Happiness and Industry 4.0

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There is talk about a "fourth industrial revolution" that will change how goods are produced, itself a result of the underlying digital transformation and global economic shifts. Much of this has been a discussion of what manufacturing will be like, and how this influences economic and social progress. However, an understudied question is how this transformation can affect human well-being. Clearly past shifts in human modes of production and societal organization have changed both the opportunities for living a good life, and how they can be expressed. This paper aims to analyze how Industry 4.0 affects these factors, and in particular note where

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research, technical or policy work is needed to ensure that it enhances well-being rather than impairs it.

What is Industry 4.0?

The concept of Industry 4.0 is partially a description of an ongoing change in industrial society, partially a marketing banner for particular technologies involved in manufacturing, and partially a way of labeling a discourse of where manufacturing is going.

The standard account argues that there have been several industrial revolutions or transitions. The first one was marked by the transition from handmade manufacturing to machine manufacturing, powered by water and steam. The second one involved electrification and the construction of railroad and telegraph infrastructure. The third one was using electronics to automate manufacturing. The fourth one represents a fusion of digital and mechanical technology creating a cyber-physical manufacturing economy.[3]

This is dominated by interconnectedness between devices and people, large amounts of information available to operators, assistive automation where software augments human decision-making and decentralized decisions. This shift is claimed to be fast, having a broad impact across many sectors, and requiring paradigm shifts in technology policy in order to reap the benefits.

In particular, there is much talk about modular production of goods in "smart factories" and 3D printing, smart objects (with both user-directed smart functions but also predictive maintenance), robotization, customisation and sustainability.

There are many enabling and related technologies that matter in our context[4]. In particular:

- **The Internet of Things:** smart, networked objects. This includes ubiquitous computing, sensors, and methods for local connectivity.
- **Cyber-physical systems**: seamless integration of software and physical components. This includes numerous mobile and wearable devices making distributed computing and sensing intimate with people.

[3] Schwab, K. (2015). *The fourth industrial revolution*. Foreign Affairs. 12 Dec 2015

[4] Knudsen, M. S., Kaivo-oja, J., & Lauraeus, T. (2019, July). Enabling technologies of industry 4.0 and their global forerunners: An empirical study of the web of science database. In International Conference on Knowledge Management in Organizations (pp. 3-13). Springer, Cham.

- **Machine learning and AI**: systems that behave in ways based on examples or data rather than a fixed design, and exhibit various forms of "smart" behavior with varying degrees of autonomy.
- **Big analytics** turning the large data flows into decision-relevant information.
- **Recommender systems**: systems that use customer and user feedback beside other data to recommend products or actions in a personalized way. This allows selecting from overwhelming numbers of options.
- **Identity technology**: technologies such as RFID tags or computer vision that allows identifying objects and people automatically in an unobtrusive way. This is closely linked to location detection technologies.
- **Cryptographic technology**: ensuring the integrity, authenticity, privacy (or publicness) and security of interactions.

Others, such as business and industrial integration, simulation, digital twins, additive manufacturing, and cloud computing are important for Industry 4.0 but maybe less relevant here.

Beyond manufacturing there are changes in economy and society interacting with this trend: globalized and de-globalising supply chains, the shift to a full knowledge economy, a fluidly wearable-centric society, and teleworking. Many of these technologies and trends will have major effects on society. Just as the industrial revolution led to the appearance of feedback loops enabling new forms of economic and hence social organization we should expect the same in regard to Industry 4.0. However, from our perspective what matters is the impact on happiness and wellbeing.

What are the impacts on happiness, wellbeing and related concepts?

Happiness is a very understudied topic in the Industry 4.0 domain, at least compared to other issues such as the circular economy and privacy.

Most papers mentioning happiness and Industry 4.0 mainly explore it in the context of work, entrepreneurship and human capital. There are often acknowledgments that wellbeing has a far wider importance in society, but the focus tends (understandably) to be on the

industry/business part[5]. They are mostly concerned with the here-and-now industrial issues rather than the large-scale social effects. A 2021 review paper investigating the links between the circular economy and Industry 4.0 stated[6]: "In our review, we found very few studies that address the impact of CE in society, as well as the mechanisms used to measure the effects that CE implementation generates in people. " The same appears to be true for Industry 4.0.

Happiness in the broad spectrum view[7] has a number of prerequisites. They are not absolute, but when absent the chances of happiness decrease.

