishment of businesses. Before



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drawing conclusions, it is therefore important to pay close attention to the methodological approach of the respective studies.

The proof of causal relationships is one of the great challenges in empirical economic research. While counterfactual methods are often used to determine causal effects and prevent erroneous conclusions, this is not possible when analyzing the local effects of universities, since an existing university cannot simply be wished away for the sake of the counterfactual. Therefore, one compares—similar to medical research—the development of a randomly selected group that receives a certain treatment with a randomly selected control group that receives no treatment or a placebo. Since the two groups were randomly selected, they should only differ on average in terms of treatment, but not in terms of other characteristics, making it possible to attribute differences in development to the intervention. In the case of the local effect of universities, such a setting can be obtained by random selection from a group of potential university locations.

Since in economic research it is often not possible to conduct experiments with defined control groups, the next-best option are so-called “natural experiments”, i.e., situations in which part of the population is affected by a measure, and part is not. Whether a location is affected by the establishment of a university must not depend on aspects that also influence the outcome variables, e.g., the innovativeness of firms, the share of highly qualified workers, or regional growth. The challenge is therefore to find a control group of regions without universities that do not differ from the university locations except for the absence of a university. In essence, such studies must be measured by the extent to which they succeed in identifying a convincing control group.

EFFECTS ON INNOVATION AND GROWTH

In a large international comparative study, Valero and van Reenen (2019) examine the importance of universities based on nearly 15,000 universities in about 1,500 regions in 78 countries. They look at the period after World War II, when higher-education expansion was accelerating in most countries, and analyze how

the establishment of universities is related to future economic growth. To do this, they estimate an econometric model at the sub-national level for the period 1950 to 2010, and demonstrate that increases in the number of universities are positively related to future GDP per capita growth: a 10%-increase in the number of universities per capita in a region is associated with a 0.4%-increase in future GDP per capita in that region. The authors show that this effect goes beyond the influence of the direct expenditure of the university, its staff and students: the increased supply of human capital and innovation also play a role.

The following studies make use of institutional characteristics of higher-education policy combined with modern statistical methods to further explore the channels through which universities affect their surroundings and to identify causal effects.

Education Spending Boosts Innovation and Growth

Aghion et al. (2009) develop an endogenous growth model in which they assumed different effects of basic education (school) and higher education (university, doctorate). They postulate that the latter leads to more knowledge, new research results, and technological innovations. Basic education, in turn, creates a foundation upon which the new developments can flourish, as basic skills are necessary for their implementation and realization. In the empirical part of the study, the authors test the model by examining how additional financial resources for universities influence per capita income. To identify a possible causal relationship, they used so-called instrumental variables, i.e., indicators that influence the level of education spending but have no direct effect on income levels.

For their empirical approach, the authors used specifics of the appointment process of members of the US Congressional Appropriations Committees, which are responsible for allocating federal funds for research. The committees allocate a lump sum to a funding institution, such as the National Science Foundation, which then awards funding through competitive application processes. However, committees may also fund individual projects without regard to merit or larger policy considerations. Such individual projects are the main route through which MPs can channel funds to their constituencies, which makes a seat on these committees highly desirable. MPs who hold such a seat do not give it up voluntarily and both houses of Congress respect the right of a sitting committee member to remain on that committee. As a result, MPs tend to stay on the committee for several years, and almost all vacancies occur because a member dies in office or retires from political life. A vacancy sets in motion a complex internal political process of replacement based on a combination of majorities, regional proportionalities, and the distribution of seats in other committees. The authors

use this for their instrumental variables approach. The process of appointments causes variations in the level of funding of different universities; at the same time, it is neither plausible that this process influences the performance of universities in any other way than through the allocation of funds, nor that the performance of universities influences the appointment to committees. It is crucial that these instruments emerge through internal political details and are not influenced by general political tendencies.

Thus, the additional funding to universities located in members' constituencies resulting from such members' political appointment process can be viewed as a natural experiment that allows to infer causal effects by comparing universities that received additional funding and those that did not. The authors show that this additional funding increases the growth of real per capita income in US states. However, as expected in the theoretical model, the effects differ depending on the type of funding and the state's technological level. Overall, the US is a technologically advanced country, so that positive growth effects of additional investment in four-year college education are shown for all states. However, additional research-related investments only have positive growth effects in states that are relatively close to the technological frontier, i.e., where the industry is a technology leader. An additional US\$1,000 of research-related investment per person in a cohort increases economic growth in that state by 0.04 percentage points. Additional budget for research-related investment averages US\$500 per person over a 6-year period. Thus, an average budget increase raises growth by 0.12 percentage points. The effect of additional budget for a four-year college education is higher (0.07). However, the average budget increase here is lower than for research-related investments, which is why the average effect is lower (0.011). In US states that are behind the technology frontier, the effects differ significantly and, as predicted by the model, are smaller or negligible.

The size of the effects on income suggest that beyond the additional individual human capital, indirect effects such as innovation also play a role. Therefore, the authors investigate whether budget increases have an impact on university patents. In states at the technology frontier, an additional US\$1,000 of research-related investment per person in a cohort leads to a 0.06-pp increase in patents per person (the effect of additional budget for four-year college education is similar). In states behind the technology frontier, there is no effect on patent activity.

Autonomy and Competitive Funding Procedures Make Universities More Productive

In another study using the same methodology, Aghion et al. (2010) analyze the role of university governance on the impact of additional research funding. They

hypothesize that universities are more productive when they are both highly autonomous and highly competitive. The idea behind this is that the production function for research and knowledge is hardly observable or comprehensible for outsiders, such as politicians or funding institutions. In such a setting, dirigiste measures seem to make little sense, compared to a combination of autonomy for the research institutions coupled with competitive funding procedures in which the research institutions must prove their productivity.

The authors show that increasing funding for a university increases patents and publications more when the university has more autonomy and faces stronger competition. This confirms the authors' hypothesis that cutting-edge research is a highly complex process that is most successfully promoted by granting research institutions freedom, but at the same time requiring them to prove their productivity in performance-based competition. From this they derive recommendations for European universities: greater autonomy combined with greater accountability by pushing for competitive grants, greater student and faculty mobility, and competitive procedures and assessment programs.

Local Spillover Effects of Research Institutions: US Agriculture

Kantor and Whalley (2019) examine one specific type of research and its effects, in the field of agriculture. At the end of the 19th century, agriculture experiment stations were established at many US universities, driven not by regional difficulties, but increased global competition. Instead of implementing protectionist measures, the productivity of US agriculture was to be increased.

The authors investigate whether the agriculture experiment stations had spillover effects on local agriculture production. Again, a mere correlation does not allow any conclusion on the direction of the effect, e.g., farmers who were very interested in technological novelties and therefore already had above-average productivity might have lobbied for such an experiment station to be set up at a university near them. To identify a causal effect, the authors go back in the history of the US higher-education system to the founding of the so-called land-grant colleges, since it was near these types of colleges that agricultural experiment stations were set up. The crucial question was therefore how the locations of the land-grant colleges were determined.

Land-grant colleges are state universities in the US whose foundation and funding are based on the Morrill Land-Grant Colleges Acts of 1862 and 1890. The US federal government transferred land ownership to each state under the condition that the proceeds from the sale or use of this land be applied to the establishment and running costs of an institution of higher education. Being the site of a land-grant col-

lege was highly coveted, and a veritable competition began between local governments within the individual states. Political skill and good connections to the state government were helpful, but geographical location also played a role. The authors argue that because of these different criteria the decision for the locations of land-grant colleges was independent of the economic development and the productivity of agriculture at the location.

The authors find that the effects of proximity to research were initially small and only increased after a few years, peaking 20 to 30 years after the opening of the experiment station, until they disappeared again 50 years after the stations opened. Before 1920, the spatial proximity to a station was important for innovation; after 1920, this cannot be confirmed. The spread of innovations was much faster in the post-1920 period. Cars and telephones were widely available and an agricultural extension program was available in almost every district. The increasing speed of innovation diffusion largely explains the decline in the observed effect of proximity.

Varying Role of Proximity by Sector

The waning importance of proximity for the diffusion of innovations is a peculiarity in this study and is not confirmed in other studies on knowledge spillovers. One explanation for this is the different degree of complexity of the innovations. No interaction with the research institution is likely to be necessary for the use of a new seed. It is enough to know about it and sow it. Complex technologies, on the other hand, often require face-to-face interaction. For example, patent research has found that the mere patent description is often not enough to replicate technologies or processes. Inventors often have no incentive to write patents in such a way that they can be used as recipes or blueprints. Therefore, direct exchange between researchers and inventors is necessary to build on patents and their own research (Moser and Voener 2012; Watzinger et al. 2020). The following papers, which mainly use patents as outcome variables, confirm the importance of spatial proximity.

