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Changing Conditions for Innovation in Different Arts and Sciences

by Richard Whitley (University of Manchester) and Jochen Gläser (Technical University Berlin)

Abstract

In this paper we explore how recent changes in the socio-economic environment of novelty production, dissemination and evaluation in the arts and sciences can be expected to influence the development and institutionalisation of different kinds of innovations in differently organised fields as a contribution to the broader understanding of innovation development processes in novelty-driven cultural production systems. While the production of novelties has become a central feature of the modern arts and sciences, it is important to note that only some novelties become innovations in the sense that they have a lasting effect on the work of other producers. The processes by which new ideas become innovations and affect established ways of doing things vary between different fields of cultural production according to a) the degree to which practitioners depend upon each other in producing and evaluating new outputs, b) the extent of their collective authority over technical and significance standards, resource allocation procedures and dissemination of outputs, and c) the importance, variety and organisation of non-practitioner audiences for new art works and research results. These differences depend in turn on the broader socio-economic conditions in which artistic and scientific activities are conducted. We argue that recent changes in socio-economic conditions make fields of cultural production prioritise short-term novelty over time-consuming and resource-intensive innovation and turn the opportunity to innovate into a privilege of a relatively small elite that is secure in its career and reputation, thereby diminishing the diversity of sources of innovation.

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Introduction: Novelty and Innovation in the Arts and Sciences

To a considerable extent, both the arts and the sciences have become novelty-driven fields of cultural production in which originality is an essential quality of significant contributions (Bonds 1996: 24-27; North 2013: 50-59, 147-190). The modern sciences began to become substantively organised around the collectively coordinated production of new knowledge by communities of scientific researchers in the 17th and 18th centuries (Collins 1998: 532-8; Gläser 2006: 187-249). In the arts, the growth of market demand for works of art and artistic experiences in the 19th and 20th centuries in Europe and elsewhere encouraged both a considerable expansion of the number of practising artists competing for recognition and other rewards and an increased focus on the production of novel works as they sought to differentiate themselves from colleagues and predecessors and establish greater collective authority over aesthetic standards and goals (Menger 2014: 131-140; North 2013: 3-10; Shiner 2001: 197-205).

However, while the production of novelties has become a central feature of the modern arts and sciences, it is important to note that only some novelties become innovations in the sense that they have a lasting effect on the work of other producers (Becker 1982: 301-313). For new work to be noticed and be regarded as significant in such fields of cultural production its distinctive qualities have to be accepted as legitimate and to make a difference to fellow practitioners' practices and purposes on a continuing basis (Galenson 2006: 8; North 2013: 4). It is the extent to which novel ideas, techniques and results alter the nature, organisation, and valuation of artistic and scientific activities and outputs that determines their long-term importance as aesthetic and epistemic innovations.

This distinction between novelties and innovations in cultural production systems is different from that between inventions and innovations in economic systems. As Fagerberg (2005: 4-5) emphasises, an invention is the first occurrence of an idea for a new product or process while innovation refers to the first attempt to carry it out into practice for commercial purposes, and Smith (2005: 149) flatly asserts: "innovation is, by definition, novelty." In the arts and sciences, though, while the production of novelties for the collective cultural purposes of fellow producers and allied audiences is central to the identity of competent practitioners, these only become innovations when they have some impact on the practices, standards and purposes of fellow practitioners and so the direction of the field.

The processes by which new ideas, purposes, and practices become accepted as legitimate and significant innovations and affect established ways of doing things can be expected to vary between different fields of cultural production. These differ significantly in: a) the degree to which practitioners depend upon each other in producing and evaluating new outputs, b) the extent of their collective authority over technical and significance standards, resource allocation procedures and dissemination of outputs, including how much authority over the valuation of contributions and distribution of resources for novelty production is shared with different kinds of external actors and organisations, and

c) the importance, variety and organisation of non-practitioner audiences for new art works and research results. These differences depend in turn on the broader socio-economic conditions in which artistic and scientific activities are conducted, including: a) the overall level and organisation of societal interest in, and support for, the arts and sciences as distinct fields of cultural production, b) the ease of acquiring human and material resources for developing and disseminating new contributions and c) the diversity of external actors' interests and objectives, especially those providing resources.

