Transdisciplinarity: Context, contradictions and capacity

A. Wendy Russella,*, Fern Wicksona,b,1, Anna L. Carewc

a School of Biological Sciences, Faculty of Science, University of Wollongong, NSW 2522, Australia
b Science, Technology and Society, Faculty of Arts, University of Wollongong, NSW 2522, Australia
c Centre for Educational Development and Interactive Resources, University of Wollongong, NSW 2522, Australia

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Abstract

Transdisciplinarity has been proposed as a response to the shifting knowledge landscape in contemporary society. It promises to bring universities and other knowledge organisations into line with new demands and opportunities. In this study, we have investigated drivers of change in the shifting landscape, and note disparate drivers that plot different courses for transdisciplinarity. We describe three drivers: ‘the knowledge economy’, ‘the environmental imperative’ and ‘the engaged populace’. We discuss their different prescriptions for transdisciplinary knowledge production and contradictions that arise from these, including tensions between consolidation and interconnection, and between knowledge commodification and mutual learning. In response, we suggest that rather than investing in knowledge ‘products’, universities should focus on developing capacity for transdisciplinarity, and for knowledge production generally.

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1. Introduction

Developments in contemporary society are creating a shifting landscape of knowledge production. These developments include changing roles for knowledge institutions in a global ‘knowledge economy’; increasing demands for knowledge production to address growing national and international environmental problems; and changes in the demography of knowledge as education and information become more widely distributed. This shifting context creates a demand for organisations such as universities to change their approach to knowledge production [1]. The response of universities to this demand will shape the university of the future and its contributions to knowledge production and society.

One response to the shifting knowledge landscape that has gained popularity in the last decade is transdisciplinarity [2–4]. In contrast to multidisciplinarity—in which disciplinary specialists work together maintaining their disciplinary approaches and perspectives—and interdisciplinarity—in which areas of overlap or intersection between disciplines are investigated by scholars from two or more areas—
transdisciplinarity has been described as a practice that transgresses and transcends disciplinary boundaries [5,6]. Of the various cross-disciplinary\(^2\) approaches, transdisciplinarity seems to have the most potential to respond to new demands and imperatives. This potential springs from the characteristic features of transdisciplinarity, which include problem focus (research originates from and is contextualized in ‘real-world’ problems), evolving methodology (the research involves iterative, reflective processes that are responsive to the particular questions, settings, and research groupings) and collaboration (including collaboration between transdisciplinary researchers, disciplinary researchers and external actors with interests in the research) [8]. Given this potential for collaborative and responsive problem-solving, transdisciplinarity has much promise in bringing universities into line with the new knowledge landscape and in meeting global challenges of the 21st century [1,9].

Transdisciplinarity is arguably not a new practice, and there have been a number of internal (within university) drivers for the development of transdisciplinary approaches, including creative activity at disciplinary margins, tensions created by disciplinary inertia, unions of disparate disciplines around new problems or industries, and collaborations based on newly developed equipment and techniques. Historically, external drivers, such as the imperative for contributions to national military goals, have also pushed for transdisciplinary approaches. However, there has been a recent increase in interest in transdisciplinary, and cross-disciplinary approaches generally, and calls that initially came from practitioners and theorists within a variety of disciplines in academia [4], have been taken up by government, industry and the non-government sector [10–12].

Calls for a shift away from the constraints of disciplinarity appear to unite to promote transdisciplinarity and to re-position universities within contemporary society. However, there are in fact several disparate drivers, which potentially drive the development of transdisciplinarity in quite different directions. In the first section of this article, we identify three drivers within the shifting knowledge production context: ‘the knowledge economy’, ‘the environmental imperative’ and ‘the engaged populace’. These drivers can also be seen as lenses—they have particular focuses that give different perspectives on the shifting context. We describe the different ways these three drivers shape the promotion and practice of transdisciplinarity. We go on to highlight some of the tensions and contradictions arising from these different drivers and the perspectives they represent and how these tensions threaten the development of transdisciplinarity and its contribution to the public good. In the final section, we suggest that a remedy lies in universities developing transdisciplinary capacity specifically, and intellectual capacity generally, rather than focusing on knowledge ‘products’.

