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THE AGE OF SCIENCE-TECH UNIVERSITIES

Responsibilities, Challenges and Strategies

THE AGE OF SCIENCE-TECH UNIVERSITIES

Analysing past and ongoing trends that have shaped the landscape of universities worldwide, this book explores the possible paths for the future of universities along three main dimensions characterizing key strategic choices: knowledge creation and dissemination, relationships within society and governance mechanisms.

By sharing reflections and offering directions on the changing role of technical universities, especially in Europe, this book considers the change and disruption that are causing universities to reconsider their role.

This book:

- provides an up-to-date picture of the role of technical universities in the European context
- critically discusses the strengths and weaknesses of technical universities
- identifies emerging challenges that will shape their evolution going forward
- provides insight into how current models can be adapted and adopted for future use

Impinging on extensive transdisciplinary research, this book highlights the need of the technical university within society and its role not only to improve skills, but education in the most articulated sense, to train future citizens and professionals. The book is a must-read for all those interested in the future of technical universities.

Paola Francesca Antonietti, Paola Bertola, Antonio Capone, Bianca Maria Colosimo, Davide Moscatelli, Carolina Pacchi and Stefano Ronchi are Professors at Politecnico di Milano with expertise ranging from urban planning to mechanics, from design to chemistry. Together they form PoliMI 2040, a team built to support the strategic decision-making process by developing possible future scenarios.

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*Paola Francesca Antonietti, Paola Bertola,
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PREFACE

Since I have started my mandate at the helm of Politecnico di Milano, I immediately realized the needs and demands of complex organizations. Universities make no difference, especially those oriented towards research and innovation. Particularly those aiming at contributing to a sustainable socio-economic impact shaping the future of next generations.

Indeed, education is a multifaceted industry that, just like all the others, needs a compass to support strategic directions. For this reason, together with a group of very committed colleagues, we decided to give birth to a cross-disciplinary team involving a number of departments of our university in order to stimulate an internal and external debate about future challenges and possible crossroads.

This was the beginning of the PoliMI 2040 project in 2017, whose outcomes are reported in this book. Of course, there have been key contextual and long-term factors influencing the project. The first one, no question, is the speed of technology, especially information technology, its acceleration and consequent driving force. Evolution is becoming exponential and disruptive, making it mandatory to anticipate the change rather than being guided by it.

What is more, we are becoming more and more aware that global challenges – such as the ones dealing with the environment or energy consumption, cyber threats or artificial intelligence, just to mention a few of them – require a multi-disciplinary approach. For instance, we cannot face the future of mobility if we do not consider engineering when it comes to new vehicles, but also sociology when developing targeted services, as well as law and philosophy when asked to decide on ethical questions, such as the ones belonging to algorithms functioning in autonomous driving.

Last but not least, we are more and more aware that, in a global context, competition relies on cooperation. Europe, which should be the third actor in the worldwide scene, recently experienced the failure of policies implemented by centrifugal

forces, gradually appearing more isolated and less influential. However, in the last year and a half, Europe has implemented extensive supportive measures and fostered common policies and research networks as a reaction to Covid-19 pandemic, a lesson learned at a very high cost.

As a matter of fact, while accomplishing PoliMI 2040 project, we found ourselves working alongside the rampant coronavirus pandemic. Some of the ongoing processes of change took off at a greater pace. The emergency also stimulated a renewed interest in science and in innovation, seen as the only possible way to cope with complicated problems suddenly affecting the entire planet. Therefore, many assumptions and trends analysed during the course of our study have been rapidly corroborated and eventually proved to be right.

Academia too went through a process of self-analysis, a very quick one. The unexpected Covid-19 outbreak forced us to react rapidly and efficiently to the crisis by turning all our courses online. Despite and also because of a very unstable scenario, we did what we could to keep our labs open to help institutions and industries on the front line against the virus. We enforced our alliances with foreign universities and drew common plans despite mobility being put to a halt.

Now time has come to look ahead and plan for the future. When I say this, I am not referring to immediate solutions, rather our ability to seize a big opportunity for the world to change the way we teach, learn, work and interact. We are now asking ourselves what kind of knowledge will be developed, how are relationships going to change, and how will the whole system adapt to a post-pandemic reality.