In this paper we explore how recent changes in the socio-economic environment of novelty production, dissemination and evaluation in the arts and sciences can be expected to influence the development and institutionalisation of different kinds of innovations in differently organised fields as a contribution to the broader understanding of innovation development processes in novelty-driven cultural production systems. These changes include shifts in the level and organisation of public support for universities, research institutes and arts organisations, the growing influence of funding agencies' priorities and interests on the criteria governing the allocation of resources and assessment of outputs, the expansion and diversification of authoritative actors and organisations affecting aesthetic and epistemic judgements and the shifting organisation of actors and processes connecting producers to audiences in a number of fields (Alexander and Bowler 2014; Crane 2009; European Universities Association 2017; Paradeise et al. 2009; Stephan 2012: 141-150; Thompson 2012; Whitley et al. 2010; Whitley et al. 2018).

In the following section we distinguish between different kinds of innovations and change in the arts and sciences that affect established production and dissemination practices in a variety of ways. The next section summarises the major differences between artistic and scientific fields in terms of practitioners' mutual dependence in the production and assessment of outputs and their collective authority over the allocation of symbolic and material rewards and access to the means for producing novelties. The impact of such differences in levels and types of mutual dependence and authority relationships on innovation development and establishment are discussed in the following section. In the final substantive section, we suggest how this approach can be used to understand the impact of recent shifts in socio-economic conditions on patterns of innovation and change in different artistic and scientific fields.

Varieties of Innovations and Change in the Arts and Sciences

Innovations in the modern arts and sciences can be distinguished in terms of their deviation and radical difference from established patterns of working and dominant objectives. On the one hand, there are incremental shifts in novelty production techniques and purposes that do not involve reorganising coordination processes and authority relationships or investing much time and resources in developing

substantially new skills and knowledge, while, on the other hand, there are more substantially different and unorthodox changes that involve reorganising working practices, the development and/or acquisition of quite different kinds of resources and skills and the restructuring of authority relationships governing judgements of legitimacy and worth.

For the arts, Becker (1982: 302-307) has distinguished between incremental shifts in techniques and subject matter, such as the use of vibrato by string players, and more transformative changes in aesthetic goals and conventions and in the organisation of artistic production and dissemination. In the latter cases, such as Cubism in painting and total serialism in music, major changes in the character of the works produced and how they were understood were associated with shifts in the organisation of novelty production and dissemination as well as in the authority relationships governing evaluative judgements and resource allocation (Cottingham 1998, 2004; Ross 2012: 386-404; Sgourev 2013). While a similar distinction does not yet seem to have been made in the study of scientific innovation as opposed to novelty (Gläser and Laudel 2019), it is clearly possible to identify incremental scientific innovations in the sense used here.

An important aspect of this distinction between kinds of innovative processes in terms of their deviation from, and challenge to, established conventions and standards concerns the extent to which practitioners have to invest substantial amounts of time and other resources in learning new ways of doing things, developing new forms of collaboration and organising work practices, and dealing with changed sets of authority relationships and roles. Radically unorthodox innovations usually require much longer periods of time to learn or otherwise acquire unconventional skills, apply these to dealing with novel kinds of problems and seize new aesthetic and epistemic opportunities. Such investments of time and other resources are often additionally required of closely associated non-practitioner audiences and authoritative actors that have to learn to appreciate and support radical innovations if they are to become established, especially in art worlds that “consist of all the people whose activities are necessary to the production of the characteristic works which that world, and perhaps others as well, define as art” (Becker 1982: 34). Generally speaking, radical transformations of established goals and working practices involve much greater shifts in aesthetic or epistemic conventions and the institutional arrangements governing the organisation and direction of production and dissemination of outputs than do more incremental innovations.

In the case of painting in the latter half of the 19th century, for instance, the development and establishment of what came to be known as Impressionism and subsequent artistic movements in France was accompanied by substantial changes in the training and certification of artists, the distribution, sale and evaluation of paintings and the nature of authoritative actors that resulted in a major qualitative change in the organisation of the dominant art world of the time (Bourdieu 2017; Cottingham 1998, 2004; Galenson and Weinberg 2001; White and White 1993). Similarly, the

development of molecular biology has played a major role in changing dominant working practices, skills and resource allocation priorities in cancer research (Fujimura 1988).