2. Shifting landscape of knowledge production

2.1. Knowledge economy

A focus on a ‘knowledge economy’ is emerging as a feature of global capitalism. Knowledge, innovation and ‘knowledge services’ are seen as increasingly central to economic growth and international competitiveness by governments, particularly within the OECD.\(^3\) This trend signals a move away from a reliance on primary production and natural resources (for countries like Australia) and from manufacturing and industrial production (for countries in Asia, for example) towards a focus on the production, trade and application of knowledge [13,14]. Knowledge is seen to contribute to the national and international economy in two major ways: in reshaping and adding value to existing manufacturing, service and primary industries, and in creating new industries and ‘knowledge intensive commercial activities’, particularly in the context of globalisation [13, p. ii]. This new focus has challenged perceptions of the role of the university in contemporary society, and has resulted in significant shifts in the approach of governments to providing core funding and competitive research grants to universities [15–17].

\(^2\)Cross-disciplinary is used here as an umbrella term for approaches that break with disciplines; as used, for example, by Grigg [7].

\(^3\)Raised, for example, at the OECD Global forum on the Knowledge Economy: Policy Frameworks for ICTs, Innovation and Human Resources, Brasilia, Brazil, September 2002.
Universities are no longer regarded simply as sites of knowledge production and dissemination, but are increasingly encouraged to apply their knowledge and capacity to economic growth and industrial problem solving; the so-called ‘third role’ [18,19]. Paradoxically, while universities are increasingly expected to contribute more to the economy, they are also expected, in being able to generate returns from their own knowledge resources, to support their own activities. Both of these demands are related to the increased public investment in universities in the era of mass education [20]. Despite the greater proportion of government budgets required to support universities, core funding is effectively shrinking, in real terms per student [15,21, p. 16]. Universities are being forced into a cost-recovery mode that encourages them to focus on knowledge as a means to attract returns and investment to support their continued operation [18,22]. Funding is made increasingly conditional on the performance of universities in generating ‘knowledge intensive commercial activities’ and commercialising intellectual property. This has contributed to the corporatisation of universities [15,23].

One aspect of an emphasis on economic returns from knowledge is a recent trend towards consolidation, which can be recognized as a version of the ‘Matthew effect’—‘those that hath shall get’ [24]. In universities, this is apparent in an internal emphasis on research strengths and an external (government) emphasis on priority areas [20]. Research strengths are a way for universities to market themselves in a competitive environment, to attract strong staff and students and to earn research funding. A simple survey of websites indicates that the majority of Australian universities have reorganized their research priorities into 12 or fewer research strengths. Building areas of strength is seen as a more efficient way to achieve excellence and gain returns on research and infrastructure investment than spreading support thinly. At the same time, governments are tending to take a more interventionist approach in ‘steering’ university research by identifying and funding priority areas as strategic building blocks of national knowledge economies [26]. These have included, in particular, new technologies, such as biotechnology and nanotechnology. The two emphases (research strengths and priority areas) are tending to strengthen certain research areas and weaken others [23]. There is also increasing pressure to link research training with research strengths and this trend may conceivably spill over into university undergraduate courses.

Consolidation and support for existing strengths is partly a strategy for achieving excellence and critical mass in research. Ziman [20] describes this shift as a response to science reaching a ‘steady state’, in which the scope for expansion is limited and areas compete for support. An extension of this response, however, is a shift from seeing research as a means for achieving a range of outcomes, to seeing research for its commercial potential. If funding is limited, why not find research areas that can pay for themselves? And if they bring in extra revenue for the university, the research organisation or the nation, all the better.

A further characteristic of the economic driver is the push for partnerships, particularly between universities and industry, including local and international firms [15,28,29]. Together with increased involvement of government in university business, this trend has been described as a triple helix of university–industry–government relations [30]. Such partnerships are seen as an avenue for ‘transferring’ knowledge and innovation into productive sectors, this transfer requiring the transformation of knowledge into products and services. For universities, industry represents a benefactor to assist them in their struggle for survival and, in the context of the knowledge economy, prosperity. Government sees this opportunity to overcome the growing problem of funding universities and provides new support contingent on such partnerships.

An example of both the partnerships push and the consolidation trend is the Australian Cooperative Research Centre (CRC) Programme. The programme, established in 1990, aims to ‘focus R&D efforts on progress towards utilisation and commercialisation’ [31]. CRCs bring together researchers from universities and public research bodies such as the CSIRO with industry partners, who contribute further R&D dollars to match government funding. As such, CRCs could be in the vanguard of shifts to Mode 2 knowledge production [1,32]. In December 2004, the Australian government committed over $407 million to the programme. While this was a similar expenditure to their 2002 commitment of $478 million, the 2004 funds

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4Although Merton’s original conceptualisation of the Matthew effect related to cumulative advantage in terms of recognition and status among scientists, it has more recently been extended to cumulative advantage in resourcing and financial reward [25].