Importance of Spatial Proximity for Knowledge Spillovers

Li et al. (2020) examine the importance of local knowledge spillovers in a study on China, looking at the effects of increased student numbers on innovation activity. Again, it is not sufficient to prove a mere correlation between the indicators to determine the direction of the effect: do more students lead to more innovation, or are there many innovative companies in a region which demand university graduates, leading thus to more students at nearby universities?

For their analysis, the authors use the fact that the Chinese higher-education system is centrally

planned and managed from Beijing. Students are allocated to universities nationwide based on test scores. Therefore, higher-education policies are independent of regional developments such as economic growth or demand for graduates. In 1999, China began an educational expansion with the aim of significantly increasing the number of university graduates to counter the effects of the Asian financial crisis, as well as of the massive layoffs resulting from the reforms of the state-owned enterprises in the late 1990s. In June 1999, a new university recruitment plan envisaged 1.5 million freshmen in the autumn of that year, a 42-percent increase over the previous year. The distribution of the additional new students was based on centrally determined quotas, which were primarily oriented towards central plans and existing capacities at the universities.

In their analysis, the authors find that the expansion of universities significantly increased innovation capacity and led to a marked rise in patenting activity by nearby companies. Moreover, corporate patents cited university patents more frequently. As a measure of the actual generation of innovations, the authors also examine the introduction of new products by companies in the vicinity of universities. Here, too, they find clear effects of expansion. However, the effects strongly decreased with spatial distance. Overall, the authors concluded that the knowledge spillovers from universities are considerable, but highly localized.

Executive Networks as a Channel for Knowledge Spillovers

In a study for the US, Charles (2021) analyzes the channels of local knowledge spillovers between universities and companies. He investigates whether research at universities leads to more patents in existing companies or whether it is mainly that new innovative companies settle nearby. For his analysis, the author uses universities that have evolved from land-grant colleges (described above), since their location can be seen as exogenous to current economic development.

The author analyzes changes in university budgets and research activities, particularly in research-intensive faculties such as medicine or engineering, resulting from philanthropic donations by university alumni. The links between a university and its alumni were forged decades earlier and should therefore be independent of current developments. It turns out that companies whose executives are more strongly connected to the university produce more valuable patents in the years following the donation. The effects are particularly strong if the connection was forged through an executive's master's degree or doctorate at the university and are largely driven by companies that settle near the universities, since these are more closely connected to the university (even before the donation) than other companies.

Type of University Decisive for Regional Impacts

The study by Howard et al. (2021) suggests that the location and type of university is relevant for knowledge spillover and co-location effects. They examine the effect of universities that have developed in the US from so-called normal schools, which train teachers to the "norm" of good teaching (Labaree 2008).

Social reform movements of the 19th century included the expansion of education and advocacy for better care for people with mental illness. Local governments established community schools, creating a great demand for qualified teachers. To meet this demand, many states established normal schools. At the same time, a movement for better care of the mentally ill began, which contributed to states establishing mental health facilities. The location of both kinds of institutions was a political decision, with proximity and easy access to population centers, an attractive natural environment, and transport routes all playing an important role. Location decisions typically depended on the political influence of a district, and in both cases entailed large government investments associated with jobs and economic opportunities.

At the beginning of the 20th century, normal schools and mental health facilities were similar in size in relation to the district's population. But by the mid-20th century, most normal schools had expanded into regional state colleges and universities, and students made up a large proportion of the district's population. Today, these colleges generally focus on undergraduate and master's education and are not as research-intensive as flagship state universities. By 1980, they awarded about 42% of all bachelor's degrees in the US. Unlike the normal schools, the psychiatric institutions never grew large, and most are still state-owned.

The authors find that universities that have emerged from normal schools have a clear positive influence on the number of students and graduates in a region, but that they seldom stay around after graduation. The latter may be one explanation for the fact that such universities have hardly any effect on the local economy. Another possible reason is that these universities are not very research-intensive, which results in little potential for knowledge spillover and attraction of companies to their proximity.

LABOR MARKET EFFECTS OF UNIVERSITIES

It has been shown that for the individual, higher education leads to higher income. The central question for education policy, however, is whether there are effects beyond individual incomes. This has often been postulated but was not empirically proven until Moretti (2004), in a seminal paper, showed that the

social returns to education are indeed higher than the sum of additional income of individuals.

Moretti compares the salaries of people in the US who are similar in many respects but live in cities with different proportions of university graduates. Several aspects must be taken into account to interpret the differences as a causal effect, such as unobservable characteristics of individuals and cities. For example, employees with high levels of unobservable skills, like talent, competence, or motivation, often move to cities with a high-skilled workforce. Furthermore, city-specific unobserved characteristics are correlated with the share of graduates. For instance, the boom in the computer industry has driven up the wages of skilled workers, attracting high-skilled workers to places like Silicon Valley. In this case, the high wages lead to an increase in the number of graduates in the city and not the other way around.

Moretti uses special econometric methods to take these unobservable characteristics into account. First, he examines longitudinal data to observe individuals over time. Second, he uses an instrumental-variables approach based on differences in the age structure of cities to account for the trend of increasing participation in education in recent decades. Further, he exploits whether a city has a land-grant college.

The results of the different approaches provide consistent results. A 1-percentage point increase in the share of graduates raises average wages by 0.6 to 1.2%, over and above the private returns to education. To find out whether spillover effects also play a role, Moretti compares the effects of changes in the share of graduates on the wages of different education groups. Classical economic theory predicts lower wages in the presence of higher supply, i.e., in the absence of knowledge spillovers, the wages of graduates should fall. Empirical analysis shows that a 1-percentage point increase in the share of graduates in the labor force increases graduate salaries by 0.4%. Hence, there must be positive spillover effects: a higher supply of well-educated workers increases the incomes of the well-educated. The salaries of school dropouts and high school graduates also increase, by 1.9% and 1.6% respectively.

The social returns of more university graduates therefore consist, on the one hand, of increased wages for the low-skilled, whose jobs are complementary to those of the highly qualified, and on the other, knowledge spillovers that increase the knowledge of the labor force beyond that imparted at universities.

University Research and Local Entrepreneurship Ecosystems

Stern and Tartari (2021) examine the importance of universities and research institutes (national laboratories) for regional entrepreneurship ecosystems in the US, and in particular whether the effects of the two

institutions differ. Both universities and research institutes conduct research that can become the basis for new businesses. However, universities also generate graduates who can potentially become entrepreneurs or employees of start-ups in the region.

Universities, research institutes, and regional entrepreneurship ecosystems influence each other, for example through infrastructure, amenities, or knowledge transfers. Therefore, the authors used for their causal analysis the changes in the amount of federal funds allocated to both research-oriented and general, non-research-oriented institutions. Most of these funds are allocated through competitive processes that are independent of future changes in the regional entrepreneurship ecosystem.

The authors document a clear influence of universities and research institutes on the regional entrepreneurship ecosystem. However, the influence differs along some dimensions. First, while federal funds for non-research activities increase the quantity of entrepreneurship (but decrease its average quality), funds for research activities increase both the quantity and the quality-adjusted quantity of entrepreneurship. Second, the research activities of universities are more strongly associated with spillover effects on the regional entrepreneurship ecosystem.

University Expansion in Germany in the 20th Century

At the beginning of the Industrial Revolution, several universities were founded in Germany, mostly in the south and Prussia, while there were still no universities in large parts of the country. Emperor Wilhelm II feared the “free spirit” educated at universities in areas where Prussia had less influence and control. During the First World War, founding universities was hardly possible. The subsequent Nazi dictatorship was little inclined to found universities that could foster free thought and intellectual human capital. Therefore, new universities were only founded in the late 1950s and early 1960s (Slavtchev and Noseleit 2011).

Typical criteria for a new university were the creation of spatially evenly distributed educational opportunities and the avoidance of overcrowding at existing universities. Consequently, mainly regions without universities at the time were considered. The final location decision was complex and depended on a variety of different factors, such as a repeated postponement of university establishment for the reasons mentioned above; or geographical distribution considerations, or simply good contacts between local administration and state government (for more details, see Slavtchev and Noseleit 2011). Overall, the establishment of new universities cannot be considered a typical reaction to structural change. Therefore, university expansion in Germany is well-suited to analyze the causal effects of new universities. In

the following, three studies are presented that take advantage of this and evaluated various outcome variables using different statistical methods.

Proximity to Universities Increases a Region's Proportion of University Graduates

Siegler (2021) examines the effect of new universities on the likelihood of the local population to obtain a university degree. A new university near one's place of residence can potentially increase the probability of entering university, thanks to lower monetary costs such as through the possibility of continuing to live in the parental home, or due to personal preferences such as staying close to familiar surroundings and friends and family.

For his analysis, Siegler uses geographical differences in local access to university. He compares cohorts who were at a typical age for entering university at the time when a new university was founded in a county nearby a county without a university. The results show that a new university in a neighboring county increased the proportion of university graduates in a county by 8 to 10 percentage points. Women and immigrants in particular were more likely to graduate from higher education institutions due to their proximity to a university.

