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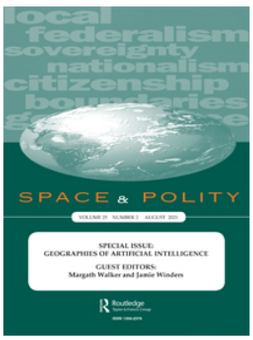

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Futurological fodder: on communicating the relationship between artificial intelligence, robotics, and employment

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ABSTRACT
This article examines the debate concerning the employment implications of the so-called 'Fourth Industrial Revolution' (FIR) or the increasing presence of artificial intelligence and robotics in workplaces. I analyze three 'genres' associated with this debate (academic studies including neo-classical and heterodox/post-human approaches, the 'gray literature', and popular media) and I argue that together they represent 'futurological fodder' or discourses and knowledges that 'perform' the FIR and its purported consequences. I contend further that these genres involve a complex mix of ethics and politics, and I conclude with a reflection on the political implications of the FIR debate.

KEYWORDS
Artificial intelligence; robotics; fourth industrial revolution; futurity

Introduction

Anxiety, hope, and speculation concerning the implications of technological innovation for work and employment are *at least* as old as capitalism. The proliferation of AI/robotics in the twenty-first century workplace, what has come to be understood by many observers as a 'Fourth Industrial Revolution' (FIR), seems to have only heightened the impetus to understand their consequences. Indeed, between 2013 and 2020, the publication of academic research dedicated to the implications of AI/robotics for employment exploded (e.g. Acemoglu and Restrepo, 2018; Autor, 2015; Brynjolfsson and McAfee, 2014; Cameron, 2017; Ford, 2015; Frank et al., 2019; Frey, 2019; Frey and Osborne, 2013, 2017; Korinek and Stiglitz, 2017; Susskind, 2020; Susskind and Susskind, 2015).[1] This was accompanied by a slew of 'gray literature', including from consultancies, governments, think-tanks, and corporations, which are often authored by academics (e.g. Arntz et al., 2016; Muro et al., 2019). During roughly the same period (but especially from 2016 to 2018), a wide variety of economic and business-oriented journalism (henceforth, the 'media') reported nearly every week with predictions of 'what was to come' in terms of U.S. employment, the focus of this article.[2]

Ultimately, these three forms of communication ('genres', hereafter) have offered what I term 'futurological fodder'. Such apparently influential fodder consists of discourses and knowledges which provide a mainly teleological, capitalist, and techno-scientific vision of the future (at least in the U.S.) in which advances in AI and robotics and their implementation in the workplace are considered to be inevitable. Yet, part of this futurological

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fodder also involves sometimes-overlapping and sometimes-incompatible and contradictory visions of the future labour market *effects* of AI and robotics. That is, the debate on AI/robotics and employment is not simply a dialogue between those who imagine a jobless future and those who believe that AI/robotics will create a yet-unknown array of new jobs but rather involves a more nuanced tableau of what appears to be imminent. According to Frank et al. (2019), this debate involves three imaginaries: a 'doomsayer's perspective', an 'optimist perspective', and a 'unifying perspective', to which I add a fourth, as noted below. These four broad imaginaries do not, perhaps surprisingly, coincide with any particular 'genre'. The doomsayer's perspective envisions that AI/robotics will eliminate a large proportion of employment by substituting for labour in certain sectors, occupations, or tasks. The optimist perspective holds that AI/robotics will certainly destroy jobs but that this destruction will be balanced by the creation of a range of new jobs. The unifying perspective sees complex dynamics in technological change which makes prediction difficult. A key element of this latter view is that occupations are understood to contain a mixture of skills and that technological change affects the demand for specific skills, rather than necessarily making whole occupations redundant. A fourth imaginary, perhaps similar in some ways to the 'unifying perspective', entails a 'post-humanism' in which human beings are fusing (or have always fused) with 'the machine', what Marchant and Donohoe (2019) call '*homo prostheticus*'.

Given these genres and their various imaginaries, as well as anxiety about the truthfulness of information, news, or science in the putatively 'post-truth' twenty-first century, my concern is *not* with their veracity, nor is my preoccupation with the 'actually existing' relationship between AI/robotics and labour markets, for which there is now a sizeable literature. Rather, inspired by a small literature critical of the FIR (Avis, 2018; Boyd and Holton, 2018; Greaves, 2015; Morgan, 2019; Reid-Musson et al., 2020; Wajcman, 2017), a more general literature on futurity, and the relationship between academic discourse and the two other genres, I make three related arguments in the context of the United States. First, I argue that the FIR literature provides 'futurological fodder' for a range of societal actors (academics, firms/capitalists, policy makers, workers, unemployed persons, and the broader public) that *may* lead to various types and degrees of political action or inaction and not necessarily only in the United States. That is, my emphasis is on the ways and degrees to which these genres dialogue with one another and, in doing so, how they might 'perform', 'anticipate', 'calculate', or 'pre-figure' the FIR and its consequences for employment, as well as politics. However, while such fodder does not result in a uniform discourse, I argue that it mostly involves what Anderson (2010) calls an 'anticipatory politics' or what Appadurai (2013) conceives of as an 'ethics of probability'. This is in contrast to Appadurai's 'ethics of possibility' or what Jeffrey and Dyson (2021) call a 'pre-figurative politics'.