5The term ‘research training’ itself reflects the shifting role of postgraduate education in training researchers for the knowledge economy [27].
were distributed between 16 CRCs, approximately half the number that were funded in 2002, which had been selected from over 50 established initially. The potential of CRCs to generate revenue and exploit the commercial potential of their research was a strong basis for the selection process. It lead to the controversial closure of a number of CRCs with clear public interest potential, such as the Tropical Rainforest CRC [33]. In addition to the consolidation of support into an ever-decreasing number of areas, CRCs also put constraints on the career prospects and research freedom of individual scientists and on the science system to provide the basic research to support their applied focus [32].

Central to the economic lens that focuses on the role of universities in a ‘knowledge economy’ is the reconceptualisation of knowledge as a tradable commodity, of use to paying ‘knowledge consumers’. This reconceptualisation has been a driver for transdisciplinarity in increasing the demand for knowledge that is problem-focused, relevant and communicable to stakeholders outside the university and generated through collaborative partnerships. A key feature of the transdisciplinarity that responds to this driver is that problems are defined by knowledge consumers and partners. Importantly, the knowledge generated is subject to ownership. In addition, the role of universities in deciding what constitutes ‘worthy knowledge’ and what areas and directions of knowledge production should be pursued is increasingly shifted to external ‘knowledge consumers’ and towards commercial priorities.

2.2. Environmental imperative

Since the 1960s, modern industrial societies have witnessed a dramatic increase in social concern for ‘the environment’. As the social movement of environmentalism has gathered force, pressure has been placed on governments to recognize and attend to environmental problems arising from modern industrial and social practices. This imperative has been articulated internationally in UNESCO’s ‘Man and the Biosphere’ programme in the 1970s, The Brundtland report in the 1980s and the Rio Earth Summit in the 1990s. Governments have responded by developing national environment ministries, signing international agreements and treaties on environmental issues and participating in the creation of international environmental agencies. One of the clearest indications of the increasing salience of environmental issues is the way in which the aim of progress through economic development has been tempered by emphasis on sustainability [34].

Despite increased awareness and concern, environmental problems remain pervasive. The extent of these problems has been documented by international agencies such as the United Nations Environment Programme (UNEP). In a recent briefing paper [35], the UNEP outlined some of the key environmental concerns facing the globe in the 21st century, which included record levels of ozone depletion, degradation of more than half of the world’s major rivers, deforestation at a rate of 16.1 million hectares annually and land degradation resulting in the loss of billions of tonnes of fertile topsoil a year. When the cumulative impact of these problems of air and water pollution, deforestation, loss of biodiversity and land degradation is added to the threat of climate change, the situation looks particularly dire. Indications of a warming world and a changing climate also herald disruption of ecosystems from disturbances such fire, drought, pest infestation, storms and coral bleaching events, which can be expected to increase significantly [36].

Apace with political awareness, academic research investigating ‘the environment’ has also increased in recent decades. Although studies carried out under the auspices of disciplines such as biology, geology, hydrology, geography, archaeology, etc. have arguably generated knowledge on different aspects of the environment for centuries, it is only relatively recently that researchers have recognized the need to begin connecting the knowledge from these different spheres to understand the complex and interconnected nature of ‘the environment’, especially in the quest for sustainability [37–39]. This recognition has been a major driver for a shift toward research that is capable of working across disciplinary boundaries. The concept and pursuit of sustainable development has also drawn attention to the importance of combining knowledge from the natural and social sciences [40,41]. The interconnectedness of environmental problems has also called for cross-institutional and transnational cooperation. As the desire to understand the environment as a whole and to develop solutions to serious environmental problems facing humanity has spread, research centres and student courses focused on the environment have emerged as some of the first and foremost exemplars of transdisciplinarity [42].
A perspective that focuses on the environmental imperative recognizes problems as existing in an interconnected social and natural context and, as such, being complex, uncertain and lacking clearly defined boundaries [43]. Moreover, finding solutions to environmental problems requires not only an understanding of the environment and threats to it; it also involves influencing the actions and behaviours of multiple societal actors. This lens sees solutions as requiring knowledge production that is systems-based rather than reductionist or separate, not constrained by strict knowledge boundaries, able to deal with complexity and uncertainty and able to integrate and communicate knowledge among many actors and between fields of knowledge. The potential for transdisciplinarity to provide this type of knowledge production means that the environmental imperative has been a strong driver for transdisciplinarity [2].

2.3. Engaged populace

Relevant changes in the social context of knowledge production include the high levels of education achieved by increasing proportions of the populations of most countries [45,46]. In addition to more education, information technology has given people access to vast amounts of information. Although this information does not constitute knowledge, together these trends mean that education and knowledge are more socially distributed than ever before [1,47,48]. The educated populace is increasingly a feature of the knowledge production landscape and this feature has been an important part of calls by Gibbons and co-workers [1] for a shift to Mode 2 knowledge production, which is synonymous with transdisciplinarity.