- **Enough resources**. This is both the prosperity needed to sustain a good life and the recognition that one has enough. The spread of post-materialist values[8], partially as a result, may act to encourage such recognition.
- **Lack of stress**: having demands that overwhelm one's capacity of coping, especially on an everyday basis, is corrosive for happiness.
- **Agency, a sense of control**, is necessary for feeling one is in charge of one's life and hence at least potentially able to be autonomous or an active, responsible member of one's community.
- **Connectedness**, a feeling that one both has external social contacts and a link to one's environment, and an internal sense of who one is, is another prerequisite.
- **Reflection**, the ability to recognize and analyze one's life and feelings, is needed for noticing what works and what doesn't. It is enabled by inner connectedness and can drive autonomous action.

How does Industry 4.0 affect these?

Resources: to state the obvious: a wealthier, safer world is going to be somewhat happier. Achieving prosperity and preference satisfaction does improve many measures of subjective wellbeing. The effect is stronger for the most deprived and vulnerable but it is nevertheless a

[5] See for example Ripoll, R. R., Romero-Rodríguez, L. M., & Ahumada-Tello, E. (2022). Guest editorial: Happiness management: key factors for sustainability and organizational communication in the age of Industry 4.0. *Corporate Governance: The International Journal of Business in Society*, *22*(3), 449-457. And articles in the issue linked to the Iberoamerican Research Group of Multidisciplinary Studies on Happiness (IGOMSOH) which is focused on exploring happiness as an element of social value in the era of Industry 4.0.

[6] Tavera Romero, C.A.; Castro, D.F.; Ortiz, J.H.; Khalaf, O.I.; Vargas, M.A. Synergy between Circular Economy and Industry 4.0: A Literature Review. Sustainability 2021, 13, 4331. https://doi.org/10.3390/su13084331

[7] Sandberg, A., Jedlovszky, K. (2022) Defining happiness: a pragmatic introduction. Technical Report #2022-1, Future of Humanity Institute, University of Oxford

[8] Delhey, J. (2010). From materialist to post-materialist happiness? National affluence and determinants of life satisfaction in cross-national perspective. *Social Indicators Research*, *97*(1), 65-84.

pervasive effect. That there are forms of contentment and meaning that are independent of, or even distracted by, prosperity does not diminish the value of it.

However, even in Schwab's influential article defining Industry 4.0 there is a concern about inequality and disruption of labor markets. The inequality here is twofold. On the one hand, there is a significant market concentration towards a few players with better suited IP and resources.[9] On the other hand, automation and the aim to increase profits can contribute to decreasing the number of skilled and unskilled workers needed for production. These tendencies contribute to increases in both poverty and inequality. Ensuring that the transition does not cause widespread insecurity is a recognized goal for Industry 4.0 policy even disregarding the negative effects on happiness.

Importantly, the inequality in resources due to Industry 4.0 are not just the financial, but the social. Public social services, such as healthcare are in the hands of individual governments, however, novel Industry 4.0 technologies are concentrated in the hands of a few private companies. These technologies have the ability to completely transform healthcare (through personalized medicine, 3D printed surgical devices, to name a few), however, due to the lack of competition, they can be sold at the highest prices imaginable and will not be widely available for all. This completely goes against the principles of public healthcare, that should be equally available to all. The extent to which public healthcare is at the mercy of developer companies can be illustrated best with the distribution of vaccines during the COVID-19 pandemic. To remedy this, governments should focus on acquiring these technologies and incorporate it into public healthcare, to offer an accessible alternative for private companies.

Stress can be generated from both unavoidable demands such as risk and material needs, by social demands from other people and other autonomous agents, and by a feeling of inadequacy when facing a complex, uncertain, rapidly changing or otherwise unmanageable world. While a functioning Industry 4.0 may reduce actual material stressors and risk, it does not necessarily reduce the feeling of these demands. Many people are today worried about low-probability but salient risks despite the actual risk spectrum being fairly benign. The highly networked, ML/AI infused world envisioned, makes avoiding social demands by being unavailable hard, and introduces many non-human agents that can cause stressful interactions whether by requests or security vulnerabilities. Most seriously, if there is a perceived lack of control over one's life, it can cause serious ongoing stress.

One big cause of stress is transformations of employment conditions. Industry 4.0 promises a transformation of many domains that will require significant adaptation and acquiring new

[9] UNCTD, 2019. https://unctad.org/system/files/official-document/ciid43_en.pdf

knowledge. While calls for a focus on life-long learning have been made for decades, Industry 4.0 steps up the need significantly since many jobs are likely to be transformed relatively quickly - and not just in the manufacturing industry. Meeting these needs is important, and helped if they are not seen as a stressful social challenge or a threat but opportunities.