More Employment in High-Tech and Knowledge-intensive Sectors

Slavtchev and Noseleit (2011) analyze the effects of new universities on regional development in West Germany by going one step further than graduates and examining the effects of universities on regional employment. The results show positive effects on employment and start-up activity in high-tech and knowledge-intensive industries. Overall, the results suggest that the establishment of a new university is associated with a shift in the local economy towards this type of industries.

Long-Term Positive Impact of University Start-ups on Local Wages

Do the higher numbers of graduates and increased employment in high-tech and knowledge-intensive sectors ultimately translate into higher wages? The question was examined by Fuest and Immel (2021) using the event-study method (also called dynamic differences-in-differences estimator). Their results show that new universities have a long-term positive effect on wages in a region, but that the effects differ along the wage distribution. In the higher-wage bracket, the effect sets in earlier and is stronger than in that of lower wages. This is consistent with the findings for the US (Moretti 2004) and suggests spillover effects of education. A detailed analysis of the types of higher education institutions shows that regional

wage increases are mainly due to universities of applied sciences and higher-education institutions in urban regions.

POLICY CONCLUSIONS

Methodologically valid studies have shown that higher-education institutions positively influence the development of a region in various ways. Universities have a positive effect on the share of graduates in the region, as well as on the region's employment in high-tech and knowledge-intensive industries and on long-term wages. Social returns exceed individual returns to education. Research results from universities and highly qualified graduates are the basis for technological progress, new products, and start-ups. In addition to spin-offs from universities, companies are also settling in the vicinity of universities.

However, the positive effects do not occur automatically and everywhere to the same extent. Existing framework conditions and institutional characteristics play an important role. For example, the effectiveness of education and research budgets depends, among other things, on university governance – autonomy combined with accountability – and the level of technological development of a region. Furthermore, the impact differs depending on whether the funds are used for research or rather for undergraduate education. The former has the potential to trigger innovation, especially if there is a suitable innovation ecosystem with innovative companies in the vicinity of the university.

Despite modern communication technologies, spatial proximity, and close personal connections are important for knowledge spillovers, cooperation, and joint development of innovations. This is especially true for complex technologies and methods.

Finally, it has been shown that the effects of new universities take time to materialize: networks, cooperation, and innovation ecosystems grow over years and decades. Therefore, higher-education policy must be long term and strategic.

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Harold James

Institutions – Moving to the Global?

KEY MESSAGES

- **Domestic (but not foreign) borrowing became cheaper after the 17th century financial revolution**
- **Trilemmas present a way of weighing the losses and gains from trade-offs from capital openness**
- **The policy limitations on democracy resulting from capital openness may be treated analogously**
- **Limitations from the international system or order can also be treated in this manner.**
- **The 17th century domestic analogy suggests a need for coordinated or linked up global governance**

A dominant strand of modern policy literature has revived what used to be a particularity of the German Historical School of Economics. The interpretation puts institutions and institutional design at the center of an analysis of economic growth, stability, and sustainability. The modern version was formulated in the influential work of North and Weingast (1989), with multiple important contributions by Acemoglu and Robinson (2006). The key is a historical parable from the end of the seventeenth century, when a fiscal revolution in England in the wake of the 1688 Glorious Revolution, in which a Protestant constitutional monarchy (under William of Orange and his Stuart wife Mary) replaced the less constrained and (under James II) Catholic Stuart monarchy. The core of the transformative deal as presented by North and Weingast was that the British monarchy borrowed from a class of creditors, institutionalized through the Bank of England created in 1694, which also dominated the constitutional political institutions, or parliament.

The creditors could thus be secure that their debts would be serviced and repaid punctually by the Crown, because it was they who in parliament decided the taxation that would allow repayment.

Default, which was the regular story of early modern monarchies, including the spectacular cases of the Spanish and French

monarchies, was thus impossible. The security of borrowing increased and drove down the rate of interest. The cheaper public debt also affected private credit markets, where borrowing was also cheaper. Investment was hence cheaper and more plentiful. Thus, the stage was set for the Industrial Revolution. Over centuries, the central bank accumulated an ever more extensive role in guaranteeing monetary and hence economic stability (Bagehot 1873).

The move also had international consequences. Britain, although substantially smaller in terms of population than France, could borrow more cheaply and thus afford a more vigorous naval and military presence, while France struggled with the cost of wars. The security implications of the British financial revolution made thinkers and political leaders in other countries keen to emulate the British example; for example, after political revolutions, the new United States (under Alexander Hamilton as Treasury Secretary) and France (under Emperor Napoleon) introduced variants of the British scheme and drove down the cost of debt. The advantages of establishing credibility were so great that even after the restoration of the French monarchy in 1815, there was no default on the debt of revolutionary and imperial France, with policymakers arguing on the basis of the importance of maintaining credibility. By the middle of the nineteenth century, international banking houses – notably the Rothschilds – urged their customers to constitutionalize in order to get access to cheaper credit (Ferguson 1999).

AN INTERNATIONAL ANARCHY

Unfortunately, the development of international borrowing subverted some of this cycle of benign institutionalization. There were substantial temptations to borrow – and overborrow – from foreign creditors, and these were not represented in the political institutions, with the consequence that default (expropriating the foreigners) might seem an attractive option. Globalization, in the form of capital flows, in this way undermined the perfect model of self-discipline presented by the British seventeenth-century model. Globalization thus undercut a key part of the institutional model. Policymakers over the past two centuries, from John Stuart Mill onwards, have attempted to find ways of building a more resilient international framework at a global level. The dream of a world monetary union and of a universal central bank is often at the center of such a coordination effort, but



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this is sometime a pipedream, and sometimes – when translated into a regional or even a wider reality – a nightmare.

The first three-quarters of the nineteenth century were replete with debt crises caused by capital mobility. Then, at the turn of the new century, they became less common, and the world looked more stable. The instability returned on a devastating scale in the Great Depression. Dealing with the legacy of Depression and the Second World War, which was widely believed to have arisen out of the social and political strains of the Depression, raised a challenge: the need to design an international institution that might have the same beneficent consequences as the domestic financial revolution of late seventeenth-century England.

CAPITAL CONTROLS

A new consensus on the causes of the Great Depression had shifted the emphasis away from the favorite villains of the 1930s literature: the uneven distribution of gold and the sterilizing policies of the Banque de France and the Federal Reserve System, the allegedly excessive monetary inflation of the 1920s, or structural weaknesses in major industrial centers. Rather, the new view looked at the transmission process of depression and came to the conclusion that the large short-term capital flows of the 1920s and 1930s had led to disaster (Nurkse 1944). These movements had made it impossible for states to pursue stable monetary policies, threatened exchange rate stability, and made fiscal stabilization highly hazardous.

John Maynard Keynes, one of the principal architects of Bretton Woods, did not believe in what might be called the “globalization paradigm” – the theory, elaborated already by Montesquieu and celebrated by Richard Cobden and John Bright as well as by Norman Angell, that commerce and commercial interconnectivity would by themselves bring international peace and order (Keynes 1919).

The Bretton Woods scheme depended on a worldwide agreement on the control of capital movements, which was presented as a “permanent feature” of the post war system. In the British draft, what was initially called the Clearing Union (which later developed into the proposal for the International Monetary Fund) would work closely not only with an agency dedicated to stabilizing prices (in order “to control the Trade Cycle”), but also with a supranational peace-keeping agency (“charged with the duty of preserving the peace and maintaining international order”). The British draft concluded that the proposal was “capable of arousing enthusiasm because it makes a beginning at the future economic ordering of the world between nations and the ‘winning of the peace’, and might help to create the conditions and the atmosphere in which much else would be made easier” (Horsefield 1969, III, 13).

TRADE-OFFS AND THE TRILEMMA

Capital movements, however, turned out to be hard to suppress or control. They were often initially hidden in trade financing, as leads and lags of payments. Debates about the weaknesses of Bretton Woods, and then later about whether a new version of Bretton Woods could be applied in the regional setting of the European Monetary System after 1979, revolved around an inconsistent trinity famously identified by Robert Mundell (1963): fixed exchange rates, capital mobility, and independent monetary policies are inconsistent with each other. The presence of capital mobility in a fixed-rate regime makes it impossible for countries to set their own monetary policies or determine their own monetary preferences. As applied to Bretton Woods, Mundell’s interpretation emphasizes the frustration of some of the growing export economies about rising levels of inflation that were interpreted as being imported from the United States, and hence the need to control international inflation by monetary reform.

Later Tommaso Padoa-Schioppa (1988) reformulated Mundell’s proposition as the “inconsistent quartet” of policy objectives by bringing in commercial policy, another central part of the globalization package: free trade, capital mobility, fixed or managed exchange rates, and monetary policy independence. In both the Mundell and Padoa-Schioppa formulations, the impossible choice provided a rationalization for building a more secure institutional framework to secure cross-border integration, especially to deal with the problem of small or relatively small European countries. Both economists were major architects of the process of European monetary union. They justified this step of further integration on the grounds that the exchange rate was a useless instrument – the monetary equivalent of a human appendix or tonsils – that could be conveniently and painlessly abolished. However, some countries continued to regard the exchange rate as a useful tool for obtaining trade advantages.