However, major changes in aesthetic or epistemic conventions, technical skills and priorities do not always displace established authorities and the dominant organisation of resource allocation practices and valuation standards. Nor need shifts in dominant goals and standards and the nature of the authoritative agents legitimising innovations necessarily alter the mechanisms through which authority is exercised over decisions about the merits of contributions, as the continued reliance on peer review during many periods of radical changes in the sciences illustrates.

Substantial changes in techniques, skills and kinds of results can often be accommodated within higher order goals and standards by legitimising and supporting the establishment of new specialisms in the sciences and art worlds, particularly when they improve existing ways of producing novelty or create additional opportunities for novelty production by exploring new “areas of ignorance” (Mulkay 1975: 517) and kinds of aesthetic problems. This arguably happened in the case of radio astronomy (Edge and Mulkay 1976) and other emerging scientific fields, as well as the development of new genres and approaches in many artistic fields. Thus, radical innovations can result in the differentiation of artistic and scientific communities rather than the complete transformation and displacement of established goals and standards.

These varying characteristics of innovation processes in the arts and sciences can be summarised in terms of two distinct dimensions. First, the extent to which they change established aesthetic/epistemic norms, priorities and working practices into radically different ones: The degree of novelty and deviance from current practices and aesthetic/epistemic priorities. Second, the extent to which they change the dominant ways of working, standards of practitioner competence and aesthetic/epistemic priorities in an established field of cultural production: The degree to which competent producers in a field have to accept and implement innovations to continue to make recognised contributions to its goals. The stronger this is, the more artists and scientists have to learn and practice the innovations if they are to be able to continue as competent practitioners dealing with significant problems of the field. Less transformative innovations can, though, change some established ways of working and priorities of a field of cultural production without necessarily displacing all its dominant practices and standards and becoming constitutive of the entire field.

At least three distinct kinds of innovations can be distinguished in these terms. First, *drift* or incremental changes in working practices and goals consist of minor shifts in how work is carried out and/or for what purposes that can be accommodated by most practitioners without extensive periods of retraining or reorganising established patterns of collaboration and authority (Becker 1982: 303). Such innovations may provide new ways of doing things or new problems to work on without

significantly altering the nature of the field in terms of its identity, distinctive competences, central problems and standards or changing established authority relationships. Over time, however, a number of incremental innovations may generate more substantial shifts in priorities and approaches that result in the establishment of new fields of cultural production, as in the case of bacterial physiology (Kohler 1985) and perhaps the establishment of “new” rock and roll music in the 1960s with new audiences and means of reaching them (Becker 1982: 313; Laing 2002).

Second, *complementary* innovations involve more substantial deviation from established norms and practices in the pursuit of new priorities and problems. Developing new ways of working, forms of collaboration between practitioners and kinds of goals here means investing considerable efforts in creating novel kinds of knowledge, artworks and skills. These often diverge from established prestige hierarchies and standards for evaluating contributions and allocating resources, but rarely lead to the wholesale transformation of established competences, authoritative actors and significance standards of the whole field. Rather, they focus attention and resources on exploring novel kinds of problems with different approaches and techniques.

In the sciences, examples include the realisation of Bose-Einstein condensates in Atomic and Molecular Optics (Laudel et al. 2014a), the development of electroencephalography (Borck 2006), the development of monoclonal antibodies (Cambrosio and Keating 1995), and the emergence of new fields described by Edge and Mulkay (1976: 350-402; see also Mulkay 1975 on ‘branching’ as a type of scientific change). In the arts, developments such as academically supported, or “uptown”, minimalism in music could be seen as complementary innovations in that they did not radically transform compositional practices, relationships between composers and performers or performers’ skills throughout the music world (Gilmore 1987, 1988; Ross 2012: 517-547). Similarly, while Alexander Calder’s development of mobile sculptures represented a radical departure from traditionally static art forms, they did not become the dominant form of three dimensional art works (Steinkraus 1982).