Another feature of the social driver is the weakening of the authority of science and academia in contemporary society. This weakening partly results from the education of the populace and the social distribution of knowledge, which is no longer the exclusive domain of experts. The tainting of some of the Mertonian norms of science—disinterestedness and objectivity—by values of the market and by the contingencies of application [29,49]; and past failings of science to adequately address complex and uncertain problems have also lead to challenges to the monopoly authority of science [43,50]. This loss of authority, which has been described as a ‘crisis of public confidence’ [51,52], creates new opportunities for other sources of knowledge to gain legitimacy. This is supported by movements inside and outside academia challenging the dominance of scientific knowledge and promoting respect for diverse lay and indigenous knowledges [52–54].

A lack of faith in the power of science to provide all the answers, or even to ask the right questions, has led to increasing demand for the public to be included in decision-making processes and for science to seek a ‘shared vision’ or ‘contract’ with the public [55–57]. At the same time, the dominance of the market has weakened the hegemony of nation states, particularly through processes of globalisation, and has placed increasing emphasis on ‘civil society’ as an actor in modern democracies [58]. As parliamentary democracy is weakened, other forms of democracy, such as deliberative and participatory democracy, are put forward as important political institutions, particularly in a globalising world [59]. In this sense, as well as being more educated, people in society are also potentially more engaged in generating and using knowledge, and in political processes.

The engaged populace is a driver for transdisciplinarity in creating new demands for knowledge, in ‘speaking back to science’ [47, p. 50] and in providing new opportunities for collaboration in knowledge production. The development of transdisciplinarity has been influenced both internally and externally by these social trends. For those involved in theorising transdisciplinarity, who promote the transgression of boundaries between institutionalized knowledge ‘experts’ and society, a central question for transdisciplinary research is ‘Where is the place of people in our knowledge?’ [60, p. 75]. Externally, the engaged populace creates demands for knowledge that is responsive, relevant, translatable into different languages and contexts and problem-focused. Additionally, there are increasing demands for public participation in knowledge creation and policy deliberations, both from the bottom-up (i.e. from a more educated populace which lacks confidence in science) and from the top-down (i.e. from researchers and government who recognize the value

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6Environmental science and natural resource management scholars tend to refer to integration research, referring to integration of disciplinary knowledge and integration of research and policy; We see this as synonymous with transdisciplinarity (see, for example, Dovers [44]).
of lay knowledge for decision quality). This translates into the need for an approach to knowledge production that is consultative, deliberative and participatory. This has given rise to the concept of mutual learning [61].

The three drivers described above do not originate from separate or independent parts of the shifting context. They can also be understood as lenses; they focus on different aspects and give different perspectives and consequently different recipes for a transdisciplinary response. The knowledge economy is driving problem-oriented or applied research geared to the needs of the knowledge consumer; the environmental imperative prompts recognition and consideration of the problem-in-context and a systems approach to research; and the engaged populace calls for researchers to take a more consultative approach and recognize other sources of knowledge. If overlaid, these lenses give a richer and more complex picture of shifts in contemporary society and this integrated perspective demands new, broader prescriptions for transdisciplinarity. Overlaying these lenses also highlights significant contradictions and tensions that exist between the different drivers.

3. Contradictions and tensions

The knowledge production context is shifting in complex and contradictory ways. For example, knowledge is becoming more socially distributed at the same time as it is being consolidated. Scientific knowledge is becoming more valuable at the same time as its authority is being challenged. Public forms of knowledge are becoming more legitimate as other forms of knowledge are being privatised. These contradictions have implications for the practice and role of transdisciplinarity. They indicate where the drivers are heading in different directions—the fault lines in the shifting knowledge landscape. They are the areas and issues that are most likely to be influential in shaping knowledge production, and the transdisciplinary response. They require a watching brief, as it is here that problems and conflicts are likely to arise.

We focus here on two specific tensions: cross-disciplinary ‘mega-silos’, created through consolidation of research strengths, which stifle further transdisciplinary connections; and the juxtaposition of mutual learning and knowledge commodification.