Another source of stress is the always-on, highly interactive mode encouraged by current communications methods where alerts and incoming messages can interrupt lines of thought and there is a constant fear of missing out on important things going on somewhere. Artificial autonomous agents can generate attention-requiring signals at an arbitrarily high rate, and an Internet-of-things world introduces such agents into nearly every part of life. While good design of messaging may reduce the interruptions the fear of missing important background processes remains.

In order to remedy this situation we need to find better ways of coping (both with a more fluid working life and with a more interactive world), improve interaction to be less stressful, and perhaps structure the lifeworld to reduce stress by giving a sense of control.

A sense of **control** is, like security, a feeling rather than an actual objective state. A person who is in control of their life feels that they can make autonomous decisions that meaningfully result in change. At first glance Industry 4.0 seems ideally suited for this: mass customisation allows getting products suited for whatever life projects we have, machine learning allows outsourcing and expanding our decision/action capacity to our extended self[10]. Unfortunately it also introduces hidden complex dependencies, artificial agents with their own kind of autonomy or allegiances that are hard to predict, large and changing sets of options, and decision making itself contested and manipulable.

These complexities are also sensed by the general public and importantly, the decreasing understanding of the increasingly complicated newer technologies leads to reduced perceived control and can build a strong distrust. Here, it is particularly important to emphasize the difference between perceived and actual control, as many distrust issues can be redeemed with increasing perceived (but not actual) control. For example, cryptocurrencies have undeniably been reshaping the economic world, yet, understanding the blockchain technology they rely on in sufficient depth is less obvious to the general public. Yet, people who have been investing in them without in depth research have a generally more positive attitude and more trust towards this instrument.

[10] Sandberg, A. (2021). Post-Human Design: The Crafted Human Body and the Exoself, in Sandra Kemp, and Jenny Andersson (eds), *Futures*, Oxford University Press

Decreased sense of agency and distrust are also heavily interlinked with issues around privacy. Privacy is an important aspect of the sense of control, both as an interaction-reducing choice but also as room for experimenting with views and decisions that are as yet tentative and not open for public scrutiny.

Remedies involve methods of clarifying dependencies and making it possible to change them, methods of establishing trust both in the technical sense, in the sense of plausible incentive structures, and in the social way of being a trustworthy partner in an interaction. They may also involve establishing chains or authorities of trust, whether consumer information sources to certification systems.

Connectedness is again not a matter of information transmission - in principle the majority of humanity could have called any other member over the phone the past few decades - but a matter of having meaningful social relations: either deep ones with key people, weak but broad networks of acquaintances, or the general tenor of one's social environment (involving such feelings as trust, belonging, and shared intentions). Social media demonstrates the tremendous power and demand for social interaction but often do not necessarily lend themselves to supporting connectedness.

Industry 4.0 is rarely framed as a social revolution, but many of the key promises are strongly linked to social media. Sites such as Amazon, Etsy and Redbubble demonstrate how recommender systems, social media and mass customisation interact. Kickstarter and other crowdfunding systems allow specialized interests to pool resources into projects and products. Phenomena like Pokemon Go make use of the cyberphysical and interactive aspects of technology to produce augmented reality social spaces. However, most of these systems have only incidentally caused a stronger sense of connection. Conversely, much of the necessary data to train recommender systems and machine learning requires public production of input. Here Industry 4.0 rides on the coattails of the search for connection.

Achieving social connection requires the right kind of interactions. Knowledge about how online relations, communities and institutions work is still forming, and complex like any other human social structures. There are also great individual differences in what forms of interaction are effective.

To improve connectedness there is a need to avoid maladaptive effects: "social bulimia" where approval from distant people act as a strong motivator, fear of loss of status, attacks or intimacy, how to manage multiple social personas etc. There is also a positive need for establishing the spaces where human interaction can grow into appropriate levels of connectedness, and ensuring that such spaces both respect the need for control (e.g. privacy) and reduce stress (e.g.

by acting as separate social domains from work or public personas). It might also be possible to develop tools for helping learn useful social skills or support existing sociability.

Internal **reflection** is fundamental for being a self-directed agent able to recognize one's needs, wants, and function. Actually being able to recognize one's own mental states, habits, preferences and, indeed happiness, is not automatic. Many people lack the emotional vocabulary to express themselves even internally, find introspection hard, and may not even recognize the benefit of reflection when so much is going on in the external world. Reflection can equally be external, involving thinking about one's life situation, other people, and how they can be changed (plus how this relates to the internal states, that are often meaningless without the external world). Again there are issues of skill and motivation.