The policy constraint following from free capital movements has recently been posed in a more severe form by H el ene Rey (2013), who shows that in a globalized world of free capital movements, monetary policy is limited even with flexible or floating exchange rates. A choice to have a floating exchange rate thus does not give a free pass to monetary policy. Rey identifies “an ‘irreconcilable duo’: independent monetary policies are possible if and only if the capital account is managed, directly or indirectly, via macroprudential policies.”

This argument does not necessarily lend itself to the demonstration of the necessity of monetary union: If the aim is to preserve national policy autonomy, a better choice is to control capital movements, as was envisaged in the 1944 Bretton Woods Conference and provided for in the Articles of Agreement of

the International Monetary Fund. Capital movement across borders – through both inflow surges and the consequences of reversals – may fundamentally limit the scope of national monetary policy. Since the 2008 global financial crisis, the articulation and elaboration of institutional solutions – macroprudential policies – has become a way of trying in practice to limit or manage the extent to which capital may be mobile; consequently, the discussion of the monetary policy trilemma leads in a straightforward way to the discussion of financial policy issues (Klein and Shambaugh 2015; Jeanne 2021).

Capital mobility, however, continues to be attractive. Financially constrained borrowers – corporations as well as governments – see capital inflows as a way of obtaining access to financial resources. In addition, the inflows may be linked to institutional innovation and governance reform. After waves of overborrowing, the costs may be clearer: capital flows, in the neat analogy of Stiglitz, generate such large waves as to upset the delicate rowing boats of small countries afloat on the sea of globalization. But many participants in the process quickly forget the possibility of the large waves and tides.

The logic of the original Mundell trilemma thus points either in the direction of closer cooperation (including perhaps political arrangements that constrain domestic choices) or toward capital controls as a way of rescuing national policy autonomy. In light of the gains that may be lost as a result of capital controls (and of an awareness of the necessarily incomplete character of capital controls that makes them prone to evasion), the process of globalization would suggest a need for cooperation and coordination. But the policy solutions are not in the corners or on the sides of the triangle of options, but rather in the middle: there is never complete capital mobility or immobility; exchange rates are never completely fixed (even a currency union in theory allows exit); and monetary policy is informed by news from abroad (see Bordo and James 2019).

THE TRILEMMA AND DOMESTIC POLITICS

There exists another well-known trilemma, concerned with political economy, and most famously described by Dani Rodrik (2007 and 2011). After a period of financial opening, the consequent development of financial imbalances may strain the political system, undermining the constitutional compromise at the heart of the North and Weingast institutional model. States (whether they are autocracies or democracies) initially like the benefits of open capital markets. Democracies, in which governments are responsive to the short-term demands of voters, are also likely to want to set monetary policy independently. They need to work out a trade-off between present monetary autonomy and the ability to attract inflows.

In addition, both policies have time-consistency problems of a different character. First, the monetary stimulus will bring immediate benefits only if it is unanticipated; if there is an expectation that the behavior will be repeated, agents will build the future into their responses to the stimulus. The stimulus relies on the non-continuation of the policy.

Second, by contrast, capital inflows may also bring short-term effects, but if there is a sudden stop, investment projects will remain unfinished and repayment will be problematic. The benefits rely on the expectation that the flows will continue. But states, especially democratic states, find it hard to commit to policies that will lock in the institutional basis on which long-term inflows can occur; instead, there is an incentive to derive simply short-term advantages (such as those following from monetary stimulus) and leave the longer-term problems to successor governments.

While capital inflows continue and the financial imbalances build up, the system looks as if it is politically attractive and stable. Indeed, political parties often make compromises to support governments that can promise the institutional reforms needed to allow the inflow of capital to continue. Because inflows are generally the result of external financial conditions or a global financial cycle (Borio James Shin 2014; Borio 2019), they should not be interpreted as a response to particularly suitable or well-designed economic policies; but that is how they are commonly interpreted by voters, who view economic success as a key determinant in their choice (Kayser 2009). In practice, large inflows may weaken effective economic policymaking, because they relax the constraints under which governments operate and because the generally rising tide means that signals are suppressed that might indicate problematic features of the economy (Fernández-Villaverde et al. 2013).

Capital flows thus may suppress basic signals about government effectiveness that are essential to the functioning of democracy because voters are not correctly informed about the level of competence of their governments. Warning against the potentially deleterious effects is a business that is unattractive and as result left to outsiders, who make Cassandra-like prophecies. The insiders who benefit from inflows can in aggregate behave to ridicule the Cassandras.

However, when financial strains appear as a result of capital account openness, political parties no longer wish to be associated with the consequences. Voters blame the parties that have been associated with power for their past mistakes and flock to parties that define themselves as being against the system. In modern parlance, these parties are often described as “populist.” The populist parties may be on the left or on the right; in fact, most anti-system parties combine elements of a left-wing and a right-wing critique of the system they are trying to overthrow. The left-

wing critique is that the burden of crisis adjustment of incomes and wealth falls unequally and unfairly on the poor. The right-wing critique emphasizes that the adjustment works to the benefit of foreign creditors and represents a derogation of national sovereignty. These opposing arguments are not really contradictory; they can be (and are) easily combined. In these circumstances, the democratic principle is simply recast as a defense of national sovereignty.

Examples of the disintegration of traditional party systems in the aftermath of severe financial turbulence can be found in twentieth-century history and in the story of the European debt crisis. The Great Depression produced disintegration of democratic systems in central and eastern Europe and Latin America.

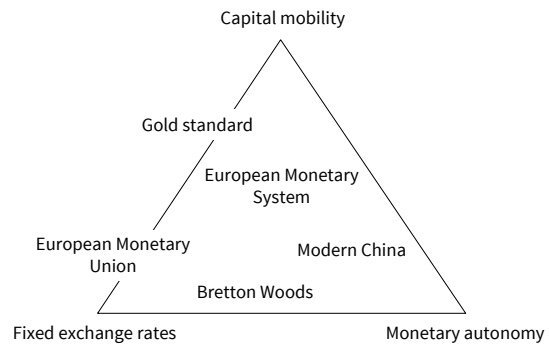
The iconic case of democratic failure is that of Weimar Germany, which had a constitution and political system that had been carefully designed by distinguished political theorists (notably Max Weber and Hugo Preuss) to be as perfect a reflection as possible of popular voting preferences: the system featured both a direct election of the president and proportional representation designed so that there would be no “lost” votes. However, the parties committed to democracy progressively lost voting shares, and the parties associated with government lost especially badly. By the time of the Great Depression, both the center-left (the Social Democratic Party) and the center-right (the Democratic Party and the German People’s Party) had lost significantly and were no longer capable of commanding a parliamentary majority. In terms of policy, the governments could do little, and their policy options were profoundly limited (Borchardt 1991). The disintegration of system parties in the face of economic constraints was also a key element in the modern financial and political crisis in Europe.

In hard times – when politicians demand sacrifices from their voters – they often explain their position by saying that their hands are tied (Giovazzi and Pagano 1988). While that may be a plausible argument in very small countries, the larger the country, the less compatible this stance is with the idea of national sovereignty. Consequently, the demand for an enhanced national sovereignty appears as a frequent response to setbacks, and even small countries may rebel against the system (Financial Times 2015).

But it is also striking that small countries that are frequently the victims of international financial turbulence in the longer term do not see a turn to populist politics. Thus Greece, indisputably the most suffering victim of the European debt crisis, by the early 2020s no longer had either right- or left-wing populism: Golden Dawn collapsed, as did the Independent Greeks; Syriza became a mainstream center-left party, and the country was ruled by the old center-right party, New Democracy.

The demand for national policy autonomy affects the policy equilibrium that arises out of the first tri-

Figure 1
The Macroeconomic Trilemma



Source: Author's compilation.

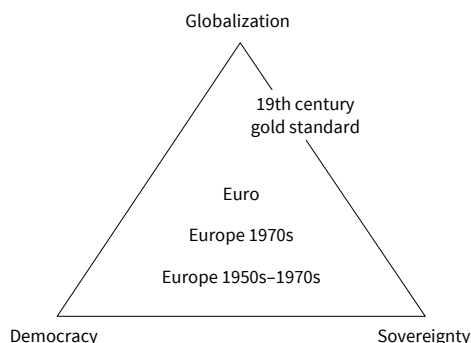
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lemma. When monetary independence might lead to the possibility of short-term stimulus at the cost of longer-term credibility, such autonomy would be undesirable. Monetary independence would lead to political pushes to manipulate monetary policy for short-term advantages without providing any long-term gains. The Mundell trilemma in these circumstances points in the direction of constraining national monetary autonomy. If the outcome of a likelihood of turning to a more national monetary policy is known in advance, it will influence investors’ calculations. They would see commitment to a gold standard or fixed exchange rate regime as ultimately lacking credibility, and that reflection in turn influences politics.

