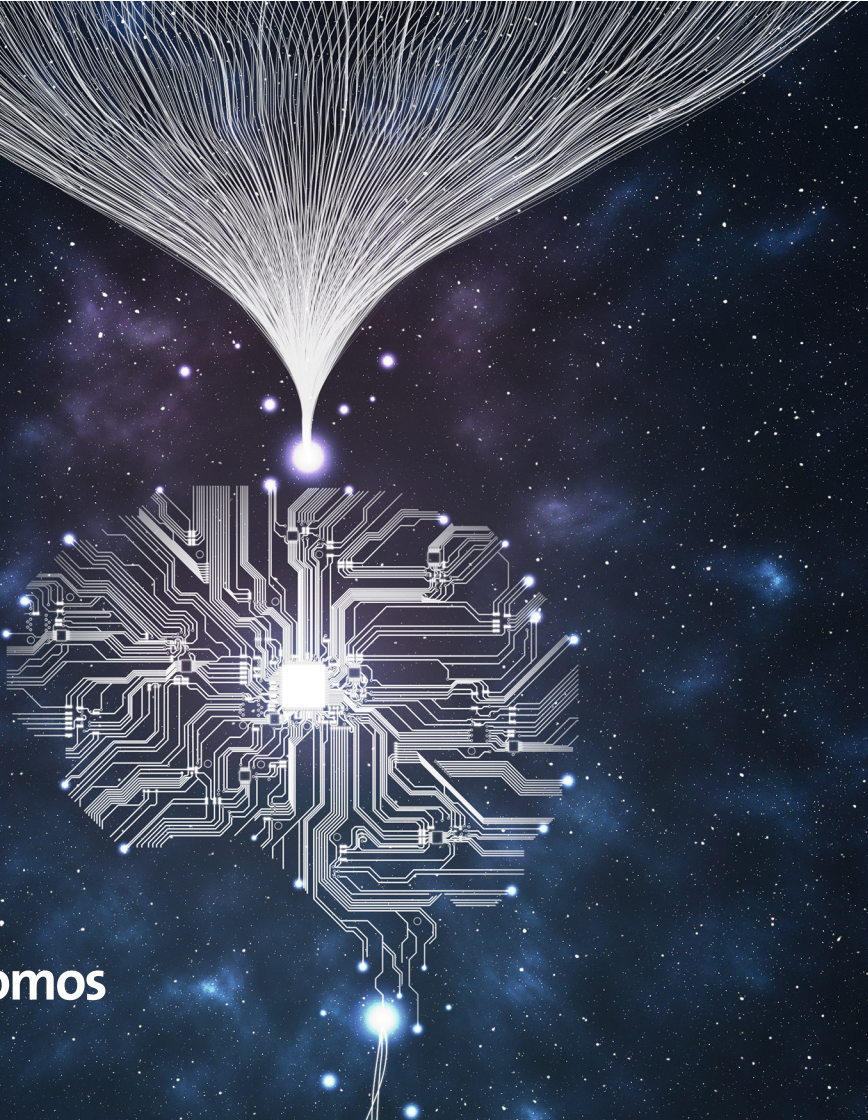


Léa Steinacker

# Code Capital

A Sociotechnical Framework to Understand  
the Implications of Artificially Intelligent Systems  
from Design to Deployment



Nomos

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**Nomos**

The author is thankful to the Swiss National Science Foundation for partly funding a survey as part of the research.

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**Die Deutsche Nationalbibliothek** verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über <http://dnb.d-nb.de> abrufbar.

**The Deutsche Nationalbibliothek** lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available on the Internet at <http://dnb.d-nb.de>

ISBN 978-3-8487-8890-3 (Print)  
978-3-7489-2945-1 (ePDF)

#### **British Library Cataloguing-in-Publication Data**

A catalogue record for this book is available from the British Library.

ISBN 978-3-8487-8890-3 (Print)  
978-3-7489-2945-1 (ePDF)

#### **Library of Congress Cataloging-in-Publication Data**

Steinacker, Léa

Code Capital

A Sociotechnical Framework to Understand the Implications of Artificially Intelligent Systems from Design to Deployment

Léa Steinacker

239 pp.

Includes bibliographic references.