3.1. Institutionalisation vs. interconnection

Disciplines are often described as ‘silos’, which concentrate resources and research activity into isolated structures with little interconnection. Transdisciplinarity (and cross-disciplinarity generally) is seen as an antidote to the formation of knowledge silos and as providing a more effective and productive organisation for knowledge production. As part of this, research centres and institutes have been formed in transdisciplinary, multidisciplinary or interdisciplinary modes, bringing researchers from various disciplines together around particular areas or topics. Although some of these are established around themes such as environment or climate, many are organized to support emerging areas of science and technology, areas of ‘big science’ that require considerable resources and are seen as cutting-edge and potential earners.

In the original description of Mode 2 knowledge production, such collaborations were seen as flexible and transient [1]. In the new fashion for research strengths, some universities have developed broad, overarching themes that unite researchers in different disciplines in a fairly fluid way. However, enthusiasm for commercialisation and partnerships within universities and government has resulted in a variety of policy instruments that attempt to capture and consolidate transdisciplinary activity by building structures around it. This institutionalisation, although built on principles of cross-disciplinarity, potentially creates ‘mega-silos’, new structures of knowledge production that are built up vertically as islands of strength.

This consolidation reflects the knowledge economy context, where commercial potential has become a significant source of advantage and recognition. In this context, the Matthew effect confers differential advantage not only on individual scientists and organisations, but also on areas of research [25]. Because of government and industry priorities, research strengths are not evenly distributed across the range of topics of potential importance to society. They concentrate in areas characterised by existing strength and commercial potential. Particularly when universities recreate themselves on the basis of these areas of strength, restructuring departments, recruitment and even undergraduate courses in line with them, universities and
knowledge production are in danger of being reshaped in line with market forces, to the detriment of transdisciplinarity and disciplinarity.

Transdisciplinarity is a practice that requires flexibility and fluidity. There are several ways in which attempts to institutionalise it may in fact inhibit it. Firstly, mega-silos replace disciplinary boundaries with topic, technology and industry boundaries. Research strengths may become like disciplines, stabilising topics, methodologies, priorities and perspectives and detracting from flexible, adaptable and critical approaches. While transdisciplinarity or other cross-disciplinary approaches may operate within the mega-silos, transdisciplinary activity is likely to be starved of resources in the spaces inbetween. While collaboration is encouraged and promoted within the mega-silos, it may be inhibited outside and between them, not only because of their boundaries and the barren land between them, but also because of the commercial imperative that emphasises the value of the intellectual property generated within the mega-silo, and the competitive advantage it confers for the institution.

Secondly, there is a danger that the centres and institutes, and the universities that invest in them, will be unresponsive to new problems and unable to shift into new areas. Researchers, constrained to particular topics, may become less creative and innovative [22, p. 55]. Dogan and Pahre [62] describe the ‘paradox of density’, in which innovation in a research area is proportionally greater when the area is new. In moving from cutting-edge to research strength, a research area suffers from ‘the law of diminishing marginal returns’ in terms of innovation and is likely to be of poorer quality [62, p. 29]. Consolidation may result not only in diminishing innovation returns, but also in lost opportunities for ‘creative marginality’ leading to new research areas and for the ‘dialogue at boundaries’ required for Mode 2 knowledge production [48, p. 109]. Moreover, while such institutionalisation may not directly threaten existing disciplines, it potentially threatens the evolution of disciplines, which also requires the flexibility to change and venture into new territory. An approach based on the current pattern of institutionalisation, as well as inhibiting transdisciplinarity, is likely to be unsustainable, because the clustering of resources and talent around selected central topics or research questions potentially undermines the source of new ideas and new research areas—activity at the margins.

Thirdly, institutionalisation may detract from a knowledge production approach that provides interconnection, complexity and systems thinking. While this approach may not be critical for the development of new technologies and industries, it is key to a range of pressing societal problems, including the social and environmental impacts of new technologies and industries. Sustainable development requires an understanding of the interconnections between economic, environmental and social dimensions, an appreciation of the complexity of interactions between these dimensions, and the development of systems approaches to problem solving. Institutionalisation potentially undermines the flexibility and interconnectedness that is required. In addition, the investment in research strengths by university management channels resources away from problems that fall outside of research strengths, and potentially away from critical and reflexive approaches, which may affect the attractiveness of strength areas to investment partners.

This leads to the fourth concern with institutionalisation, namely that when research strengths are associated with industry partnerships, or are built around commercial opportunities, this tends to lead to the realignment of priorities and research agendas. While these partnerships promote transdisciplinarity in creating imperatives for problem-focused research and consultation with knowledge users, the selection of ‘worthy’ areas of study has the potential to be co-opted by narrow views of worthwhile research (e.g., that which contributes to economic growth) and by the interests of commercial partners and commercial imperatives. Once again, the Australian CRC programme is an example in which this significant source of research funding has whittled these areas of strength down to a few commercially promising industries.