The memory of the politics of turning against creditors during the Great Depression faded as the credit super-cycle emerged in the second half of the twentieth century, when the argument began to re-surface about the compatibility of globalization with democracy in emerging markets (Eichengreen 1996). Rodrik formulated the point in this way as a general argument about the incompatibility of hyperglobalization, democracy, and national self-determination: “democracy, national sovereignty and global economic integration are mutually incompatible.” He also presented the European Union as the best template of a new form of global governance with supranational rulemaking. After the global financial crisis, the same problems and policy dilemmas appeared in rich industrial countries, and globalization appeared vulnerable again.

Democratic politics can be thought of as evolving two types of operation: the formulation of laws based on general principles of conduct, and redistribution of resources. The capacity to redistribute is limited if there is a large cross-border mobility of factors of production: capital is most obviously mobile, and it escapes if rates of capital taxation are too high; but the same process may also hold true in the case of taxation of high incomes, which may prompt income earners to try to operate in a different national and tax setting. Even the capacity to formulate general

Figure 2
The Political Economy Trilemma



Source: Author's compilation.

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laws may be limited, in that incompatible principles in different countries may produce anomalies or loopholes and possibilities for forum-shopping. Again, the sustainable policy choices will lie in the middle of the triangle.

THE TRILEMMA AND INTERNATIONAL RELATIONS

Finally, there is an international element. Considering a broader concept of democracy in an international setting reduces the political logic of a zero-sum-game mentality, in which one country's gains can be achieved only through losses imposed on others. A larger security umbrella can therefore provide a framework for a system of rules about capital movement and a framework for stability that would limit or circumscribe the destructive capacity of capital-inflow fueled credit booms.

Alliances and treaties can lead to a prospect of stabilized capital inflows, that in turn – it is hoped – produce better relations. “Tied hands” could serve as a way of making capital flows more reliable. The “tied hands” argument with regard to ensuring that democratic decisions were compatible with a longer-term framework of stability was frequently presented in the form of treaties or security arrangements. Often the reassurance creditors needed to convince them to lend was political rather than simply a monetary commitment mechanism (such as participation in the gold standard, an exchange rate mechanism, or the monetary union).

How could a political tie make investors more secure or overcome concerns that the investment had not been sound in the first place? A functioning global political order can generate more financial security by increasing the degree of commitment – and also the cost of default. In this way the international system may in the right circumstances reproduce elements of the North and Weingast domestic compromise.

Alliances offered investors the security that creditor governments would put pressure on banks to continue lending and hence reduced the likelihood of sudden stops. The search for enhanced credibility

might then lead to a security commitment, in which countries would seek ties with powerful creditor countries because of the financial benefits. This kind of argument about the security bulwark that locks in capital movements applies to both democratic and nondemocratic regimes.

Like the other mechanisms involved in the various trilemmas, the security relationship too thus may reverse. If the security regime were severely challenged, the gain in credibility would no longer look attractive. And if capital flows reversed or financial fragility appeared, there would be fewer gains from participating in the international order. Potential borrowers that had locked themselves into security or other cooperative arrangements would then be tempted to defect.

When capital dries up, incentives to make international commitments also disappear. Interwar Italy is a good case of the consequences of the logic of the reversal – when the international system no longer promises large financial gains. When the capital market was open in the 1920s, the fascist dictatorship of Benito Mussolini stabilized its currency and entered a fixed exchange rate regime (the *quota novanta*). Mussolini also moderated his foreign policy and suppressed any proclivity for political adventurism. When the international financial system broke down in the banking crisis of 1931, foreign policy restraint no longer offered any financial benefits, so Mussolini reoriented his policy toward imperial expansion. Adolf Hitler proposed a similar response to the Great Depression: Germany should break with international constraints and enrich itself at the expense of neighboring countries. Thus, a reversal of the gains that follow from security commitments is likely to be associated with a backlash against democratic politics.

There are more modern variants of the same process. After private capital flows in Europe from north to south halted in 2008, many southern Europeans lost their enthusiasm for European integration and turned against both the euro and the European Union.

The case of modern Russia is even more striking. Initially Russian President Vladimir Putin seemed to be a rather pro-Western, modernizing leader who sought engagement with the world economy, which included access to capital markets that would allow Russia to develop. Before 2008, Russia acquiesced to the logic of global capitalism; it needed to cooperate with global multinational companies to build an economy based on raw materials and energy production, as well as technologies to process the raw materials. But in 2007–08, Russia's strategy changed. On the eve of the global financial crisis, Putin spoke to the annual Munich Security Conference about the new power potential of the BRICs (Brazil, Russia, India, and China) as an alternative to what he dismissed as an arbitrary “unipolarity.” His audience was shocked, and many saw the speech as evidence of insecurity or irrationality.

However, as the financial crisis spiraled out of control, Putin reached the conclusion that he had been prophetic. After the crisis (in accordance with a Realpolitik power logic instead of the logic of economic growth) there was no longer so much to be gained from global markets. Instead, the best game in town was to cooperate with other countries with more state-centered capitalism, notably China. In this case, the escalation of sanctions as an instrument of financial warfare has threatened to produce a new division of the world into blocs, reproducing aspects of the deglobalization experience of the 1930s.

Grand compacts (of which the best historical example is Bretton Woods) are hard to achieve without a substantial amount of fear and uncertainty. The equivalent today of the time pressure that existed at the end of World War II is an urgent but also uncontrollable global crisis. The sad lesson of Bretton Woods (and the strains that it produced) is that things need to be extremely dangerous before a political dynamic of reform develops.

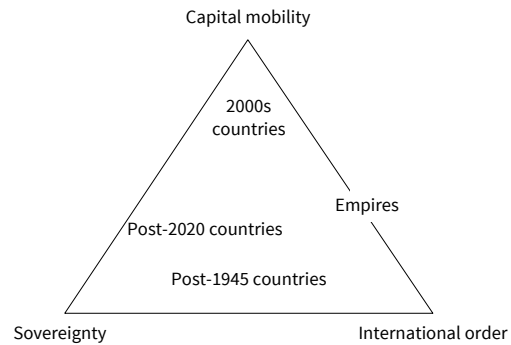
A WAY FORWARD?

Are there ways of constructing or reconstructing a robust international economic order that would reproduce the domestic commitment mechanism described by North and Weingast? The modern global financial safety net, as constructed in response to the Global Financial Crisis of 2007-8, was a patchwork of global with bilateral solutions, that depended in each instance on ad hoc cooperation; it built on earlier experiments with central bank swap arrangements, but now with a greater involvement of China (McCauley and Schenk 2020). At first, the solution was hailed as a brilliant conceptual breakthrough that removed the need for an impossibly large augmentation of IMF resources. But it depended on cooperation and on the idea that there was a common threat of financial and economic instability. That network is under strain because of the threat of a new generalized debt crisis coinciding with a world that is increasingly envisaged in terms of competing blocs (Giorgieva 2022).

We are facing problems that are very new and very old at the same time. We are confronted by a paradox: technology allows an instantaneous connection across the world, but it is also pushing the development of a localist backlash. Information is more available, and the cost of processing it is falling. That means that the advantages of managing, manipulating and even monopolizing it at the same time become greater. Financial flows and their instability can best be seen as responses to imperfect information. In order to produce stability, the information disequilibrium needs to be tackled.

How should a resilient global financial safety net be managed that does not encourage countries to attempt to externalize the costs of financial crises –

Figure 3
The International Relations Trilemma



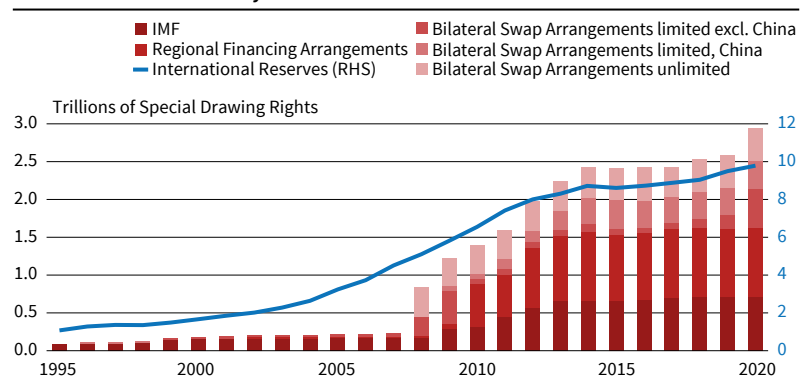
Source: Author's compilation.

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imposing losses elsewhere, on other societies, and encouraging nationalist responses (as happened over the course of the European debt crisis since 2010)? There is a general risk of a deglobalization that could reverse the successes of a process that has brought about a substantial reduction in poverty and deprivation across the world. I offer two lessons: one drawn from history, one from thinking about how change is transforming the complex institutional world.