ISBN 978-3-8487-8890-3 (Print)  
978-3-7489-2945-1 (ePDF)



Onlineversion  
Nomos eLibrary

1. Auflage 2022

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*I dedicate this dissertation to  
Daniel Schillinger  
(1979 – 2010)  
for introducing me to the world of computers.*



## Acknowledgements

Around the turn of the millennium, my second cousin taught me how to code. Daniel, a computer scientist eager to share his knowledge, first trained 12-year-old me in HTML and CSS so that we could experiment with commands, classes, and color codes together. We moved on to Visual Basic which allowed me to develop small programs with inputs, outputs, buttons, and if-then loops. Mesmerized by the possibilities, I used these skills to earn my very first money designing a website. And thus, code and capital ironically merged early on for me.

Twenty years later, my journey from social justice to technological innovations brought me full circle: I am now exploring systems running on code as amalgams of many forms of capital. In my exploration of their power, I had the great privilege of being accompanied by several people without whose help this dissertation would not have emerged in quite the same way. First, I want to thank my supervisors, Damian Borth for his guidance and tireless willingness to debate with me, as well as Veronica Barassi for her insights and valuable pushback. Both took an interdisciplinary adventure ride with me that significantly shaped my thinking. Along the way, fellow researchers and dear friends engaged in illuminating discussions with me about their perspectives on how we construct technology that touches our lives. Several opened their doors to offer me immensely helpful writing retreats across the globe: Thank you to Mirco Günther in Singapore, Matt Listro in New York, Christiane zu Salm in Rottach-Egern, and Rahaf Harfoush with Jesse Morgan in Griège. Equal thanks to Antonia Baskakov for her patient eagle eyes. My deep gratitude goes to Joan Kingdom for encouraging me to play with words; to Valentin Jeutner for our ever so thoughtful discussions; to Sarah Chynoweth, who always had my back and feedback during this rollercoaster; and to Miriam Meckel for our inimitable flow in conversations about humans and machines. My family has given me unwavering support: David, Adanna, Kian, Noah, Ada, and Hilde. And none of this would have been possible without my parents, Dagmar and Gerd. I am so very grateful. Last but foremost, thank you to Ida Dizu Okadawe for facing and embracing the right now with me.

*Düsseldorf, January 2022*

*Léa Steinacker*



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## Abstract

Advanced techniques in the field of Artificial Intelligence (AI) have been applied in commercial applications and public service across sectors to classify data, predict behaviors, and orchestrate choices. Today, experts agree that AI systems have immense economic, social, political, and environmental implications. But many recent institutional endeavors to assess them have been conceptually diffuse, overly focused on technical aspects at the cost of socialized context, and fueled by dichotomous narratives. Given the outsized influence of these sociotechnical systems, how can we capture the interdisciplinary factors that lead to their transformative effects on our social fabric? In this dissertation, I introduce my original notion of *Code Capital*, an interdisciplinary account of the intangible and material configurations that comprise an AI system's source of impact. Through the eponymous CODE framework, this new concept allows an analysis along four dimensions - Conception, Operations, Data, and Environment – to express bespoke circumstances of each system, bringing to the fore its normative forces. To test the applicability of my approach, I conducted CODE analyses of two real-life AI systems using qualitative and quantitative techniques. For my first case study on facial recognition technologies, I present empirical results from a cross-country survey I conducted with a team of researchers that underline the need to contextualize AI systems in their social embedding. My subsequent CODE analysis of a particular deployed system illustrates the framework's explanatory power for impact. I show how even thoughtful objectives risk producing unwanted outcomes and that the selection of material features has decisive effects on how the system is used. In my second case study on synthetic text-to-speech technologies, I examine the Code Capital of a system in its design phase to demonstrate how the concept can be used as a tool to guide the development process. My results show the importance of forecasting and contingency planning for potential misuse, such as the risk of identity fraud. Both case studies also emphasize the need for considering diverse representation in material design and training data to ensure inclusive participation and harm mitigation for users. Moreover, they demonstrate how centrally both the Conception and Environment dimensions contribute to the range of implications of a socially embedded AI system, which sets Code Capital apart from dominant existing approaches. Through the

*Abstract*

instructive CODE model, relevant stakeholders from the technological as well as the sociopolitical realm can employ a shared ontology to better anticipate and understand AI systems, with Code Capital as the novel descriptor of their potential power.