A rather general example of the influence of commercial imperatives is found in the area of plant improvement. Agriculturally important plants have been ‘improved’ over centuries through plant breeding and selection, a practice that has become increasingly sophisticated. In parallel, and contributing to this sophistication, is molecular biology research into plant traits, which has emerged as part of the ‘genetic revolution’ and the global biotechnology industry. Besides contributing to plant breeding, this molecular biology underpins the genetic engineering of varieties and the characterisation of genetic elements, which, as intellectual property, are grist for the biotechnology mill. Where plant breeding efforts represented iconically ‘public’ research, providing improved varieties for rural industries, modern-day molecular plant improvement work is equally absorbed in ‘inventing’, commercialising and trading genetic intellectual property in order to
capture a piece of the global biotech market and to attract partnerships with well-resourced (both financially and in the ownership of essential intellectual property) Life Science companies [63]. Not only has this expensive, but also lucrative molecular work tended to drain resources and personnel away from classical breeding work, the plant characteristics that are the focus of ‘improvement’ have tended to shift from general performance characteristics to a limited range of commercialisable traits such as herbicide tolerance.

Interestingly, a recent investigation of claims of shifting research priorities found little evidence, based on publications, of research becoming ‘skewed’ towards applied or technology-focused work among scientists associated with industry partnerships [26]. However, the basic/applied, science/technology dualities do little to illuminate the ultimate agendas of research effort, particularly as they relate to the application of knowledge to public interest problems vs. commercial problems. The question of whether public funds should support commercial endeavours and the parallel question of whether private investment should support fundamental research are eclipsed by larger questions about what research is needed in society and who decides.

Entrepreneurial approaches and alliances have various legal, economic and social risks and pitfalls for public universities [15,22, p. 57]. In addition, as university researchers become increasingly entwined with commercial interests, including their own, conflicts of interest become commonplace, affecting not only research agendas within public organisations such as universities, but also compromising other roles that universities and university academics have traditionally played, for example, on regulatory panels and advising to government [28].

This first contradiction—institutionalisation threatening interconnection—represents a tension between the ‘knowledge economy’ perspective and the environmental imperative, in particular, because interconnection, responsiveness and flexibility are so important when dealing with environmental problems. However, this contradiction may also signal problems within the knowledge economy driver, in the sense that the institutionalisation trend is first born of a desire to interconnect different researchers and disciplines, but then may act to solidify these connections and inhibit new ones. Consolidation also has important implications in the social dimension, in the sense that the accumulation of advantage potentially marginalises certain researchers and potential knowledge partners.

3.2. Knowledge commodification vs. mutual learning

The second contradiction we describe relates to the commodification of knowledge and the conception of knowledge as intellectual property, and the idea of ‘mutual learning’ that is suggested in discussions of transdisciplinarity. This contradiction plays out in the ownership, exchange and use of knowledge, and in the power relationships involved [64].

Discussions of transdisciplinarity have highlighted the importance of ‘mutual learning’—‘the exchange, generation and integration of existing or newly developing knowledge in different parts of science and society’ [61, p. 118]. This involves cooperation among different groups within society and within academia; in joint problem solving, an action research process that encourages the multiple stakeholders to ‘take ownership’ of the outcomes of the research [65]. This process takes place in ‘transaction spaces’ where different kinds of knowledge producers come together, and where knowledge can be shared and exchanged [48, p. 105]. The development of such processes of mutual sharing and exchange are influenced, however, by the ownership of knowledge in the form of intellectual property.

One of the most common criticisms of intellectual property is that it threatens the knowledge ‘commons’ and restricts the sharing of knowledge [66]. This criticism is not without its counter-arguments. Merton [24] argues that intellectual property, particularly associated with academia, is the one form of property that gains value in free exchange and use. Because of a strong culture of attribution, once a piece of work has been accepted into the knowledge commons of academia (that is, once it becomes known), ownership is acknowledged by those who use it (by citation). Researchers whose work does not enter the public domain and is not freely used and exchanged are the ones unable to assert ownership. This form of intellectual property gains its value from recognition and status.

The current economic context creates a different set of values for knowledge, however. Commodification involves recognition of the commercial opportunities in generating and owning knowledge, and confers monetary value on knowledge. Patenting, though much maligned by those who oppose intellectual property,
was introduced partly in order to facilitate the exchange of information about inventions (at the same time as preserving benefit for the inventor). However, in a research context, there is evidence that patenting within universities and research organisations tends to inhibit publication, even if it is only to slow it down [67]. Even delays can have important implications, particularly for students, early career and contract researchers. In addition, the push for universities to commercialise their knowledge by developing commercial products or services also tends to create a ‘commercial-in-confidence’ atmosphere [68]. Thus, while knowledge sharing is a central feature of transdisciplinary research, it may be curtailed by the push for knowledge commodification.