Sometimes history helps us understand the nature of the problem that needs to be resolved. Bretton Woods was designed as a multilateral and multipolar system, the expression of the wartime coalition (the United Nations), in which security and economic stabilization were joined at the hip. Today there is an urgent need for a similarly joined-up governance structure at the global level, offering coordination between the profusion of regional bodies. In 1944-45, the five largest shareholders of the Bretton Woods institutions, the IMF and the World Bank, which would have their own representatives on the Executive Board, were also the countries that would have the permanent seats on the UN Security Council: the USA, the USSR, the UK, China, and France. But because of the failure of the USSR to ratify the Bretton Woods Agreement and of the communist revolution in China, the IMF and the World Bank developed in a different direction, excluding both the USSR and (initially)

Figure 4
The Global Financial Safety Net



Source: IMF (2021).

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the People's Republic of China (PRC). Thus, in practice, the international financial system evolved as a unipolar order, built explicitly (as the Articles of Agreement of the IMF recognized) around the US dollar. The most complex contemporary financial crises – Ukraine or Venezuela – are also overshadowed by a distinct security dimension; and neither the security nor the financial dimension can be tackled on its own.

The Bretton Woods institutions also reflected a concern of the mid-twentieth century, the centrality of Europe in security issues (since two European powers, France and Great Britain, were also great imperial powers). That diagnosis it is no longer applicable today. Though there has been for at least two decades a widespread consensus that the European over-representation should be reduced, nothing has come of that besides relatively small quota adjustments. In the wake of Russia's attack on Ukraine, and following a much earlier initiative of President Macron (2017), there is a far greater willingness to contemplate joint European action in military and security issues; add the more effective enhanced economic cooperation that is also on the agenda, and the implications should be realized that Europe ought to be represented by a single seat in the IMF and the World Bank.

The aftermath of the Great Financial Crisis (GFC) – as was true after the interwar Great Depression – has been a revival of thinking in zero-sum terms: nations or regions are involved in a competitive struggle ruled by the tenet that what benefits one will hurt the others. That is a marked contrast with the central vision of Bretton Woods, as elaborated in his closing address by Treasury Secretary Henry Morgenthau (1944): "Prosperity, like peace, is indivisible." Competition can theoretically produce big gains, and a pluralism of political forms is also an incentive to better outcomes and to enhanced development. But competition between countries in a bid for dominance (or monopoly of power, or information) is destructive and dangerous.

Zero-sum thinking, furthermore, is not just a chance product of the financial collapse of 2008. It is fostered by new and revolutionary technical developments. That is because transformative technologies present strong gains from network effects, in which the network offers a winner-take-all advantage: there is no room left for the second player.

Another area – crucial to financial interconnectivity – is the renegotiation of public-sector debt. Over-indebted sovereigns are hardly news: the history goes back hundreds if not thousands of years. Discussions about a coordinated general mechanism in the early 2000s for sovereign restructuring of private debt (the SDRM initiative) failed. But there was a well-understood process, involving the Paris Club for official creditors in conjunction with an IMF program and conditionality.

One of the features of the recent defaults of Venezuela is that a competition arises between creditors to use favorable terms for debt renegotiation as a way of establishing or enlarging influence. Interest rate tightening, combined with soaring of the US dollar, may lead to a generalized debt crisis. The early manifestations in Pakistan and Sri Lanka look different to late twentieth-century-style debt crises in that there is a tension between satisfying China's demands and those of other creditors. Again, that looks like a historic throwback to the anarchic way debt was handled by nineteenth-century Great Powers and also endangers the access of countries to private debt markets as private creditors see an enhanced likelihood of default.

The debt dilemma directly raises the old linkage between security issues and financial stabilization. The old mechanisms have reached the limit of what can be achieved. There were three distinct ways in which multilateral governance institutions operated in the era of postwar stability. The first, and probably initially most attractive, but also most uncertain in terms of its legal status, was a judicial or quasi-judicial role in arbitrating disputes between countries. There are many cases that look as if they require arbitration: trade disputes, or – often associated with trade disputes – debates about whether currencies are unfairly valued so as to produce a subsidy for exporters. The new emphasis on sovereignty in the UK, and elsewhere in Europe where "sovereignists" confront "globalists," pushes back against this type of arbitration.

The second style of multilateralism involved institutions acting as sources of private advice to governments on policy consistency and on the interplay between policy in one country and those in the rest of the world: explaining and analyzing feedbacks and spillovers and offering policy alternatives. That sort of consultation – rather than a formal arbitration procedure – was the main vehicle for discussion of currency undervaluation issues in the 2000s (a set of problems that will reemerge as the dollar soars). The essence of this kind of advice is that it is private. It is like speaking with a priest in the confessional. The outcome may be that behavior or policy changes, but the outside world will not really understand the reason why or the logic that compels better behavior.

The third is as a public persuader with a public mission. Former British Prime Minister Gordon Brown liked to use the phrase "ruthless truth-telling" or "speaking truth to power" with regard to the advice of multilateral institutions. There is an increasing recognition of the limits of secret diplomacy and behind-the-scenes advice. Societies cannot be moved unless there is a genuine consensus that they would be moving in the right direction. The backlash against globalization is fed by a climate of suspicion: experts, economists, and international institutions are not trusted. In the course of the 2000s, the G-20 and the

IMF moved to public assessments of how policy spillovers affected the world.

The third, public, style of action looks more appropriate than the secretive processes of the second in an age of transparency, when IT looks less secure, when secrets leak, when Wikileaks flourish. Now it is unwise to assume that anything is secret. Former diplomats publish indiscreet memoirs. Officials tweet about what they are doing.

The accessibility of information opens a fundamental dilemma. Policy advice is invariably quite complicated. Spillovers and feedbacks require a great deal of analysis and explanation and cannot easily be reduced to simple formulations.

Should international institutions be more like judges, or priests or psychoanalysts, or persuaders? None of the traditional roles on their own is any longer credible. But multilateral institutions will also find it impossible to take on all three roles at the same time. Judges do not usually need to embark on long explanations as to why their rulings are correct. If they just act as persuaders, maintaining a hyperactive tweeting account, they will merely look self-interested and lose credibility. But if the judges are secret – like the World Bank's International Centre for Settlement of Investment Disputes – they may be more efficient (as measured by the gains arising out of their rulings) but they will lose legitimacy.

It is easy to see why the institutions that successfully built the stability of the post-1945 order might be despondent in the face of apparently insuperable challenges. But there is a way out that harnesses the new technologies and that allows for a successful mediation of disputes that threaten to divide but also to impoverish the world.

The post-crisis world is one in which ever larger and more updated amounts of data are available. In the past, we needed to wait for months or years before we could conclude accurate assessments of the volume of economic activity or of trade. Now real-time data on a much broader set of measurable outcomes is available. Some analysts like Yuval Noah Harari see data as a new religion.

Some of the issues that need to be addressed are new, or appear in a new form, and are global public goods: defense against diseases that spread easily in an age of mass travel, defense against terrorism, defense against environmental destruction. In each case, the quick availability of large amounts of detailed information is essential for the ability to coordinate an effective response: for instance, where there is pollution and how it impacts health and sustainability, and then where and why it originated. Even large countries on their own cannot find the right response. So the data should not be confined to financial or economic data, but include quickly available health data (on a range of vital indicators – broad demographic measures, but also the accumulation of personal data, pulse rates, or oxygen or sugar levels

in blood, or blood pressure). This is data that matter to people: it is also data that invites public-policy responses, but also private sector activity to rectify problems and satisfy demands.

The wider dissemination of data will be controversial, not least because it offers the public, the citizens, an element of control. They can ask: are governments doing well in promoting public goods? Are specific companies with substantial market power hurting and harming, or protecting and promoting the general welfare? Data would offer a basis for more informed political choice.

THE CHALLENGES AND POLICY CONCLUSION

There are three major challenges that today will force a rethinking of public goods: each of them may be thought of in terms of fundamental challenges to security, personal and national. One is the existential threat of climate change, and the bizarre geopolitical consequences of that change. The thought that, at some point in the future, the extraction of energy from fossil fuels will become impossible produces a calculation that it is an asset with diminishing returns, so that it should be utilized now. That has both production and price effects, so that more carbon energy is supplied at lower prices, and hence more is consumed, and the CO₂ issue aggravated. CO₂ reduction is ultimately a common good: the problem is that on the way individual countries will have different calculations of the trade-offs, so that an international element of compensation of trade-offs is required.

The second is the impact of AI on labor market practices. AI is not only an obvious threat to employment, but also a security challenge. It threatens to disrupt the technologies that states use to defend their populations and to deter aggression. Big states are consequently involved in a race to harness and control and dominate data technology, but it is a dangerous and unstable game in that each technological turn could fundamentally transform politics by making old defenses obsolete.

The third related challenge is the monetary revolution that is being produced by new technologies such as blockchain, and the consequent possibility of generating non-state moneys. They promise the possibility of radical disruption to existing markets. In the past century, monetary dominance was a form of power, and in particular gave the United States preeminence, both in the Bretton Woods period and after. The alternative modes of money will offer challengers a way of asserting power, and at the same time disrupt the extensive financial relations on which existing industrial societies are based.