Third, *displacement* innovations generate more widespread shifts in dominant problems, approaches and priorities by playing a major role in the establishment of new working practices, kinds of problems and evaluation standards across the field. They typically alter the nature of the skills required of competent practitioners and prevalent conceptions of the field as well as authoritative roles and actors. As with the displacement forms of institutional change discussed by Streeck and Thelen (2005: 19-22), these innovations often involve practitioners defecting from dominant norms and logics of action to promote alternative purposes and frameworks.

The dominance of molecular-biological approaches to studying cancer is an example of such innovations in the sciences (Fujimura 1988), as is the replacement of phlogiston theory of combustion by Lavoisier’s oxygen theory at the end of the 18th and beginning of the 19th century (Perrin 1988). In the

social sciences, the development of modern finance theory as the dominant approach to the study of financial markets in the 1970s can similarly be considered to be a displacement innovation (Whitley 1986a, 1986b). Total serialism, “chance” music and related attempts to transform established neo-classical forms of art music composition and performance after the end of world war II in Europe and the USA can also be seen as displacement innovations insofar as they became the dominant set of compositional practices and aesthetic ideals for the self-consciously avant-garde (Ross 2012: 386-404). The development of bebop as a major influence on the establishment of modern jazz as a distinct form of art music in the mid-20th century is another example of a displacement innovation in music (Brubeck 2002; Gioia 2011: 186-250; Martin 2002; Myers 2013: 30-47).

The Arts and Sciences as Different Kinds of Novelty-driven Fields of Cultural Production

The emergence and success of different kinds of innovations in novelty-producing fields depends on both the level of mutual dependence between participants in the production of novelties and the distribution of authority over goals, standards and the means of novelty production. While the arts and sciences can be understood as communities of practice (Lave and Wenger 1991) whose collective identity is based on members’ production of specific kinds of novelty, they vary in how that production depends on each others’ contributions to collective goals. Three modes of such mutual dependence between community members can be distinguished. They are *functionally* mutual dependent upon each other when artists or researchers depend directly on fellow practitioners’ outputs to produce their own novelties. Levels of *technical* mutual dependence vary according to how much practitioners depend on the collectively created aesthetic/epistemic standards and conventions that govern the practices by which novelties are produced, while levels of *strategic* mutual dependence reflect the extent to which artists/researchers in each field have to follow the collectively developed standards governing how the significance of their outputs is assessed and their contributions are legitimated.

A significant difference between modern scientific and artistic communities concerns the role of practitioners’ outputs in constructing new works. In most sciences, new knowledge is generated collectively by members using each other’s contributions in their own production of novelty. Although the extent to which fellow practitioners’ results are incorporated into, and directly affect, researchers’ goals and practices varies between scientific fields and over time, they must be taken into account by each researcher in the field because novelty is understood as advancing a collective state of the art.

While artistic communities also share standards governing work practices and competences and provide a source of ideas that can be used by members in their own production of novelty, artists’ production of novelty is usually not so directly dependent on what fellow practitioners have done and

are doing. Since they typically address their products to non-practitioner audiences as well as to each other, their production and dissemination of novel works of art often also depend on a variety of intermediaries who frame products as works of art, channel them to audiences, and interpret, as well as construct, demand for cultural products.

Two major sets of authority relations among practitioners and non-practitioners also vary between artistic and scientific fields and over time. The first concern the collective authority of the sciences and the arts over their novelty production, i.e. their relative autonomy as societal subfields of cultural production. A critical condition for artistic and scientific fields to exist as distinctive collective entities of novelty production and dissemination is sufficient collective practitioner authority over aesthetic/epistemic standards for producers to regard their fellow practitioners as important, if not always dominant, audiences for their work and to have to take some account of each others' contributions when constructing their own outputs. While the extent of such authority varies considerably between fields and over time as socio-economic contexts change, it has to be strong enough to ensure that artists and scientists adhere to collective standards in competing for recognition and resources for each one to function as a distinct social system of cultural production.

The second set concerns the distribution of authority over the production of novelty itself, i.e. over standards governing working practices and evaluations of outputs, as well as over the criteria determining access to the means of production among practitioners as well as between practitioners and non-practitioners. In particular, fields differ in the extent to which such authority is concentrated in the hands of adherents to a particular approach and set of aesthetic/epistemic standards or is more shared and decentralised amongst a number of groups and organisations committed to a variety of distinct approaches and interests.