There is another source of tension between the commodification of knowledge and the integration of diverse forms of knowledge that is advocated for transdisciplinarity. There have been attempts to recognize traditional and lay knowledge as intellectual property [69], but one of the major difficulties is the diffuse, shared, informal, contextual and non-codified nature of these knowledge types. Identifying and protecting knowledge as intellectual property requires agreement about what the knowledge is and who produced it. Such attribution is a feature of the culture of academia, but not of the community. It is in fact a strength of informal social learning, the kind that happens in communities, or in the public sphere, that knowledge is freely used, changed and exchanged. If mutual learning becomes a tool of transdisciplinarity as it is conceptualized within the knowledge economy, the insights of this learning may be claimed as intellectual property by the university or industry partner. Mutual learning could thus turn into a process of ‘prospecting’ for ‘raw knowledge resources’ that are then extracted and refined into intellectual property, knowledge products and services. This ‘resource extraction’ could equally result in the mining of university knowledge by industry, particularly if universities give too much power to external knowledge consumers.

This underlies a larger problem with the enthusiastic adoption of a mutual learning model in the context of the knowledge economy, and that is the general problem of power [64]. Mutual learning is described as a mutual, consensual and equal exchange between researchers and other involved people. However, as Nowotny and co-workers [47, p. 211] have pointed out in their description of the ‘agora’, the modern marketplace of ideas, ‘power certainly matters’. In the heterogeneous, complex and shifting nature of the agora, power imbalances exist between diverse knowledge producers and knowledge users, particularly when they are ‘transacting’ over controversial science and technologies. In addition to economic and political imbalances, imbalances are reinforced by the notion of expertise and by the privileging of particular types of knowledge, notably scientific knowledge [70].

Problem solving—and indeed problem formulation—is influenced by interests. If the interests of different partners in mutual learning are different (which is likely to be the case when partners include industry and the community) and if power differentials exist (as they generally do), mutual, consensual outcomes are by no means guaranteed. Just as the breaking down of borders under trade liberalisation leaves less powerful nations unprotected and subject to exploitation in a global market, the unconstrained breakdown of knowledge boundaries—between disciplines, but also between knowledge producers inside and outside the university—may render knowledge partnerships subject to power imbalances which may be amplified in the process. Similarly, ‘transaction spaces’, like ‘trading zones’ [68], can be sites of unequal and paternalistic exchange.

This also raises the question of scientists and academics generally, and their role in shifts towards new knowledge production approaches. Scientists are not passive recipients of these shifts but they are by no means unified in their responses. On the one hand, some scientists have actively embraced a move away from traditional disciplinary scholarship to a more entrepreneurial mode, ranging from interaction with industry partners, through involvement on company boards and in consultancies to the establishment of start-up companies. Such scientists are clearly driven by the knowledge economy and its opportunities [28]. Other academics fear threats to their autonomy, their academic freedom, and the quality of their work, particularly from corporatisation trends [72]. Influenced by a new culture of entrepreneurialism on one side, and the deeply held traditions of disciplinarity, academic freedom and quality on the other, it seems that few scientists may be ready to embrace the broadening and democratisation of science and engagement with the community that contemporary shifts require [72].

7An excellent example is presented in Strathern [64].
8Gibbons [48] relates ‘transaction spaces’ to the ‘trading zones’ discussed by Galison [71].
While there is evidence that the contradictions and issues we have discussed are already relevant in some situations, they have not necessarily played out in all situations and may not do so. We highlight these tensions primarily in an appeal for a cautious watch on developments. We need to consider the implications of consolidation and knowledge commodification for transdisciplinarity and knowledge production generally. We also need to consider how the development of transdisciplinarity can seek to address or circumvent the potential problems we have raised. Transdisciplinarity emerged to counteract the tendency of disciplines to place rigid boundaries around knowledge, and to separate it into artificial compartments. Building transdisciplinarity requires a strong commitment to flexibility and rejection of the temptation to institutionalize transdisciplinary excursions.