As such, every university will revise their programmes, finding new ways to engage students and bringing about additional business models, confirming the fact that the new millennium has opened the way to new prospects, especially for science-tech universities. Academia must urgently shoulder greater responsibility for the broadly unexplored impacts that scientific and technical innovation may have in its current form and commit themselves more firmly to action.

The outcomes described in this book have already inspired a series of choices within Politecnico di Milano itself, which are included in the current university's strategic plan. Nevertheless, if there is one lesson we have learned from this pandemic, it is that no one can make it alone. Hence, I believe that this book might be a useful guide for other institutions, as well as policymakers and stakeholders engaged in development processes that underline the pivotal role of higher education and knowledge, to lead a well-balanced, responsible and long-lasting change.

Ferruccio Resta
Rector, Politecnico di Milano

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This book is the result of an intensive four-year project involving a very high number of people; listing everyone would be almost impossible.

First of all, we would like to thank the Rector of Politecnico di Milano, and the Institution overall for trusting us and giving us the opportunity to work together on such a challenging project. Thanks to Vice-Rectors, Deans, Directors and all colleagues who were actively involved in interviews and discussions. These interactions gave us the great opportunity to understand and appreciate our university even more.

We would also like to thank colleagues from other universities around the globe. Discussing and debating with inspiring characters in leadership roles at other universities has been a source of keen insights for this book.

Finally, we would like to thank members of our Advisory Board, alumni from our university with high seniority, experience and international visibility, for their valuable and visionary comments and inputs to our work.

In a nutshell, thanks to Politecnico di Milano and its international network.

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INTRODUCTION

Early universities first saw the light of day in Mediaeval Europe, their roots firmly implanted in Roman Catholic congregations with flourishing monastic schools of philosophy, theology and the humanities more widely. With the onset of the First Industrial Revolution and under the inspiration of illuminism, universities were remodelled to place greater emphasis on scientific subjects and studies, helping the progress of ongoing technological development. During the Second Industrial Revolution, there was the drive to introduce greater specialization within the various academic fields, and new technical and scientific universities were established, thus re-enforcing and consolidating the place of sciences. The task of exploring new technological frontiers had, until then, been left to individual scholars. From this moment on, the effort became collective, leading western countries, often backed by local industries, to invest in new universities where the scientific method could flourish in purpose-built facilities, ensuring continual advances in research and innovation.

The Third Industrial Revolution, interpreted through the lens of “knowledge economy”, shifted the centre of gravity from technical and scientific subjects to social sciences. Neoclassical economics and other new concepts together created the theoretical bases to sustain the process of financialization of the economy. During this phase, studies in law, economics and organizational sciences gained ground, leading to the unprecedented rise in schools of law and economics, and the proliferation of Master’s in Business Administration, a model that became one of the most powerful factors homologating organizational thought across the world.

At the end of the 20th century, network technology and global connectivity flung open the doors to the Fourth Industrial Revolution. The mayhem of financial crises in 2001 and again in 2007 directed the spotlight onto the limits of models for development conceived in the second half of the 20th century. As a consequence, the escalation of social and organizational sciences within universities

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eased off, as did law and economics, and the focus turned to technical and scientific subjects. This shift was supported by the breakneck development of new high-tech sectors, spewing out “unicorns” in the digital industry which are able to inject massive investment and stoke up training and research in these sectors. The new millennium started as a phase of expansion for the major technical and scientific universities, which could spy out new opportunities and see their sphere of influence expanding within new knowledge ecosystems.

The development process in universities shone the light on their increasing impact, often at global level, in terms of steering transformation in society and economy. That said, it also emphasized their *modus operandi* frequently run along the lines of adapting to contingent situations driven by single research group interests, or by pronounced changes in their own ecosystem or evermore globalization in the education and training market.

Today, this tendency to be “adaptive” rather than “proactive” is having to grapple with deep social and cultural transformations, re-arrangements in geopolitical balances, environmental emergencies and frenzied technological change, all aspects spurred on also by the global Covid health crisis. In the light of this situation, loaded with many widely unexplored implications and the potential of radically upturning entire economies and societies, universities, as the driving engine of new knowledge, are enjoined to re-appraise their roles and responsibilities. We must inevitably take a long hard look at what universities intrinsically are and the models that have written their evolution. We also need to come up with the right tools to instil the strategic vision necessary to direct education and research policies that are long-lasting and can help to provide answers to the great challenges of our millennium.