Industry 4.0 involves the assumption that massive data gathering from smart sensors, devices and people's online activity can help serve constructive goals for different stakeholders. In a sense it involves "technical reflection": cyberphysical systems that are highly responsive to the world and their internal state and (within the limits of their programming and machine learning) respond appropriately. However, the needs for internal and external reflection appear less well satisfied.

Recommender systems allow filtering information, but even ones based on user models rarely give users access to the model or help them refine and reflect on it. Maintaining an environment free from interruption and distraction is not useful against stress, but likely necessary for proper reflection: it represents deep work.

Can we make better tools for reflection? Some forms of reflection are based on internal practices where people have varying skills and mindsets, yet many psychological methods and training programs exist that might be amplified and more widely disseminated using wearable devices, AI and validation using the available data. Current external data also needs to be visualized, filtered and presented in new ways to enable proper reflection: a profound design challenge.

What can we do to enhance wellbeing in an Industry 4.0 world?

Our argument is that while Industry 4.0 doubtless can improve many areas of life, merely achieving the techno-economic framework does not necessarily help happiness but is actually likely to introduce many situations inimical to a good life. While normal adaptation and reaction doubtless will resolve such problems (just as over time the worst aspects of the

industrialized city were recognized and mitigated) good foresight and design can reduce or avoid some of the problems if undertaken at an early stage.

There is a vast literature on Industry 4.0, but surprisingly there is little that directly considers human happiness and well-being as a result or goal for Industry 4.0. This suggests that there are vast gaps in the current visions in relation to happiness, or expressed more positively, major opportunities to research, shape and profit from closing these gaps.

From a **research standpoint**, there is a need for understanding how Industry 4.0 technology and likely use impinge on happiness, both individually and collectively. Current investigations of workplace happiness and how technologies affect wellbeing are clearly relevant but need to be combined with careful technological scenario analysis and domain experts to see what pitfalls and opportunities exist in this domain. More lenses are needed than just the work or user lens: technology plays a role in most human activity and we need to consider the often surprising effects when it impinges on love, spirituality, ethnicity, play, self-definition, etc.

- Can we construct privacy-preserving ways of amassing social and personal happiness data to detect successes and failures of happiness enhancement on large scales?
- Are there ways of amassing self-reflective data at scale? What can be learned from it?
- How do people self-reflect, and how can this be enhanced?
- What are the forms of control over their lives people desire, and do they correspond to ethical and technical forms of control?

From a design and innovation standpoint, happiness represents a promising if tricky goal. Designing for psychological health and stability is a new, little investigated topic that is clearly both socially relevant and potentially promising. Given the desirable nature of it, startups may find this an extremely scalable domain. **Established businesses** on the other hand may possess data that can enable happiness improvement.

- Can we create recommender systems that optimize for wellbeing?
- Can we create social media systems that optimize for connection?
- What interfaces reduce stress, promote a sense of control, and allow reflecting on one's actions?
- What ways of measuring happiness, satisfaction and wellbeing robustly can be incorporated into products?
- Can products be constructed that give credible signals about their happiness impact (e.g. controllability or lack of distraction)?

From a **government standpoint**, the rush towards Industry 4.0 is part of a more general techno-economic change that requires careful governance - just as many governments realize that achieving citizen mental health and wellbeing may be not just nice to have, but a powerful competitive advantage, an election winner, and a moral imperative.

- How can a fruitful collaboration and careful control be established with companies that hold the key to the most important Industry 4.0 technological innovations and their products? What role can taxing play in this?
- Given that retraining and lifelong learning will become far more central, how can these be supported in a way that both produces a good learning outcome but is socially situated so that people feel they gain control and respect for doing it?
- Different generations have increasingly disparate technological worlds, and hence diverging social experiences. How can technology and policy produce stronger links between generations?
- Culture and history matters for self-reported life satisfaction – an industry 4.0 world born out of our present world may have culture that helps or hinders happiness. The scars from current pervasive traumas like wars and poverty will remain, hindering happiness in some regions – unless we find ways of healing them.

Happiness is not just a nice-to-have aspect of a product or system of production but a long-term requirement for the social sustainability of them. Products that leave users unfulfilled or frustrated will be dropped for others (unless they can maintain cling through addictiveness, formal requirements, or competitive pressures - not very good design criteria to aim at!), and systems that leave human wellbeing at the side produce social disruption, ranging from micro-sabotage to wholesale abandonment of the system (possibly years later, during a generational shift, leaving large sunk costs).