Second, I argue that at least the U.S.-focused media's vision of the FIR's consequences is ambiguous and contradictory because of its close dialogue with the equivocality of the other two genres. Arguing for the media's ambiguity and its frequent reliance on academic analysis or the gray literature is different from simply insisting that the media is 'sensational' (Bissell, 2021), that 'it is hard to distinguish fact from fiction, or sober analysis from media hype' (Butollo, 2021, 261), or that the media 'overstates' the mass substitution of labour by 'automation' (e.g. Autor, 2015, Brynjolfsson and McAfee, 2014, Kaplan and Haenlein, 2020). As with the academic literature, this is significant insofar

as the media may shape workers' embrace of – or, conversely, their potential resistance to – the implementation of AI/robotics in the workplace. I argue, third, that neo-classical studies and the media, in particular, suffer from a related set of lacunae: they say very little about how 'space', intersectionality, or how different forms of AI and robotics figure in prediction, which, perversely, may have its own geography of economic, political, and social effects.

To develop these ideas, this article is structured as follows. The first section critically frames the debate on the FIR. The second section presents an overview of the academic debate, focusing in particular on research that involves the United States from a neo-classical and a heterodox perspective. From there, the third section provides a summary of three prominent reports (a 'gray literature') on the impact of AI/robotics on U.S. employment. The fourth section undertakes a textual analysis[3] of the economic and business-oriented press and summarizes the relationship between the three genres and their four broad arguments. I conclude with a reflection on the political implications of this analysis.

Critically framing the debate on the FIR

The debate on the FIR that I interrogate in this article mainly concerns the future. While geographers and other scholars have always been interested in the future (e.g. Harvey, 2000), more explicit attention has been accorded to 'futurity' over the last decade or so (e.g. Amin, 2012; Anderson, 2010; Appadurai, 2013, Bunnell et al., 2018; Jeffrey and Dyson, 2021; Legun and Birch, 2021). Appadurai (2013) for example, distinguishes between a futurological 'ethics of probability' which involves calculation, diagnosis, counting and accounting, and an 'ethics of possibility', which he explains as

> ways of feeling, thinking, and acting, that can expand the horizon of hope, that expand the field of the imagination, that produce greater equity in what I have called the capacity to aspire, and that widen the field of informed, creative, and critical scholarship. (p. 295)

Similarly, Jeffrey and Dyson (2021) distinguish between Anderson's (2010) 'anticipatory politics', which enact a future through the style, practices, and logics of powerful actors and institutions and a 'pre-figurative politics', which refers to the politics of actors and institutions of 'marginalized or minoritized populations' (Jeffrey and Dyson, 2021, 5). That is, a pre-figurative politics seeks to shape a different and 'better' future than what is imposed by an anticipatory politics. If we can assume that the difference between 'anticipatory politics' and 'pre-figurative politics' is the political manifestation of Appadurai's 'ethics of probability' and an ethics of 'possibility', then Bunnell et al.'s (2018) critique of the latter is relevant to both. That is, they question whether Appadurai's distinction need only result in what they memorably call a 'Zoroastrian struggle' between the two ethics. Rather, they contend, an ethics of probability may contribute to an ethics of possibility, and this is certainly the case for many FIR theorists, though their ethics of possibility struggle to move beyond largely market-driven and techno-scientific futures. In a modification of Bunnell et al.*'s* rejection of the 'Zoroastrian struggle', I conclude in this article that the question should not be whether we should have an ethics of probability but what kind of 'ethics of probability' under what sort of social relations.

A second consideration concerns the neglect of 'space'. This itself works on two levels: how spatial differences might shape the production of discourse and how the relative absence of explicitly spatial thinking in FIR discourse may have economic and political effects. My last point, however, should not be taken as an exclusive attachment to the 'performativity thesis' by which economic thought creates the 'real world', not the other way around (e.g. Mackenzie, 2003). Rather, I have in mind a dialectics of material conditions and processes, futurological fodder, and performativity (e.g. Legun and Birch, 2021). At the centre of the U.S.-focused debate are a limited number of influential academic contributions authored from scholars located in major U.S. or other research institutions and empowered by the reputational weight of economics or computer/information sciences. Consequently, it is presumed that the readership is sizeable, but not that these texts are *necessarily* hegemonic in a Gramscian sense, nor that they are necessarily read by those workers who might be displaced by AI/robotics.

In any case, I acknowledge that FIR discourse elsewhere may be moulded by similar or different national and sub-national material conditions and processes (such as international competitive pressures for certain sectors or firms, demography/aging, labour availability and costs, social differentiation/the intersectionality of labour markets and social reproduction, firm size, the availability and costs of technology, the spatial dynamics of off/re/near-shoring, and laws and regulations). Indeed, in some regions of poorer or middle-income countries, the possibilities for employment that digital platform labour affords, regardless or because of its precarity (e.g. Ettlinger, 2017; Graham and Anwar, 2019; Ojanperä et al., 2018) and the increasing use of software platforms in business-process outsourcing that threatens jobs (Peck, 2019) may shape the FIR's production and reception in these (sub-)national spaces in ways dissimilar to the U.S.

The second 'level' of my spatial concerns reflects the relative absence of explicitly spatial thinking (or its inchoateness) in the FIR's predicted labour market effects. If spatial metaphors based on or beyond political territories (such as large city, metropolitan area, small city, rural area, 'developed' or 'developing' country, etc.) are not simply mirroring the 'real world' but actively constructing it (Dikeç, 2012), this, in turn, has implications for the performativity of FIR discourse. But it is not space alone that matters. That is, alongside the spatial immaturity of neo-classical models is the inadequate (even absence) of any discussion of social differentiation or 'intersectionality' (the latter referring not just to future segmentation by 'race', gender, ethnicity, and so forth but also to how the intersecting identities of workers or unemployed persons might shape the FIR and its labour market effects).[4] A further set of inadequacies refers to the vague (or widely disparate) notions of time that are used by all three genres. Again, we can speculate that such flawed socio-spatio-temporal models of the future of AI/robotics and employment have the potential to perform a politics surrounding the FIR and its labour market consequences.[5]

The academic debate

Neo-classical economic studies

Many neo-classical economists use the term 'computerisation' or 'automation and rarely distinguish between AI and robotics or between different forms of AI (i.e. narrow AI,

general AI, and super-intelligent AI) (e.g. Frank et al, 2018; Frey and Osborne, 2017; Morikawa, 2016). There are exceptions (Acemoglu and Restrepo, 2018; Autor, 2015, Bessen, 2017; Brynjolfsson and McAfee, 2014, 2017, and Korinek and Stiglitz, 2017), but even for these authors, the relationship between data, empirical analysis, and the distinction between robotics and different forms of AI and their effects is hardly clear. This is surprising, given the possibly dramatic implications for the future of work (Gaynor, 2020).