In this book, we set ourselves the task of designing a manual to help technical and scientific universities navigate their way through their choices with a clearer vision and a better understanding of the impact and implications of their decisions.

The research process

This book is the outcome of the work carried out by a research group set up by the Rector of Politecnico di Milano in 2017. The brief for PoliMI 2040 was to develop a knowledge base that could be used to steer the university’s long-term strategies, anticipating future scenarios and challenges, and hypothesizing potential trajectories of change.

PoliMI 2040’s initial research and subsequent elaborations were geared towards analysing the ongoing macrodynamics of change and their possible repercussions on the specificity and distinctiveness of technological and scientific universities, and on these universities’ current and potential role in the medium to long term.

The project was conducted by seven professors in a range of different fields, and the research process itself drew in over 300 professors, experts, researchers and research assistants at various times. Work was organized around various topics into different phases. In each phase, the procedure was to gather preliminary data and

carry out a literature review, followed by discussions, interviews and round-table debates among professors and researchers, leading up to plenary sessions open to everyone in the university where we discussed and presented our intermediate findings. At the conclusion of our work, we elaborated several development settings, which we then validated through interviews and conversations with professors and researchers at other technical and scientific universities, chosen because of their status in international rankings, as well as with business experts and from the world of institutions.

The chart in Figure 0.1 shows our work model, split into two main phases and broken down by topics into thematic or focus scopes. As the chart shows, we organized our work into an initial phase, where we analysed the material qualitatively and quantitatively, and a second phase of synthetic interpretation and elaboration of models and possible settings.

In the first phase, we arranged our research into three focus scopes. In the first, we explored the broad trends currently in progress, so as to present an overview of the contexts where university systems have evolved. We were particularly keen to understand the ongoing dynamics of change determined by the shift in geopolitical balances across the globe, the impact of these dynamics on the new geographies of knowledge that are now taking shape, as well as on the current transformations within economies and societies worldwide. In parallel with analysing the

FIGURE 0.1 Project breakdown.

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literature, we studied international research papers and reports that shed more light on the nature of the different innovation systems in the world today, and changes in work practices and professions expected to feature prominently over the next decade or so.

In the second focus scope, we explored different university systems across the world, to gain a good understanding of their disciplines specificity, educational provision, focus of their research, and how research was advanced and promoted. We also tried to decode the profile of lecturers and students in the various universities, and how universities were able to promote themselves, their technology transfer undertakings and their social impact within their local and/or supranational systems. In this stage, we concentrated on a competitive landscape of the world's leading technical and scientific universities, identified through their position in the leading international rankings. Our data analysis and research allowed us to profile some of the universities we were examining and outline several reference models and trajectories of evolution, where we also drew on strategic planning documents published on their websites (see Table 0.1).

TABLE 0.1 Sample of technical universities grouped by geographical area

<i>North America</i>	<i>Europe</i>	<i>Asia</i>	<i>Oceania</i>
Massachusetts Institute of Technology	University of Cambridge	The University of Tokyo	The University of Melbourne
Stanford University	University of Oxford	Tokyo Institute of Technology	The University of New South Wales
Harvard University	Imperial College London	Kyoto University	Monash University
University of California, Berkeley	University College London	KAIST – Korea Advanced Institute of Science and Technology	The University of Sidney
Georgia Institute of Technology	KTH – Royal Institute of Technology	Seoul National University	Australian National University
California Institute of Technology	Technical University Denmark	Tsinghua University	
Carnegie Mellon University	Delft University of Technology	Peking University	
UCLA – University of California Los Angeles	Technical University of Munich	Zhejiang University	
Princeton University	Technical University of Berlin	Fudan University	
University of Illinois at Urbana-Champaign	RWTH Aachen University	Shanghai Jao Tong University	

<i>North America</i>	<i>Europe</i>	<i>Asia</i>	<i>Oceania</i>
University of Michigan – Ann Arbor	KIT – Karlsruhe Institute of Technology	Chinese University of Hong Kong	
University of Texas at Austin	ETH – Swiss Federal Institute of Technology	Hong Kong University of Science & Technology	
Cornell University	EPFL – École Polytechnique Fédérale de Lausanne	The University of Hong Kong	
University of Toronto	Politecnico di Milano	National Taiwan University NUS – National University of Singapore NTU – Nanyang Technological University, Singapore	

In the third focus scope, we switched our attention to the models of governance in academic organizations, to glean the interrelation between success factors and a few interesting organizational levers. We examined the overall scale, type and amount of public–private resources invested in the academic system, together with the models in place to manage teaching, research and the universities’ third mission. This analysis was correlated to the relational models between universities and their institutional and legislative contexts of reference. We conducted our research by gathering data of universities in the sample, which were then supplemented by interviews with representatives from those universities selected as “archetypes” of academic governance systems.