Levels of Mutual Dependence between Practitioners in Different Fields

The arts and sciences can be grouped according to three distinct levels of mutual dependence between practitioners. The most interdependent fields, which combine high levels of functional, technical and strategic mutual dependence, occur in sciences where decontextualized observation, experimentation and theory development proceed on the assumption that practitioners everywhere deal with the same objects using the same observation theories and descriptive vocabulary. In general, this occurs in what Collins (1994, 1998: 532-8) termed "rapid discovery sciences".

He highlighted the development and standardisation of research technologies in a few areas, such as mechanics and mathematics in 17th century Europe, as major factors in the increasing coordination and codification of research practices, which contributed to the institutionalisation of sciences that are

characterised by a high level of consensus among practitioners, genealogies of research technologies and the rapid production of new discoveries that make their predecessors obsolete. The emergent idea of a cumulative science that progresses by partial contributions rather than constructing new universal epistemic systems benefitted from the combination of new ways for researchers to make more precise and formalised descriptions of phenomena and reach some consensus on disputed ideas with a technical apparatus for making new discoveries and so gaining further recognition and symbolic rewards from their peers. By building on a constantly evolving state of the art, scientific communities continuously modify some of their conventions, standards and priorities.

Mutual dependence is lower in most social sciences and humanities. They are more organised around competing theoretical perspectives with a relatively weak consensus throughout the field on basic assumptions and accounts of phenomena and are able to develop only a limited codification of techniques and descriptive vocabularies. While major contributions are usually acknowledged through citations, and colleagues' findings are often taken into account when planning future work as methodological guidance or as providing empirical context for arguments, they are rarely directly incorporated into, and systematically determine, colleague-competitors' work processes and goals. Levels of functional mutual dependence on each other's methods, results and theories typically remain limited in these fields, although practitioners' dependence on peer recognition remains similar to that in the more integrated sciences. Functional interdependence can, though, be considerable within opposing schools of thought that have strongly hierarchical authority relationships.

The extent of mutual dependence in producing and disseminating novelty in many artistic fields tends to be lower than that typical of the social sciences and humanities. As a result, novelties rarely directly steer the nature of fellow artists' work practices and problem formulations in the modern arts, although the use of portable *plein air* materials, such as paint tubes and the retractable French case, by the Barbizon school of landscape painting can be seen as an important influence on the development of the French Impressionist movement (Malafronte 2009). Nor are all artists in a field tightly constrained to follow collective standards of competence and worth to be considered competent producers of artistic novelties. While unorthodox working practices and styles may be relatively easy to develop and gain acceptance among limited groups of practitioners, their widespread adoption as governing standards for the whole field tends to be more difficult to establish.

Levels of technical mutual dependence can be considerable in artistic and scientific fields that produce novelties collaboratively by integrating the work of different highly trained specialists as well as in fields that depend on complex shared technical infrastructure. In some of the performing arts, creators of new works depend on performers who have been trained in advanced specialist skills to present them to audiences. As Rosen (2000: 303) has emphasised, new art music survives if enough musicians insist on playing it, however difficult it may appear to audiences at the time of its premiere. Scientists'

technical mutual dependence is similarly high in many instances of interdisciplinary collaboration, which is largely due to growing specialisation and the need to combine expertise in the production of novel contributions (Laudel 2001). High technical interdependence is also mediated by shared research technologies, and by the work of specialists running these technologies (Knorr-Cetina 1995; Hoeppe 2018).

Levels of Practitioners' Collective Authority in Different Fields

The extent of practitioners' collective authority over artistic and scientific activities varies on a number of dimensions. Three are particularly important in differentiating between fields: a) influence over the standards governing the working practices involved in producing novelties and judging their significance and worth, b) control over the training and assessment of legitimate practitioners' competences, and c) influence over the criteria governing the allocation of human and material resources needed to produce and distribute novelties to audiences. In some fields, collective authority levels may be quite similar on all three of these dimensions, as perhaps in many rapid discovery sciences, while in others they may differ considerably between them, as in the development and certification of skills in different performing arts. Additionally, they may change over time as broader socio-economic conditions alter, as with the expansion of public provision of resources for scientific research allocated through peer review.