Despite these fundamental difficulties, neo-classical economic studies, or modifications of the neo-classical framework (e.g. Berg et al., 2018), have relied on mainly quantitative or scenario modelling to argue that technological innovation has consequences for employment in at least four ways. The first, and consistent with Frank et al.'s 'doomsayer's perspective' is that the FIR will displace workers from occupations, jobs, or tasks they were previously undertaking (variously called substitution labour-saving or task encroachment). Here, economists are particularly interested in 'skill bias' – namely, that AI/robotics might substitute entirely (or partially) for some workers, such as 'less-skilled workers',[6] especially in manufacturing. Yet this concern has been extended to 'middle' and 'highly skilled' workers, as AI/robotics become more adept at handling non-standardized, non-routine and more cognitive-intensive tasks. A starting point for this debate is the highly cited 2013 working paper by Oxford University economists Frey and Osborne (and in published form, 2017) in which they analyse over 700 occupations and calculate the number of jobs at risk and the relationship between an occupation's probability of 'computerization', wages, and educational attainment. They distinguish between high-, medium-, and low-risk occupations and focus on potential job automatability over some unspecified number of years. According to their estimates, around 47 percent of total U.S. employment is in the high-risk category and could be automated relatively soon (perhaps over the next decade or two). Frey and Osborne (2013) argue that 'computerization' will *mainly, but not exclusively*, involve less-skilled and low-wage occupations but that less-skilled workers will reallocate to tasks that are not susceptible to computerization – that is, tasks requiring creative and social intelligence, which they will eventually need to acquire.

Other economists also express concerns about the substitution of less-skilled workers but focus on highly skilled workers (Susskind, 2020; Susskind and Susskind, 2015; Webb, 2020). Susskind and Susskind (2015), for example, imagine 'incremental transformation' (p. 302) where professionals (doctors, lawyers, teachers, etc.) will be gradually replaced by 'less-expert people' and 'high performing systems' (p. 303). They are reluctant to provide a time frame for this transition and insist that they are resisting a teleological argument in which human beings *can* control their future, although it becomes clear they see these changes as more likely than not. In a follow-up work, Susskind (2020) is more certain that 'task encroachment' will eliminate most work for all human beings by rejecting neo-classical economists' 'lump of labor fallacy' (the argument that 'there is no fixed lump of work in the economy to be divided up between people and machines' p. 126). Instead, he cleverly argues for what he calls the 'lump of labor fallacy fallacy' because 'while it may be right that technological progress increases the overall demand for work, it is wrong to think that human beings will necessary be better placed to perform the tasks' that are created by involved in meeting that demand (Susskind 2020). At the even more pessimistic or dystopian end of this substitution argument,

Harvard Economist Richard Freeman (2015), writes, 'If you understand comparative advantage but still fear robots turning you jobless, technophiles of innovation will denounce you as a neo-Luddite alarmist, a socialist, or a sociologist – or something worse' (p. 3). Thus, Freeman (2015) argues, we are moving toward twenty-first-century economic feudalism, given the ownership of these technologies.

More aligned with Frank et al.*'s* (2019) optimist perspective is a second consequence in which workers might adapt to these new technologies (complementarity, capital-skill complementarity, or labour augmenting). A third scenario is that workers will perform tasks better, more efficiently, and/or more cheaply than new technologies (comparative advantage), or fourth, technology can increase the demand for labour in new industries and jobs (a 'compensation effect') that stems from innovation and productivity increases (Acemoglu and Restrepo, 2018; Autor, 2015; Bessen, 2017; Brynjolfsson and McAfee, 2014; De Canio, 2016; Huang et al., 2019). Even Frey himself in a later work (2019) is rather equivocal on whether AI/robotics will be labour saving. Acemoglu and Restrepo (2018) envision a progressive complication of tasks over time and that assume labour *in aggregate* has a comparative advantage, while also recognizing that automation may reduce employment for less-skilled workers. They consider the case where some tasks in the 'long run' will be 'standardized' so as to employ less-skilled labour and reach a dynamic equilibrium – a 'balanced growth model' in which inequality is reduced. In turn, Bessen (2017) argues that employment in the next 10–20 years will depend on the demand for new products and services. He points out that despite AI's incorporation into the legal profession, 'the booming market for electronic discovery applications, for instance, has been associated with an increase in the employment of paralegals' (p. 16). While De Canio (2016) and Berg et al. (2018) envision equally strong economic growth from AI/robotics, they also see falling real wages and growing inequality.

Ultimately, then, the FIR debate among neo-classical economists raises the question whether 'this time might be different' (Mokyr et al., 2015) in terms of substitution vastly outweighing complementarity, comparative advantage, and compensation, even for highly skilled workers. Yet there are, in fact, only a handful of studies that entail model-based predictions (Berg et al., 2018). Instead, studies rely mostly on theoretical argument or draw on empirical data from past analyses of technological change, rather than on AI and robotics (Morikawa, 2016).