In the second phase, associated with the fourth focus scope, we worked on consolidating and fleshing out our findings and the contributions and interpretations arising from internal and external discussions. We held several workshops which provided the material to build an interpretive model based on three axes that redefine the identity of contemporary universities, that is, the nature of knowledge produced, its system of relationships, and the organizational and governance models. We anchored several strategic guidelines to this model, each with potential settings outlining the possible impact of the different choices taken within the model’s three axes. The settings developed by the work group were successively validated through discussions with representatives of the international universities and analysed in the preceding phases by experts from the worlds of business and institutions.

Contents

This book consists of five chapters in which we summarize our research, examining the findings of our analysis and elaborating our interpretive models. In the conclusions, we present our process to build strategic orientation settings.

Chapter 1 explores the role of tertiary education within processes of social and economic development, and examines its outlook and impact on the main political, economic and social trends. Starting from our analysis of how university systems co-evolved with social and economic systems, in this chapter we analyse the fundamental role that these institutions play within today's "knowledge economy". This analysis examines the changes currently in progress, from the role of technology in society and the urbanization of our world to climate change and growing inequality, and identifies the responsibilities and challenges that all universities in general, and the scientific and technical institutions in particular, will be facing over the next decades.

Chapter 2 covers the spheres of action in universities, showing how past and current changes are transforming the operational boundaries of universities. In practice, what is happening is that they are branching out from their two longest-standing functions, education and research, first to include entrepreneurship innovation and, more recently, to embrace the more active role of driving awareness of technology in society and influencing policies both in the private and in the public domain. The analysis in the chapter is based upon an ideal hypothetical competitive landscape, where we selected about 20 technical and scientific universities from our initial sample, recognized internationally for their excellent performance. The comparative analysis, backed by statistical reports and theoretical insights, identifies the main trends that play an essential role in steering academic strategies in research and education, in transferring innovation to the entrepreneurial system, and on their impact and influence on society.

Chapter 3 is a critical reflection on the evolution of governance models in universities, from Humboldt's original model to the current situation where many models are in place, each having been influenced by the background conditions that determined how they evolved. This chapter first investigates the interrelations between forms of governance and the context which generated that specific arrangement, especially when juxtaposed with the various national economy development models and specific regulatory constraints. We then went down to the level of single universities, where we identified a series of archetypical models in order to summarize possible approaches to governance systems that universities can take. Starting from this analysis, and recognizing that each university is bound by national checks in the institutional, political and economic sphere, in this chapter, we trace several common trends across Europe, which are now playing a significant role in moulding university choices.

Chapter 4 outlines the directions that universities could take over the upcoming years, proposing a model which bolts the possible strategies along three axes.

FIGURE 0.2 The 14 crossroads.

As mentioned, these axes redefine the identity of today's universities, and consist of the type and methods to create and transfer **knowledge** (*what*), the actors and their set of internal and external **relationships** (*who*), and the **system** of organizational models that govern their actions and activities (*how*). On the basis of our model, we then set out 14 crossroads that delve into the possible strategic choices that each university can make on the basis of its own objectives and the after-effects that these can determine. We identified two possible polarities for each of these 14 crossroads, with a critical discussion of the associated benefits and potential threats, in order to present well-organized arguments for or against each choice (see Figure 0.2).

Chapter 5 sets out an assessment of the prospects arising from the different choices and settings described in Chapter 4. It was possible to highlight how the various social, economic and cultural features in each context, in combination with the various institutional aspects, all contribute to shaping the array of decisions to be taken and also make one path more practical or effective under certain conditions. Under this interpretation, we are propounding a model of correlation

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between choices that can be made at the different crossroads. It also presents a critical interpretation of the contextual properties of each university system, giving individual universities a strategic orientation tool that can help them plan their transformation strategies in the medium to long term, while keeping a close eye on potentially imminent predicaments.

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