For many of the sciences, considerable collective authority over standards has become established through the institutionalisation of peer review procedures governing access to communication media such as journals and to livelihoods and facilities in universities and similar organisations conducting research, albeit with varying degrees of codification and intellectual consensus (Biagioli 2002). This is less so in the arts where artists are more dependent on gaining the support of non-practitioner audiences and the various intermediaries that both control access to them and participate in the legitimation of particular art works as aesthetically valuable.

As Howard Becker (1982) has emphasised, the recognition, dissemination and reward of artistic novelties often involves the cooperation of non-practitioner intermediaries and aesthetically informed audiences with artists in variously organised art worlds that play major roles in establishing, applying and altering dominant aesthetic standards. Such influential audiences can be distinguished in terms of the extent of their knowledge of, and commitment to, aesthetic values and standards. What can be termed strongly aesthetically restricted audiences include closely associated intermediaries, such as gallery owners and managers, critics, curators, impresarios, directors of arts organisations, as well as regular attendees at theatrical, musical and other kinds of performances that collectively "consecrate" (Bourdieu 1993: 120-125) new works as legitimate and significant contributions.

Collective practitioner authority over aesthetic standards is enhanced where strongly restricted audiences combine with producers to play the dominant role in determining the aesthetic worth and significance of art works. In contrast, when novelties are assessed largely in terms of their appeal to aesthetically unrestricted, or mass heterocultural (Crane 1976), audiences that have little interest in, or influence on, aesthetic standards, collective practitioner authority is considerably reduced .

Practitioner control over training and certification programmes has become considerable across most sciences since knowledge production was institutionalised in universities and similar research organisations. This has helped to ensure the continued expansion and specialisation of scientific fields as well as their epistemic insulation from non-practitioner groups and organisations. The level of standardisation of formal training programmes and uniformity of working practices do, though, continue to vary between scientific fields and national educational systems, particularly in many of the social sciences and humanities.

Differences in the extent of collective practitioner authority over the standards governing the training and certification of producers are even more pronounced between artistic fields. After the decline of guild and national academy-based systems of training and certification in many European countries, the education and assessment of skills for most painters and sculptors became more individualised and quite variable in both length and extent of formal evaluation according to common standards. This enabled considerable expansion of the number of producers as well as increasing the variety of working practices and influence of new kinds of gatekeepers controlling access to collectors and audiences (Bourdieu 2017: 106-151; Menger 2014: 131-141; White and White 1993).

In other artistic fields, though, the technical training required for practitioners to become recognised as competent artists is much more extensive and strongly institutionalised throughout the field. Here, extensive preparation is required before artists are able to attract audiences, as in art music and classical ballet, and most producers of new works depend greatly on the aesthetic and performance standards of professional colleagues to gain acceptance for their outputs. Such extensive standardised training also provides opportunities for closely associated means of gaining support such as teaching and involvement in training and assessment organisations, increasing the overall level of mutual dependence to a much greater extent than occurs in painting and literature (Menger 2014).

Collective practitioner authority over the criteria governing resource allocation tends to be greatest in fields where peer review dominates the distribution of both livelihoods and material resources for novelty production and of the means for novelty dissemination to audiences, as in many modern sciences. It is least where resources for producing new outputs are cheap and widely available and dissemination is dominated by large commercial firms seeking to appeal to mass audiences, as in fields generating multiple reproducible art works.

These variations in levels of collective practitioner authority over standards, training and resource allocation across the modern arts and sciences have, of course, been considerably affected by the broader socio-economic conditions in which novelty production and assessment have taken place. An important condition that enabled cultural producers to develop some autonomy from non-practitioner groups and establish their own goals, practices and evaluation standards is the overall level of interest in, prestige of, and support for, the arts and sciences as valued collective creators of cultural products among the general population. In the case of the sciences, engagement with research into natural phenomena has been a legitimate pastime of the wealthy and educated classes in Europe at least since the Renaissance and the work of Newton and others generated considerable prestige for natural philosophers in late 17th and early 18th century Europe (Mokyr 2017: 103-114). Authority over scientific production grew with the separation of scientific from much religious discourse, the creation of chartered associations devoted to science and the expansion of research in new and reformed universities in the 18th and 19th centuries, which became more autonomous in intellectual matters (Clark 2006).