Fitting into Frank's 'unifying perspective', the MIT economist Autor's (2015) analysis fits somewhere between the processes of substitution, comparative advantage, and complementarity. Critical of Frey and Osborne's (2013) emphasis on the automation of entire occupations rather than specific job tasks, he insists that it is necessary to examine tasks to understand why some might be automated and some not. To do so, Autor draws on what he calls 'Polanyi's paradox'. Polanyi (1966) argued that much of human knowledge is tacit and not easily codified, and Autor suggests that tacit knowledge creates a barrier to automation, including at the lower end of the employment spectrum. This paradox is, in turn, referred to as Moravec's paradox by computer scientists, in which the seemingly most difficult tasks are easier to automate than the apparently most basic ones (see also Brynjolfsson and McAfee, 2014).

Autor agrees that many routine tasks, especially in 'middle-skilled jobs', can be automated away, but he is less certain about other tasks at the poles of the skills spectrum. These entail certain manual tasks which require in-person interaction, cognitive, and

physical flexibility, situational adaptability, 'common sense' [*sic*], creativity, intuition, judgment, and visual and language skills. These include tasks in the field of the three Cs (care, catering, and cleaning), especially nurse practitioners who increasingly perform tasks (such as diagnosing) that physicians used to perform, grounds maintenance and security, and repair occupations, including automotive specialists, builders, and electricians. The second set of tasks that are difficult to automate are found in managerial, professional, and technical occupations and require workers to have high education levels, analytical and problem-solving abilities, communicative and persuasion abilities, creativity, expertise, inductive reasoning, and intuition. For Autor, Polanyi's paradox provides the clue as to why AI/robotics have trouble automating away these tasks and will, therefore, lead to job polarization at both poles of the skills spectrum. However, he also acknowledges that more might be achieved through advances in AI/robotics, especially through 'environmental control' (i.e. controlling the environment of warehousing and transportation systems) and through training AI to 'learn' tacit knowledge.

Let me finish this discussion of neo-classical studies by adding that a handful of neo-classical studies offer explicitly spatialized predictions for employment effects (Acemoglu and Restrepo, 2018; Deveraj et al., 2017; Frank et al., 2018, 2019; Frey, 2019; Frey et al., 2018; Marinoudi, Sørensen, Pearson, and Bochtis, 2019). For example, drawing on Frey and Osborne (2017), Deveraj et al. (2017) disaggregate effects to the county level and show that counties with the lowest education level in the U.S. are more susceptible to having jobs automated. Frank et al. (2018) provide parallel findings, arguing that larger cities are more likely to benefit from 'automation' than smaller cities. In terms of agricultural productivity, Marinoudi et al. (2019) perceive that AI and robotics will only reinforce the gaps in agricultural productivity between so-called 'developed' and 'developing' countries'. Ultimately, then, neo-classical studies provide a highly abstracted prediction of the labour market effects of AI/robotics by neglecting the socio-institutional embeddedness of labour markets and either relying overly on methodological nationalist analysis (the above exceptions aside) or neglecting a range of possible intersectional consequences beyond educational attainment (e.g. Deveraj et al., 2017 or Marinoudi et al.'s, 2019 crude distinction between 'developed' and 'developing' countries).

Heterodox studies

Under the term 'heterodox studies', I include any research that is explicitly or implicitly critical of a neo-classical economic framework. Beyond this fundamental difference, one can identify at least three broad differences between neo-classical and heterodox studies. First, while neo-classical studies are based on modelling, heterodox studies examine, often in the context of specific sectors, the effects of 'actually existing' AI/robotics through anecdotal, critical-conceptual (including post-humanist), or qualitative studies, which also may involve surveys. Concerning this first distinction, heterodox studies often rely on the critical analysis of sectors and include a long list of occupations, jobs, or tasks that have been, *or could be*, eliminated in the future across the spectrum of agriculture, manufacturing, and services (e.g. Berezina et al., 2019; Bissell, 2021; De Falco, 2020; Fleming, 2019; Graham and Anwar, 2019; Holton and Boyd, 2021; Howard, 2019; Lloyd and Payne, 2019; Munoz and Naqvi, 2017; Ojanperä et al., 2018; Paluch and Wirtz,

2020; Peck, 2019; Qureshi and Syed, 2014; Rotz et al., 2019; Susskind, 2020; Wilson et al., 2017). Some of these studies accord explicit attention to space (e.g. Graham and Anwar, 2019; Lloyd and Payne, 2019; Peck, 2019; Susskind, 2020), while others are 'spatial' by their particular focus (e.g. Rotz et al.'s, 2019 study of automation in agriculture). Emblematic of an explicitly spatial approach is Peck's (2019) study of evolution and involution in global business process outsourcing. Here, he stresses the importance of 'robotic process automation' ('software code', rather than hardware) and the development of the 'imagined territory of Robotistan' (p. 182) in which employers seek a 'no-shore' solution to problems of competitive pressures in especially routine work, such as rising labour costs and declining productivity. In a more speculative and science fiction-inspired paper, Munoz and Naqvi (2017) offer a dystopian vision in which the owners of AI live in 'Elysium cities' while those unemployed by AI are exiled to poorer cities in what they call 'de-tech migration'.

A second distinction is that heterodox studies 'embed' technological innovation within socio-institutional relations, which might include an emphasis on 'organizational power relations' (Fleming, 2019). Here, employment relations or organizational design drives technological innovation, not the other way around. While I take issue with Fleming's non-dialectical conception of innovation, such all-important socio-institutional relations might include the scope and degree of trade unionism and labour resistance, domestic politics, geopolitical risk, national, regional, and local regulations, the differential price of labour across different state spaces, the automatability of tasks, and the availability of labour (e.g. Peck, 2019). In short, technological innovation is not seen as a *fait accompli* (Bissell, 2021). These long-standing critiques, or at least alternatives to technological determinism, are foundational for rejecting the FIR's teleology, even if many point to technological unemployment in the present.