Similarly, the promising contributions of transdisciplinarity in engaging with and integrating diverse forms of knowledge need to be considered in the light of power relationships and knowledge ownership. Differences in intellectual property cultures, between academia and industry, but even more notably between formalised and lay or indigenous knowledge, leave open the prospect of exploitation of knowledge ‘resources’. There needs to be considerable transparency and negotiation, particularly in the conduct of mutual learning. More generally, the running down of core funding for universities is enhancing the commodification and commercial exploitation of knowledge, which is regarded as capital from which to gain income. Universities are not corporations, focused on their financial survival and prosperity. They are public institutions with a mandate to the public good. University knowledge is a public resource, which should serve this mandate[48].

3.3. Building capacity

In order to counter some of the tendencies in the commodification of knowledge, to put universities in a stronger and more responsible position in knowledge partnerships, and in order to better serve their public interest mandate, universities need to focus on building intellectual capacity, rather than on accumulating and exploiting intellectual property. Like the goose that lays the golden eggs, intellectual capacity underpins all knowledge work. Intellectual capacity is most useful when it spans many areas of knowledge, including those that are not currently in vogue, and when it displays depth and breadth, i.e. when it includes researchers deeply rooted in particular areas, and researchers who can move between knowledge areas, integrating, cross-fertilising and overarching. Strong intellectual capacity is therefore best served by combining disciplinarity and transdisciplinarity.

Strong foundations of intellectual capacity, which may be organized around disciplinary structures, could act as platforms rather than silos. From these platforms, universities could respond to problems, imperatives and opportunities, in flexible and responsive ways, without fixing themselves into particular strengths and trajectories. Transdisciplinarity would play important roles in broadening and connecting these platforms, and in providing the capacity to launch from them into research projects and collaborations with multiple partners, both inside and outside the university; to initiate and manage the ‘transaction spaces’ described by Gibbons [48, p. 105]. Platforms, rather than silos, would allow universities to participate in the heterogeneous, collaborative, contextualized transdisciplinarity characteristic of Mode 2.

Developing transdisciplinary capacity will require some changes in the organisation of knowledge production in universities. It is clear that structures built up to institutionalize transdisciplinary activity are unlikely to succeed; and are in fact an anathema to the flexibility and responsiveness required. However, it is possible and important to develop enabling structures that facilitate such research [48, p. 115]. These include formal and informal opportunities for interaction; flexible, researcher-driven groupings and centres; rewards and incentives; quality criteria and benchmarking. There is also a range of skills that are key to undertaking transdisciplinary work, which are not necessarily valued in traditional knowledge production, particularly communication, integration, teamwork and management skills. Developing these skills among at least some undergraduates and postgraduates would contribute to transdisciplinary capacity both inside and outside universities.9

Building capacity towards knowledge production in the modern era will also benefit from a shift in the culture of universities. This culture is characterised by individuality, elitism, the accumulation of advantage

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9Our current research aims at developing mechanisms for teaching such skills to undergraduates.
(the Matthew effect) and academic territorialism associated with disciplines and specialisations. These cultural features are enhanced by, and in turn reinforce, the competitiveness, the striving for financial gain and the commodification of knowledge that threaten to characterise universities in the global knowledge economy. For transdisciplinarity, and for a more open and interconnected knowledge production system generally, to thrive in universities, there needs to be a shift towards the intrinsic valuing of collaboration and teamwork, a culture of reward sharing, a spirit of mutual responsibility and learning and more idealism and outcome (not output) focus in the generation and use of knowledge.

4. Conclusions

Transdisciplinarity, like concepts such as sustainability and progress, is presented as a one-size-fits-all solution, which will boost the economy, save the environment and empower the community. As with these other concepts, we as proponents seem loath to engage with its contradictions, leaving it in danger of being ignored as a buzz word [3, p. 10]. Not only do these contradictions weaken the usefulness of the concept and the case for its adoption when left unanswered, they also provide the most fertile ground for developing the theory and practice of transdisciplinarity. Just as the different drivers prescribe different versions of transdisciplinary practice, changes in the practice of transdisciplinary research will feed back on these drivers and bring about changes in the knowledge production landscape. Thus, addressing the contradictions is an essential part of shaping transdisciplinarity and its role in the future of knowledge production.

Transdisciplinarity has considerable potential to provide knowledge production that is problem-oriented, responsive and open to external knowledge producers, contextualized and systems-based, adaptable, consultative and socially robust [47]. It may be an essential development if universities are to keep pace in a changing world. While there are significant obstacles to the development of transdisciplinarity in universities [73], there are also dangers in it contributing to trends of consolidation and commodification that ultimately threaten transdisciplinarity and knowledge production generally. A focus on transdisciplinary capacity could assist universities in countering these threats, in addressing complex environmental and social problems and in building public trust and confidence. Transdisciplinarity is a practice, not an institution, and the more flexible, adaptable and open it remains, the greater will be its contribution.

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