## Zusammenfassung

Fortgeschrittene Anwendungen der Künstlichen Intelligenz (KI) werden im kommerziellen und im öffentlichen Sektor übergreifend eingesetzt, um Daten zu klassifizieren, Verhaltensweisen vorherzusagen und Entscheidungen zu treffen. Expert:innen sind sich heute einig, dass solche KI-Systeme immense wirtschaftliche, soziale, politische und ökologische Auswirkungen haben. Doch viele der jüngsten institutionellen Bemühungen, diese zu bewerten, sind konzeptionell diffus, fokussieren zu eng auf technische Aspekte, vernachlässigen den sozialen Kontext und werden auf dichotome Narrative reduziert. Wie lassen sich angesichts von Bedeutung und Einfluss dieser soziotechnischen Systeme die interdisziplinären Faktoren dieser KI-Systeme analysieren, die eine transformative Wirkung auf unsere Gesellschaft, unser soziales Gefüge haben? In dieser Dissertation erläutere ich den von mir entwickelten Begriff des *Code Capital*. Er verortet die Konzeptualisierung von KI-Systemen als neue Manifestation von Kapital in der Forschungstradition zu unterschiedlichen historischen Kapitalformen und beschreibt einen interdisziplinären Ansatz des Zusammenwirkens immaterieller und materieller Faktoren und Konfigurationen, die über die Auswirkungen eines KI-Systems entscheiden. Mit Hilfe des gleichnamigen CODE-Frameworks ermöglicht mein analytischer Ansatz eine Beschreibung und Bewertung von KI-Systemen entlang von vier Dimensionen - *Conception, Operations, Data* und *Environment* -, um die spezifischen Ausprägungen und Auswirkungen eines jeden Systems zu interpretieren und einzuschätzen. Um die Anwendbarkeit meines Ansatzes zu testen, habe ich CODE-Analysen von zwei KI-Systemen unter Verwendung qualitativer und quantitativer Methoden durchgeführt. Meine erste Fallstudie analysiert die empirischen Ergebnisse einer repräsentativen Mehrländerumfrage (China, Deutschland, Großbritannien, USA) zur Akzeptanz von bereits implementierten KI-gestützten Gesichtserkennungstechnologien. Meine CODE-Analyse veranschaulicht die Erklärungskraft des Frameworks: Sie zeigt, dass soziale und kulturelle Voraussetzungen die Technologieakzeptanz von Gesichtserkennungssystemen prägen und das Design der KI-Systeme entscheidenden Einfluss darauf hat, wie das System genutzt wird. Meine zweite Fallstudie über synthetische Text-to-Speech-Technologien untersucht das Code Capital eines Systems in der Designphase, um zu zeigen, wie das Framework auch als Instrument zur

## *Zusammenfassung*

Steuerung des Entwicklungsprozesses eingesetzt werden kann. Die Ergebnisse machen deutlich, wie wichtig die Vorhersage und Eventualfallplanung für die Prävention von potenziellem Missbrauch ist, z. B. für das Risiko des Identitätsbetrugs. Beide Fallstudien zeigen auch, wie wichtig es ist, von Beginn an bei der Gestaltung materieller Features und dem Sammeln von Trainingsdaten das Kriterium der diversen Repräsentation unterschiedlicher sozialer und kultureller Kontexte anzuwenden. Darüber hinaus zeigen sie, wie zentral sowohl die sorgfältige Konzeption (C) als auch die Berücksichtigung der Umweltdimension (E) sind, wenn es um die Auswirkungen eines sozial eingebetteten KI-Systems geht – zwei Dimensionen, die in den bislang existierenden Ansätzen eher unterrepräsentiert sind. Mit Hilfe des CODE-Frameworks können Akteure aus dem technologischen wie auch dem gesellschaftspolitischen Sektor nun auf ein verbindendes Bezugssystem zurückgreifen, das ihnen helfen kann, KI-Systeme besser auszugestalten und ihre potentiellen Wirkungsweisen besser zu verstehen oder gar zu antizipieren.