A third and unsurprising distinction between neo-classical and heterodox studies is that very few of the latter offer futurological pronouncements, given their non-deterministic proclivities, although there is occasionally a slippage between an analysis of the present and futurological discussion. Indeed, Graham and Anwar (2019), for example, remain uncritical of other scholars' prediction concerning the future growth of digital platform labour. Another heterodox exception to this aversion to prediction can be found in Wilson et al. (2017), who embrace the FIR but are also skeptical of widespread technological unemployment. In some unspecified temporality, they argue, three different sets of jobs will be created, rather than destroyed, by AI – namely, 'trainers', 'explainers', and 'sustainers'. Trainers (including 'emotional trainers') will train AI systems on 'how they should perform' and teach 'compassion' (p. 14). Explainers will 'bridge the gap between technologists and business leaders' (p. 15) by offering clarity, and sustainers will 'help ensure that AI systems are operating as designed and that unintended consequences are addressed with the appropriate urgency' (p. 15).

A significant departure from other heterodox studies is a more post-human imaginary of *homo prostheticus* (De Falco, 2020; Greaves, 2015; Richardson and Bissell, 2019). Richardson and Bissell (2019), for example, are critical of FIR discourse on the grounds that it presumes workers are gradually being separated from work. They develop an understanding of skill dynamics that transcends the usual understanding of space as nested in particular containers, instead of viewing space in Foucauldian terms as 'sites' of human-machine interaction and the constant reconstruction of what

digital skill might mean. In a similar post-human vein, Greaves (2015) argues that new subjectivities will emerge from evolving human-machinic combinations with the development of AI and robotics. In this sense, there may be less of a gap between a post-human perspective and the neo-classical literature than one might presume, given some of the latter's discussion of skill dynamics, consideration of the possibility of super-intelligent AI, and flirtation with 'singularity'.

In sum, then, heterodox studies are diverse. They either focus on the past and present of AI/robotics and labour markets through a critical/intersectional lens that often involves spatially explicit analysis or critique the FIR's futurological fodder. In so doing, they avoid performing its future and provide a space for an 'ethics of possibility' or 'pre-figurative' politics. In contrast, the difficulty with more post-human interventions is that they suffer from the 'it will all be alright in the end' (or 'markets eventually clear') view of many neo-classical studies, only from a different perspective, and, therefore, neglect the present (or even the future possibility) of technological unemployment *for some workers*.

The Gray literature

The gray literature is enormous, and as such, I limit my discussion to the similarities and dissimilarities between three reports that have been frequently cited in academia and the media and vice versa, including those of the OECD (authored by Arntz et al., May 2016, and henceforth referred to as the OECD report), the Brookings Institution (henceforth BI, authored by Muro et al., 2019), and the McKinsey Global Institute Report (henceforth MGIR, January 2017).[7] All three reports paint a future picture of strong forces of 'adjustment' but not the disastrous narrative portrayed by *some* media. In that sense, these reports are closer to Frank et al.'s 'unifying perspective'.

I discuss the similarities and dissimilarities between these reports and their relation to the academic literature with respect to the terms they use, their technological emphasis, the methodologies they employ, and their projections in terms of employment, including any geographical insights. To begin, all three reports use different terms. The BI report focuses on AI, although it acknowledges that defining AI is notoriously difficult. The MGIR report sporadically mentions AI, while relying more frequently on the vague term 'automation'. The OECD report uses the term AI only twice, while principally employing the terms automation and 'automobility'.

The BI, MGIR, and the OECD all provide original analyses but also illustrate the gray literature's reliance on academic work. These three reports use a 'task based' approach associated with Autor and his MIT colleagues to investigate skill bias (defended as 'more accurate' or 'more realistic') in contrast to the 'occupation approach' of Frey and Osborne (2013). For example, the MGIR relies on a global analysis of upwards of 800 occupations, 2,000 work activities, and within these, 18 'performance capabilities', which were then aggregated into 5 groups: sensory perception, cognitive capabilities (such as creativity), natural language processing, social and emotional capabilities, and physical capabilities, such as fine motor skills. The MGIR then estimated the level of these capabilities required to undertake these work activities, as well as the required performance of 'currently demonstrated technology' (CDT), that is, technology which is commercially available or in development. The MGIR authors ask: What is the 'technical feasibility' (using CDT) of automating these different tasks?

In these three reports, there are similarities and differences in the data they employ. For example, the MGIR uses Bureau of Labor Statistics or O*NET data, as do Frank et al. (2019). The BI report uses the methodology developed by Michael Webb (a PhD student at Stanford). The OECD draws partly on Frey and Osborne's analysis since individuals might perform different tasks within identical occupations. The result, they contend, is that the data offer a more realistic picture of what people actually do in their jobs.

In terms of overall quantitative findings, the OECD report finds that 9% of jobs are automatable, on average, across OECD countries, while the MGIR finds that while less than 5% of all occupations could be completely automated with CDT, roughly 60% of all occupations contain about 30% of jobs that could be fully automated. This 'full automation' of half the work activities in 2017 could occur by 2055, but this timing might vary by 20 years on either side of this date, depending on macro-economic conditions and other variables. However, the so-called 'near-term' impact will be not so much the elimination of jobs as the transformation of work. The three reports echo most academic studies which find that the workers 'more susceptible to job losses' are those with especially low education levels, those in positions involving 'physical activities in highly structured and predictable environments' (MGIR, p. 4), and those in jobs involving collecting or processing data. In contrast, the BI report finds that 'better educated, better-paid' workers are more exposed to displacement by AI specifically. Unusually, the report further argues that 'prime-age', male, white [*sic*], and Asian [*sic*] workers will be the most affected by AI. Likewise, the MGIR assumes that automation will undertake a range of tasks that were previously not considered automatable – namely, tasks involving 'tacit judgements' and 'sensing emotion'.