Managing and publishing that data in accessible and intelligible ways can be a critical way of forming the debate about the future and about the way individuals, societies and nations interact. Instead of a judge, multilateral institutions can become purveyors

of the costs and benefits of alternative policies by making information generally available (and eliminating the partial information that is a powerful cause of unstable financial flows). They need to work on ways of letting data speak to policymakers but also to people—voters all over the world. The North-Weingast model was about creating credibility: that is the way to create a strong and credibly institutionalized international financial and monetary system, replicating but updating the resilience of the British domestic revolution of the 1690s.

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Mathias Dolls, David Gstrein, Carla Krolage and Florian Neumeier

How Do Taxation and Regulation Affect the Real Estate Market?

In the past decade, housing costs have risen tremendously. While real estate prices in Germany have increased by around 50 percent, major cities have experienced an even stronger surge (Baldeus et al. 2020; Mense et al. 2019). Likewise, rents have substantially increased, particularly in major cities. More recently, the Covid-19 pandemic and the shift to working from home seem likely to have reinforced the trend to suburbanization, which has led to rising real estate prices also in big cities' surrounding areas. Hence, the affordability of housing is perceived to be an urgent social problem. Policymakers have adopted numerous measures intended to reduce housing costs. These include taxes, homeownership subsidies, or rent regulation.

How do such measures work? Do they in fact reduce housing costs, or do they rather bring about other, sometimes unintended, effects? In several projects, we exploit big data on property prices and rents to answer such questions. These include advert data from 17 million properties offered for sale between 2005 and 2019 from F+B, as well as detailed rent data from immowelt. In addition, we make use of large-scale surveys to study how the Covid-19 pandemic and the shift to working from home affect housing preferences and the choice where to live.

The following article provides an overview of four projects that assess the effects of regulation and taxation as well as the pandemic's impact on the German real estate market, using large-scale property price as well as survey data. The projects aim to provide answers to the following questions: Do subsidies make housing purchases more affordable? How do real estate transfer taxes affect house prices? How does rent regulation such as the Berlin rent cap affect the real estate market? And, which future trends in the housing market can be expected given the pandemic's potentially long-lasting impacts on residential preferences?

HOME-OWNERSHIP SUBSIDIES ARE PASSED THROUGH INTO PROPERTY PRICES

Rising property prices have led to calls for housing subsidies, aiming to make housing more affordable. While many policy measures target renters, several countries have implemented home-ownership subsidies, most often through mortgage interest deductions. Rather than subsidizing property purchases through the consideration of mortgage interest pay-

ments in the tax code, both the German federal and the Bavarian state government introduced direct real estate purchase subsidies in 2018. While the federal subsidy, the so-called Baukindergeld, explicitly targeted families and depended on the number of children, the State of Bavaria introduced an additional flat-rate subsidy. This housing purchase subsidy (Bayerische Eigenheimzulage) subsidized the purchase or construction of real estate for all households that met certain rather generous income criteria with 10,000 euros.

How do such subsidies affect property prices? Contrary to public perception, such subsidies do not necessarily benefit the buyers of real estate: if subsidies increase the demand for real estate, prices may rise in response. In fact, most empirical evidence on mortgage interest deductions points to a pass-through into property prices (see, e.g., Bourassa et al. 2013 or Gruber et al. 2021).

Using big data on property prices offered within 50 kilometers of the Bavarian interstate border, Krolage (2022) analyzed to what extent the direct housing purchase subsidy is passed through into prices. Exploiting that the home-ownership subsidy is exclusively granted in Bavaria, the study applied a differences-in-differences approach. More precisely, Krolage compared regional trends

KEY MESSAGES

- Rent caps can have significant unintended consequences through lower housing supply
- Instead of making housing more affordable, purchase subsidies have provided a windfall for sellers
- The real estate transfer tax levied on properties' purchase price substantially decreases property prices
- The Covid-19 pandemic may leave long-lasting impacts on Germany's housing market
- Policymakers would be well advised to take into account such trends and side effects when formulating policy



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in neighboring border regions, controlling for characteristics of the properties such as floor space, construction year, or the presence of amenities. This approach assumed that property prices in regions on both sides of the Bavarian interstate border would have followed the same trends in 2018 if the same policies had been in place on both sides. This assumption was validated by comparing price trends in previous years: Trends moved in parallel on both sides of the Bavarian border until they then diverged with the introduction of the Bavarian subsidy scheme in the second half of 2018. A disproportionate rise in Bavarian property prices after the introduction of the subsidy indicated a price increase attributable to the subsidy.

Indeed, this descriptive finding was confirmed by a thorough empirical analysis. The difference-in-differences results show that the prices of Bavarian single-family homes increased by about 10,000 euros in the second half of 2018 compared to adjacent regions in neighboring states. That is, house prices have on average risen by the subsidy amount, which indicates a full capitalization of the subsidy.

In contrast, no such effect was found for apartments. This is attributable to the large share of apartments which are purchased as investment properties. As the subsidy only applies to owner-occupiers, the market for apartments is much less affected.

Further robustness checks confirmed heterogeneous effects across property types: price increases are largest for medium-sized single-family houses, which are most likely acquired by families eligible for the subsidy. Linking housing to household survey data confirmed this finding: prices may even increase by more than the subsidy amount for houses with the highest likelihood of subsidization.

In addition to increasing house prices, such a subsidy scheme may foster construction of new properties. Applying my methodology to construction permits indeed provides suggestive evidence that the subsidy gave rise to a slight increase in construction activity.

Overall, the study shows that the subsidy scheme did not fulfill policymakers' expectations. Rather than making property prices much more affordable, the subsidy scheme gave rise to substantial price increases. Hence, on average, buyers of single-family homes do not benefit. Instead, the subsidy scheme redistributes from property purchasers and taxpayers

towards property developers and existing homeowners who can attain higher prices when selling their house.

REAL ESTATE TRANSFER TAX RATES STRONGLY REDUCE PROPERTY PRICES

Taxing property purchases constitutes an important source of public revenue in many countries. However, such taxes have come under criticism for preventing property transactions and for making housing unaffordable. Against this background, we use an event study design to assess the effects of permanent real estate transfer tax changes on the housing market (Dolls et al. 2021).

Understanding the effects of such taxes is key for policymakers. On the one hand, the tax leads to additional incidental purchase costs. On the other hand, taxation can also influence the prices sellers can demand. If demand for real estate falls as a result of a tax increase, prices may even drop significantly. In this case, sellers rather than buyers bear the effective tax burden.

In Germany, the real estate transfer tax (RETT), which is charged on a property's purchase price, constitutes an important source of revenue for the states. Since 2006, German states have had the flexibility to autonomously set their RETT rates. This has led to – often several – increases in tax rates in all states but Bavaria and Saxony.

We exploit the fact that the different German states increased their tax rates at different points in time to conduct a so-called event study. This allows us to separate the effect of the tax increase from general price trends. We estimate the price effects of a one-percentage-point increase in the RETT rate with large-scale price data, accounting for property characteristics, such as living space and the presence of a balcony or parking space.

Figure 1 shows the price trend before and after a RETT increase over time. The first vertical red line indicates the announcement of the tax increase, and the dashed vertical line indicates the timing of the increase. Our estimates indicate that prices drop significantly in response to a RETT increase. About one year after the tax increase, a one-percentage-point increase in the tax rate leads to a 3-percent drop in prices.



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Effects are larger for apartments than for houses, which is attributable to the average apartment having shorter holding periods. As apartments are more often considered as an investment and are resold more frequently, lower expected future resale values lead to a stronger decline in apartment prices.

Counterintuitive to public perception, these declines in prices are particularly strong in growing housing markets: Prices drop more in growing cities where the bargaining power of sellers is high. This is because buyers in growing cities are already at the upper limit of what they can afford. Consequently, higher taxes reduce the net-of-tax price buyers are willing to pay. Therefore, sellers need to decrease their offer prices in response.

Overall, our results show that the real estate transfer tax is borne by sellers. This suggests that real estate transfer taxes do not make properties less affordable for first-time buyers. Rather, reducing such taxes will likely enable sellers to charge higher prices, resulting in windfall profits for sellers.

This finding is also relevant in the current policy debate: to facilitate the acquisition of owner-occupied residential property, the current coalition agreement envisages an exemption amount for the real estate transfer tax. Our findings indicate that this may not necessarily benefit buyers.