In the end, the goal should be “value engineering”: a field dealing with the effective design and creation of high human value states. We are far away from such a vision today, much further away than Industry 4.0. But the current transition gives us the opportunity to do the groundwork for a happier world.

Bibliography / Recommended papers

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Ghobakhloo, M. (2020). Industry 4.0, digitalization, and opportunities for sustainability. Journal of Cleaner Production, 252, pp. 1-20

Using interpretive structural modeling and MICMAC analysis to understand the contextual relationships between the sustainability functions of Industry 4.0. Found that production efficiency and business model innovation are the more immediate outcomes of Industry 4.0 and could thus be the gateway for energy sustainability, emission reductions and social welfare improvement.

Xu, L.D., Xu, L.E. & Li, Ling (2018). Industry 4.0: state of the art and future trends. International Journal of Production Research, 56(8), pp. 2941-2962

Arguing that the lack of formal methods and systems methods are currently the biggest obstacles in not being able to exploit the full potential of Industry 4.0 for industries and manufacturing.

Gubán, M. & Kovács, Gy. (2017). Industry 4.0 Conception. Acta Technica Corviniensis - Bulletin of Engineering, 1(10), pp. 22-25

Describing the conception of Industry 4.0 and how market environment and customer demands can affect the logistical tendencies in it.

Oztemel, E. & Gursev, S. (2020). Literature review of Industry 4.0 and related technologies. Journal of Intelligent Manufacturing, 31, pp.127-181

Bringing together the academic and industrial perspective on Industry 4.0 in the form of a literature review. Providing a definition of Industry 4.0 and its six design principles (interoperability, virtualization, local, real-time talent, service orientation and modularity).

Sony, M. & Naik, S. (2019). Key ingredients for evaluating Industry 4.0 readiness for organizations: a literature review. Benchmarking: An International Journal, 27(7), pp.2213-2232

Describing a framework by which Industry 4.0 readiness can be assessed in organizations.

Kamble, S.S., Gunasekaran, A. & Gawankara, S.A. (2018). Sustainable Industry 4.0 framework: A systematic literature review identifying the current trends and future perspectives. Process Safety and Environmental Protection, 117, pp. 408-425

Summarizing the state-of-the-art research approaches in Industry 4.0 and the status of such research. Also extending ideas to create a sustainable framework for Industry 4.0 with targeting technologies, process integration and sustainable outcomes.

Pereira, A.C. & Romero, F. (2017). A review of the meanings and the implications of the Industry 4.0 concept. Procedia Manufacturing, 13, pp.1206-1214

Aims to further define Industry 4.0 as a complex technological system and define its impacts on industry, markets and economy through production processes, product lifecycle, business models and the labor market.

Liao, Y., Deschamps, F., Rocha Loures, E.D.F. & Ramos L.F.P. (2017). Past, present and future of Industry 4.0 - a systematic literature review and research agenda proposal. International Journal of Production Research, 55(12), pp. 3609-3629

Reviewing specifically the academic progress in Industry 4.0 research. The authors also address important shortcomings, such as the enormous gap between laboratory experiments and industrial applications, and devise a research agenda forward.

Culot, G., Nassimbeni, G., Orzes, G. & Santor, M. (2020). Behind the definition of Industry 4.0: Analysis and open questions. International Journal of Production

Economics, 226, pp. 1-15

Highlights the lack of theoretical groundwork in Industry 4.0 research. The main issues identified are no unified definition, underlying theory and comparable research.

Nosalska, K., Piątek, M., Mazurek, G. & Rządca, R. (2019). Industry 4.0: coherent definition framework with technological and organizational interdependencies. Journal of Manufacturing Technology Management, 31(5), pp.837-862

Defining Industry 4.0 as a multidimensional system of value creation and identifying its key variables and their interdependencies.

Erboz, G. (2017). How to Define Industry 4.0: The Main Pillars Of Industry 4.0. Managerial Trends in the Development of Enterprises in the Globalization Era. pp. 767-767

Defining Industry 4.0 through nine pillars (big data, autonomous robots, simulation, additive manufacturing, IoT, cloud computing, augmented reality, horizontal and vertical integration and cyber security) and discussing how these can help businesses improve in the future, as outlined by the BCG.

Bai, C., Dallasega, P., Orzes, G. & Sarkis, J. (2020). Industry 4.0 technologies assessment: A sustainability perspective. International Journal of Production Economics, 229, pp. 1-5

Describing a measures framework in line with the UN Sustainable Development Goals and a way to evaluate Industry 4.0 technologies based on sustainability.