The point here is that there are quite significant differences across the reports in the FIR's predicted overall quantitative outcomes across variable time frames and in terms of the skill levels of workers who will face technological unemployment. The latter is consistent with contrasting emphases within the neo-classical literature. Unlike most of the neo-classical literature, however, but reflective of the heterodox literature, all three reports acknowledge that the adoption of automation and consequential changes are contingent upon a range of processes, including, as the MGIR outlines, 'technical feasibility' (the pace of technical innovation), the 'cost of developing and deploying solutions' (the relative cost of hardware and software, such as natural language processing), 'labor market dynamics' (competition with labour in terms of skills and supply), 'economic benefits' (the advantages of using automation in terms of increased output and higher quality with fewer errors), and 'social acceptance and regulations', including those of governments, firms, and individuals. Concerning the latter, the MGIR notes, a robot could in theory replace a nurse, but patients may not accept this replacement. Finally, there are some noteworthy geographical, especially sub-national, findings. The BI concludes (c.f., Frank et al., 2019) that larger metropolitan areas in the U.S. with significant employment in technology-related sectors are likely to experience the most displacement, while smaller rural communities are less likely to be impacted. However, they note, this may be less true of towns and rural areas in the Midwest and the Plains States, given their concentration in agriculture, manufacturing, extraction, and transportation. Despite the above geographical analysis, these three reports ultimately say little about spatial outcomes, much like most of the neo-classical literature.

Debate in the popular media

In the U.S.-based popular media, one might have expected a sensationalist panic about job losses and grim promises of dystopia. No doubt, such dire predictions were present during the period, 2016-2020, but the media remained remarkably measured and even at times sanguine about the effects of AI/robotics on employment. In short, arguments in the media concerning the consequences for employment are diverse, vary by occupation or economic activity, and are more ambiguous than simple unmeasured panic. Such ambiguity may be explained in part by the media's dependence on a limited number of academic studies (notably, Brynjolfsson and McAfee, 2014, Ford, 2015, and Frey and Osborne, 2017) and the gray literature (the MGIR and the OECD especially). Yet it is also a product of the technophile cheerleaders of capitalism upon which the media routinely rely for futurological commentary. For heuristic purposes, we can once again mobilize Frank's 'doomsday', 'optimist', and 'unifying' imaginaries.

The doomsayer's imaginary: catastrophic prediction and thoughtful panic

We begin with the media's representation of what I call the 'Musk-Zuckerberg spat'. According to Elon Musk (founder and CEO of SolarCity, Tesla, and SpaceX), AI will eventually supplant even the 'smartest human being' and 'humans will become useless' (CNBC, Feb 13, 2017; *MIT Technology Review*, April 11, 2017). Musk spoke throughout 2016–2017 of AI's disastrous consequences for employment, calling it 'summoning the demon' and 'a bigger threat than North Korea' (CNBC, Aug 12, 2017; *Bloomberg Business Week,* Nov. 13, 2018). In contrast, Facebook CEO, Mark Zuckerberg referred to Musk's comments as 'irresponsible' (CNBC, July 24, 2017). In turn, Musk claimed that Zuckerberg had a 'limited understanding' of AI (CNBC, July 25, 2017). At the very least, this spat is significant insofar as it is representative of the poles of the debate concerning the effects of AI/robotics on employment.

At the more doomsayer's end of the spectrum, dire predictions about employment referred to the rise of massive 'technological unemployment' (e.g. Communications of the ACM, 2013), 'structural unemployment' (e.g. *Big Think*, Dec 27, 2016), 'massive disruption' (economist Martin Feldstein in *Wall Street Journal*, June 11, 2018), 'decades of pain' (former Alibaba chairman Jack Ma, CNBC, April 24, 2017), and 'jobocalypse' where 'Within 20 years, maybe half of you will be out of jobs. A couple of decades after that, most of the rest of you will be out of jobs' (Drum, in *Mother Jones*, Nov/Dec. 2017). Drum continues:

> When robots become as smart and capable as human beings, there will be nothing left for people to do because machines will be both stronger *and* smarter than humans. Even if AI creates lots of new jobs, it's of no consequence. *No matter what job you name, robots will be able to do it.* They will manufacture themselves, program themselves, repair themselves, and manage themselves. If you don't appreciate this, then you don't appreciate what's barreling toward us (*Mother Jones*, Nov/Dec 2017).

The *Big Think* (Dec 27, 2016) adds to this disconsolate fodder:

> By 2034, just a few decades, mid-level jobs will be by and large obsolete. So far, the benefits have only gone to the ultra-wealthy, the top 1%. This coming technological revolution is set

> to wipe out what looks to be the entire middle class. Not only will computers be able to perform tasks more cheaply than people, they'll be more efficient too.

Such gloomy inspiration finds much of its source in Frey and Osborne (2013), who are cited in an endless chain of media (e.g. *Wall Street Journal,* Oct 13, 2019) that is the quintessential example of how scholarship, the gray literature, and the media loosely anticipate the future. Using Frey and Osborne's occupation approach, the *Financial Times* (April 7, 2017) even created an interactive calculator to determine which tasks could be automated in the future based on specific occupations. Yet, some media seem to interpret Frey and Osborne's research incorrectly. For example, *The Economist* (January 18, 2014) cites their apparent claim that 47% of jobs are likely to disappear, and this figure in *The Economist* was, then, cited by the 'Big Think' (*Big Think*, Dec 27, 2016, and again June 4, 2017). However, Frey and Osborne never said that 47% of jobs in the U.S. would be eliminated but rather that 47% of jobs fall into a 'high risk category' of being automated. *The Economist* (June 27, 2019) later clarified that they misinterpreted Frey and Osborne's research.