RENT REGULATION REDUCES RENTS IN A REGULATED SEGMENT, BUT WITH ADVERSE EFFECTS ON HOUSING SUPPLY AND UNREGULATE RENTS

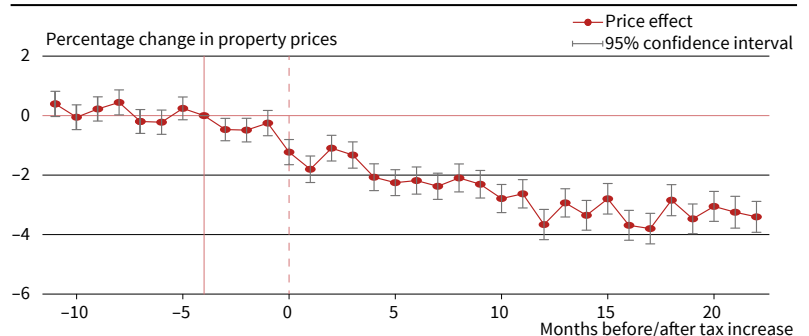
Declining affordability of housing has led to intense discussion about rent regulation, particularly rent caps. Proponents expect long-run drops in rents and relief for people struggling with high rents. Critics, on the other hand, point to possible unintended consequences, such as a drop in investment and a decline in the supply of housing. Arlia et al. (2022) studied these consequences for the case of the Berlin rent cap.

The “Law on Rent Limits in the Housing Sector in Berlin” was passed on February 23, 2020, in response to rising rents. The law implemented the so-called Berlin rent cap that limited rents for apartments. In addition to a freeze on rents at the cut-off date of June 18, 2019, a rent cap was defined depending on the residential location, year of construction, and furnishing of the apartment: net rents that were more than 20 percent above the respective rent cap were no longer permitted. However, this did not apply to new apartments built from 2014 onwards. Ultimately, the rent cap was declared unconstitutional by the Federal Constitutional Court on April 15, 2021. Immediately, the ceilings no longer applied and rents could be raised again.

This implementation and sharp reversal make this setting ideal for the study of the effects of rent regulation. Arlia et al. (2022) studied how purchase prices and rents developed in the regulated and unregulated

Figure 1

Effects of a One-percentage-point Increase in the Real Estate Transfer Tax on Real Estate Prices



Note: The first vertical red line indicates the announcement of the tax increase, and the dashed vertical line indicates the timing of the increase.

Source: Dolls et al. (2021).

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segments, i.e., those built as of 2014. To study this policy, access to timely data on the housing market in Berlin and other major German cities was key. The authors leveraged an extensive data set provided by the German real estate portal immowelt.de. The final dataset includes more than 460,000 rent ads and more than 160,000 purchase ads for Berlin and the 13 next largest cities in Germany.

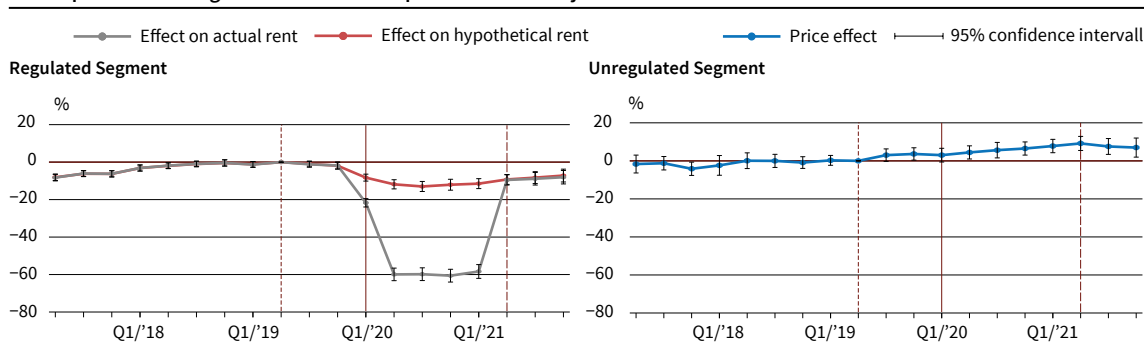
To identify the impact of the rent cap on prices and housing supply, Arlia et al. estimated a linear regression model that compared price and rent trends in Berlin with those in all other German cities with at least 500,000 inhabitants. The regression was weighted by the characteristics of the apartments, so that the distribution of apartment characteristics in Berlin and the comparison cities was identical. This ensured that divergent trends were not simply due to other apartments coming onto the market in Berlin.

Figure 2 shows the development of rents in the regulated and unregulated segments. Rents of apartments that were subject to the rent cap fell sharply after the introduction of the rent cap. In the regulated segment, we distinguish between actual rents and hypothetical rents: In many cases, contracts stipulated a higher rent if the rent cap was abolished. While the rent cap was in effect, the lower rents applied (actual rent). After the abolition, the higher rents came into effect (hypothetical rent).

In turn, rents in the unregulated segment, i.e., apartments built in 2014 or later, increased significantly. The introduction of the rent cap has thus led to a bifurcation of the real estate market: tenants of regulated apartments benefited, while tenants of newer apartments had to bear higher rental costs. Since the abolition of the rent cap, rent trends are slowly converging again.

The development for purchase prices was similar in the regulated segment. Compared to the other cities, purchase prices also rose less. This is the case even after the abolition of the rent cap. There were no clear effects on purchase prices in the unregulated segment.

Figure 2
Development of Asking Rents in Berlin Compared to Other Major Cities



Note: The chart shows the differences in growth rates of asking rents (per square meter) between Berlin and the 13 next largest cities in Germany in the regulated (left) and unregulated (right) segments for the period Q2 2017 to Q4 2021. The base period for calculating growth rates is Q2 2019. The first dashed vertical line marks Q2 2019, the date of publication of the rent cap bill and the cut-off date for calculating the rent cap (June 19, 2019). The solid vertical line marks Q1 2020, the effective date of the rent cap bill. The second dashed vertical line marks Q2 2021, the date the rent cap expires. Source: immowelt.de; authors' calculations. © ifo Institute

Finally, Arlia et al. examined the impact of the rent cap on housing supply. The rent cap led to a striking collapse in the supply of apartments: after the introduction of the rent cap, up to 60 percent fewer rental apartments were on offer. Even after the abolition of the rent cap, the supply of housing continued to be comparatively low. Conversely, the supply of unregulated apartments increased after the introduction of the rent cap and fell afterwards.

Rent regulations such as the rent cap are repeatedly proposed by policymakers. The analyses show that the rent cap had heterogeneous impacts on different groups. Individuals with an existing rent contract in the regulated segment did indeed pay lower rents. By contrast, housing costs rose for people who had to move to the unregulated segment of the real estate market, for example, due to a relocation. Additionally, reduced supply presumably made it harder to find an apartment. While the policy did reach its intended goal of reducing rents in the regulated segment, it also had major negative unintended consequences.

THE COVID-19 PANDEMIC AND THE SHIFT TO WORKING FROM HOME MAY HAVE LONG-LASTING IMPACTS ON THE GERMAN HOUSING MARKET

The Covid-19 pandemic triggered a huge, sudden uptake in working from home, as individuals and organizations responded to contagion fears and government restrictions on commercial and social activities. Recent research reveals that the big shift to work from home will likely endure after the pandemic ends (see Bloom et al. 2021, Criscuolo et al. 2021 and Aksoy et al. 2022, among others). Since the outbreak of the pandemic, there has been speculation about its effect on the housing market, in particular whether it might lead to urban flight and rural revitalization.

In order to shed light on the long-term effects of the pandemic and the shift to working from home on the German housing market, Dolls and Mehles (2021) examined residential preferences in the German population. They rolled out a large-scale survey of 18,000

people in urban, suburban, and rural areas in Germany in May 2021. A key finding of their study is that survey participants from urban areas show a higher willingness to fundamentally change their housing situation compared to respondents from suburban and rural areas. Nearly 13 percent of respondents from the 14 large German cities with more than 500,000 inhabitants say they plan to move away from the big city within the next 12 months. Short-term plans to move in this group are disproportionately more common among younger and middle-aged people and among households with children. The willingness to move among respondents from suburban or rural areas is significantly lower than among the group of metropolitan residents.

About 46 percent of respondents with short-term relocation plans indicated that their plans were influenced by the Covid-19 pandemic. The most frequently cited relocation destinations of metropolitan respondents with short-term relocation plans are smaller metropolitan areas with populations of 100,000–500,000, and suburban areas around larger cities, while rural areas play only a minor role. These results suggest that the Covid-19 pandemic and the shift to working from home will reinforce the existing trend of suburbanization, rather than trigger rural revitalization.

The above findings have important implications for municipal infrastructure planning, for example in the areas of mobility and education. They suggest that better (public transport) connections between suburban and urban areas and an expansion of the education infrastructure in suburban areas and in smaller metropolitan areas will become more important.

POLICY CONCLUSION

Large-scale real estate data permits a thorough analysis of policies affecting the real estate market. Our findings indicate that subsidies, taxes, and regulation do not always work as intended. Instead, purchase subsidies drive up prices and do not make housing more affordable, while, in contrast, real estate trans-

fer taxes lead to a reduction in property prices. Such an understanding is vital for future policymaking: Our insights help shed light on numerous current policy proposals, ranging from rent regulation to tax breaks.

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