There is some attention to the FIR's *socio-spatial* effects. One instance is the *Los Angeles Times*' (Jan. 24, 2019) reference to the BI report (discussed earlier) in which it reproduced the BI's map of 'automation potential by metro area', claiming that workers in 'Inland California' (e.g. Fresno or San Bernadino) were most susceptible to replacement by 'robots' compared to those living in San Francisco or San Jose. Susceptibility was also associated with differentiation by gender, age, race, and ethnicity, and the article generally stressed automation's consequences for less-skilled, rather than highly skilled, workers, though again, it is not clear if 'automation' refers uniquely to the 'tin men' of robots, or software as well. Finally, as with the more optimist literature (discussed below), a range of articles reported on dire predictions for specific sectors and jobs, from the eventual disappearance of accountants to baseball umpires, sometimes with specific time frames (e.g. by 2030) but often with only imprecise temporalities (e.g. 'decades from now').

The optimist imaginary: from the possibility of 'rage against the machine' to the dismissal of worries

Part of the media's skepticism about the FIR's unmitigated advance and massive technological unemployment derives from potential resistance to AI/robotics ('rage against the machine'), or at least the friction associated with such innovation. Indeed, CNBC (Aug. 24, 2017) reported on a possible ballot measure on taxing robots for the city of San Francisco. More generally, a rare article in *Nature* (Anthes, Oct 24, 2017) echoes some of the heterodox literature and notes that 'Just because a task can be automated doesn't mean that it will be; new technologies often require costly and time-consuming organizational changes. Legal, ethical and societal barriers can also delay or derail their deployment'. Indeed, 'Implementing medical machine-learning systems, for instance, requires both technological readiness and willingness to devote the thousands of person-hours necessary to make these systems operational', let alone acceptance by care providers and patients.

Beyond acknowledgement of resistance is a clear dismissal of dystopian narratives. This 'more positive' media seems to gather its futurological fodder from the gray

literature such as the MGIR, as well as a range of academics and 'business gurus' (e.g. the *Wall Street Journal*, Oct. 13, 2019). For instance, CNBC (Oct 25, 2016), cited the entrepreneur, venture capitalist, and software designer Ben Horowitz:

> Software will continue to eat – and program – the world, and erase some jobs in the process, but history suggests it will create even more …It is possible this time it's different – it's possible that this time technology just wipes out all the jobs and there's nothing for people to do and we just have to put on plays, and write music and paint pictures – but that's not the highly probable bet.

Paraphrasing Horowitz' partner Mark Andreesen, CNBC proclaimed that 'we're wrong about the robots stealing jobs, just like we've always been'. As Andreesen himself noted, 'This is the panic every 25–50 years … It never comes true' (cited in CNBC, May 31, 2017). Similarly, the *New York Times* insisted (February 20, 2017),

> The rise of modern robots is the latest chapter in a centuries-old story of technology replacing people. Automation is the hero of the story in good times and the villain in bad. Since today's middle class is in the midst of a prolonged period of wage stagnation, it is especially vulnerable to blame-the-robot rhetoric.

Likewise, the *Economist* (August 26, 2017) noted:

> When the first printed books with illustrations started to appear in the 1470s in the German city of Augsburg, wood engravers rose up in protest. Worried about their jobs, they literally stopped the presses. In fact, their skills turned out to be in higher demand than before: somebody had to illustrate the growing number of books.

The Economist conjectured that 'digital assistants such as Amazon's Alexa and Microsoft's Cortana will have to answer more complex questions. Humans will still be needed to train algorithms and handle exceptions' (*The Economist,* August 26, 2017). *The Economist* concluded that 'Technology is rarely an unalloyed bane or blessing. Indeed, in the so-called 'platform' or 'gig economy', 'more and more people are supplying digital services online via 'the Cloud' but that is actually in response to AI'. In the same vein, CNBC (2017, June 16) noted that Alphabet's Eric Schmidt claimed that 90% of jobs are not fully automatable (citing the MGI report discussed earlier): 'So what that tells me is that your future is you with a computer, not you replaced by a computer'. Despite Jack Ma's claim that there will be decades of pain, he also noted that 'humans will win' the battles against robots, essentially by learning new skills (CNBC, June 21, 29, 2017).

The optimistic media has also pronounced on the future of particular sectors or occupations. In logistics and distribution, the *Los Angeles Times* (December 30, 2019) reported on how the proliferation of AI and robotics in Amazon warehouses does not necessarily translate into the elimination of jobs but rather a complementarity between workers and AI/robotics, albeit with greater work intensity in the workplace. In medicine, *Nature* pointed out 'if automated systems start making routine medical diagnoses, it could free doctors to spend more time interacting with patients and working on complex cases. 'The fact that computers are becoming good at medical diagnosis doesn't mean that doctors will disappear as a job category'. 'Maybe it means we'll have better doctors' (Anthes, in *Nature*, October 24, 2017).

With respect to banking, the media (e.g. CNBC, Dec, 12, 2016) has picked up on a widely read study by the scholar James Bessen on how ATMs were thought to completely

destroy banking jobs, while in fact, they seemed to allow bank employees to concentrate on more personalized interaction with banking clients. Even criminal networks might hire unpaid workers by offering free on-line pornography as an incentive to decode CAPTCHA (*NY Times*, October 24, 2016).

With respect to autonomous vehicles, *Quartz* (Aug 1, 2017) proclaimed that they will increase efficiency and productivity and reduce cost per mile, leaving individuals with more income to spend on other products and services. The growing elderly population in the U.S. will create an increasing demand for such vehicles, leisure and tourism travel will increase, and we will see a greater demand for 'mobility management services', such as maintenance and remote monitoring. For truck drivers, Elon Musk argues that some will transition to fleet operators, responsible for monitoring a fleet of trucks, rather than an individual truck, and solve mechanical, computer, and logistical problems remotely if an individual or a fleet of trucks runs into difficulty (CNBC, Nov 4, 2016). Likewise, the *Economist* (August 26, 2017) argued that

> For autonomous cars to recognize road signs and pedestrians, algorithms must be trained by feeding them lots of video showing both. That footage needs to be manually 'tagged', meaning that road signs and pedestrians have to be marked as such. This labelling already keeps thousands busy. Once an algorithm is put to work, humans must check whether it does a good job and give feedback to improve it.

Conclusions

This article has *not* sought to predict the employment effects of AI or robotics. Rather, it juxtaposes three 'genres' (academic research, the gray literature, popular media) and four imaginaries (a 'doomsayer's perspective', an 'optimist perspective', a 'unifying perspective', and a post-human imaginary) to tease out how such fodder (discourses and knowledges) intersect to perform the future of the FIR and its employment effects, at least in the United States.

First, I have argued that it is especially the neo-classical literature, the gray literature, and the media which perform the teleology of the FIR and, in doing so, demonstrate an 'ethics of probability' and an 'anticipatory politics', as opposed to an 'ethics of possibility' or a 'pre-figurative politics'. However, I have also argued, second, that the neo-classical literature, the gray literature, and the media offer related but variable predictions for employment effects, even if they accept the FIR's inevitability. In that sense, the media in particular is not so consistently sensationalist in its doomsaying outlook as claimed by academic studies. Part of this can be explained by the reliance of the gray literature and the media on the ambiguous and contradictory findings of neo-classical studies, which elicits my third argument. That is, neo-classical studies (and, in turn, the gray literature and the media) rest on the vague concept of 'automation', tend to neglect intersectionality and spatial differentiation in future employment effects, and offer murky future temporalities for these effects. In contrast, part of the heterodox literature is critical of the FIR's ineluctability, but other heterodox studies also engage in prediction and recognize the deleterious consequences the FIR might have, especially for less-skilled workers. The post-human literature imagines and even celebrates the FIR and 'cyborg' futures, rejecting the notion that (post-)humans will eventually be bereft of work.

While there is little empirical research in the U.S. as to how such anxious or emollient fodder is received (if at all) by workers, unemployed persons, and the broader public, these three genres and their four imaginaries may produce contradictory political effects. For example, do the technological teleology and probabilistic doom (or optimist) imaginaries of neo-classical economics encourage the personal upgrading of skills ('*racing with* the machine') or stimulate individual or collective resistance to the FIR ('*raging against* the machine')? In turn, does the heterodox literature's emphasis on the 'embeddedness' of (and resistance to) technology provide an ethics of possibility and a pre-figurative politics? Does the diminutive post-human literature with respect to employment involve a regressive ethics of probability insofar as it does not account for the future of technological unemployment and the misery that might engender? I do not have definitive answers to these questions, and this, in turn, raises a broader question about futurity. That is, can an ethics of probability ever be politically progressive? Bunnell et al. (2018) suggest that this is possible. I would argue that insofar as a future ethics is necessary at all, an ethics of probability that performs the future of AI/robotics can only reproduce uneven development, unemployment, and social inequalities. To avoid such a future, we need an ethics of the future that involves non-capitalist relations, a democratization of technological innovation, and, thus, the technologies borne of such relations.

Notes

1. One might consider some of these works as popular non-fiction (e.g. Brynjolfsson and McAfee, 2014, Cameron, 2017, Ford, 2015, Susskind, 2020, Susskind and Susskind, 2015). Here, however, I include them as academic texts, even though some texts could fit across and between the three genres, given their mutual reliance on academia, the gray literature, and the media.
2. I focus on the US as a matter of analytical convenience. First, initial proponents of the FIR debate rooted their empirical analysis in the US, and this allows me to circumscribe the debate, given space limitations. Second, it enables me to limit the academic literature, 'gray literature,' and popular media that I analyze, especially since I am interested in their mutual interaction. However, it is certainly not my intent to reify a 'US economy,' nor to suggest that there is necessarily a US exceptionalism to the materiality and discursive content of this debate.
3. From 2016 to 2020, I used Google alerts to identify relevant articles that appear to be reasonably (but not scientifically) representative of the media's relationship to academia and the gray literature (on this general relationship, see Rowe and Brass, 2008). Since the number of articles proved to be quasi-limitless, I drew on mostly the economic and business media, nationally prominent newspapers (such as the *Los Angeles Times, the NY Times,* etc.), or other popular media sites such as *The Big Think*, *Mother Jones,* and *Quartz* that addressed the debate at length. In this article, I discuss only a small selection of the roughly 240 bookmarked articles I analysed for content.
4. Later in this article, I only touch upon segmentation and intersectionality for reasons of space. My main point again is that neo-classical studies (and probably, as a consequence, the gray literature and popular media) hardly accord sufficient attention to these processes in their predictions for future employment.
5. Heinrich and Witko (2021) argue that in the context of Europe, elites and publics have expressed little political backlash against AI/robotics, which does not appear as a central political issue. Yet they also note that there is little academic research on whether publics are aware of the ostensible threat from AI/robotics specifically and how they respond to such

threats. This may be somewhat of an exaggeration (see Legun and Birch, 2021). Nevertheless, it is certainly an under-explored research area, and in fact, a large Pew Research Center survey (2018) based in the US that queried more than 900 'experts' did not ask a single less-skilled worker for their opinion. In contrast, a Gallup poll conducted in 2018 found that roughly 75% of US workers who were surveyed thought that AI would fundamentally change their working lives, and about the same percentage believed that such changes would be positive (see https://news.gallup.com/poll/226502/americans-upbeat-artificial-intelligence-wary.aspx).

6. Economists and others use a variety of terms, including low-skill, low-skilled, and less-skilled workers. I use the term 'less-skilled' workers, regardless of the terms used by individual authors.
7. These reports are far from the only ones cited by the media, but again for reasons of space, I have selected only three of the most prominent reports.

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