While many scientific communities were able to gain more collective authority over their production processes following their growing epistemic separation from other societal concerns and their increasingly codified internal communication, the interest in, prestige of, and support for the arts depends significantly on the extent of non-practitioners' education, particularly at the secondary and tertiary levels. As national education systems expanded across age groups and economic classes in many European societies in the 19th century, the market for cultural products, particularly popular forms of literature and science (Bourdieu 2017: 142-144; Sheets-Pyenson 1985; Shiner 2001), grew considerably, as did the number of people able and willing to become more closely involved in their development and interpretation.

The further large scale and rapid expansion of higher education in many OECD countries in the second half of the 20th century greatly increased the number of people who were knowledgeable about, and interested in, the arts and sciences (Alexander and Rueschemeyer 2005: 11-15) as well as institutionalising and disseminating authoritative accounts of their histories, current artistic and scientific achievements and dominant conventions governing the production and appreciation of cultural outputs. Universities have become the primary organisations for conducting scientific research and academic researchers dominate the establishment and change of epistemic goals and standards in many political economies. As well as helping to establish the plastic arts, literature, music and other fields as intellectually and socially prestigious activities, at different times and to varying extents in different countries, they have also provided financial support for writers, composers and other artists (Fine 2018: 1-12; Garber 2008; Pasler 2008: 318-362; Ehrlich 1988: 230-2).

Additionally, various forms of public funding for the arts and sciences expanded considerably in many countries between the 1940s and the 1980s (Cummings and Katz 1987). This funding supported not only

higher education institutions and many performing arts organisations but also the expansion of museums and similar sites for displaying, performing and interpreting cultural products, which has helped to reinforce the separate status and independence of the arts and sciences from the wider society. Where governments have involved practitioners in the allocation of such public funding, typically through some form of peer review, as well as supporting the dissemination of new art works and performances on public radio and television stations, this support has further helped to increase collective practitioner authority over aesthetic standards.

In most sciences, states and other providers of large-scale research funding such as foundations have delegated considerable authority over the standards governing resource allocation to practitioners advising national research councils and agencies, albeit to varying degrees in different fields and areas of public policy interests. While such practitioner authority is especially strong for technical standards, it can be more conditioned by state priorities and purposes when establishing significance standards and the criteria governing resource allocation decisions, particularly of course in the case of military-directed research.

For some arts and sciences, commercial interests and funding can limit the authority of practitioners over access to resources and opportunities for novelty production. Particularly in artistic fields where resource allocation depends largely on success in reaching large aesthetically unrestricted audiences, collective practitioner authority tends to be less than that of the intermediary actors and organisations who help to create opportunities for the production of new novelties by organising the demand for art works. Similarly, in a number of scientific fields business groups and organisations became a more institutionalised audience for scientific contributions and funder of research in the 19th and early 20th centuries (Haber 1971; Lenoir 1997; Reich 1985). Although practitioners in most sciences remain the dominant collective influence on priorities, standards, and resource allocation for the production of novelty, commercial interests have contributed to the epistemic priorities of some fields, particularly in the engineering and biomedical sciences (Ciarli and Ràfols 2019; Wallace and Ràfols 2018).

Combining levels of different kinds of mutual dependence with variations in the extent of collective practitioner authority over aesthetic/epistemic standards and resource allocation criteria enables us to distinguish six major kinds of cultural production fields in the arts and sciences. These are summarised in Table 1 where audiences refer to non-practitioner addressees of novelty production/consumers of novel products that vary in terms of their aesthetic/epistemic restrictedness and intermediaries refer to individual and collective actors involved in the assessment, interpretation and combination of cultural products as well as trading them.

Table 1: Mutual Dependence and Collective Practitioner Authority in Different Kinds of Novelty-driven Cultural Production Fields

<i>Kind of field</i>	<i>Level of Mutual Dependence</i>			<i>Collective Practitioner Authority over</i>		
	<i>Functional</i>	<i>Technical</i>	<i>Strategic</i>	<i>Technical standards</i>	<i>Significance standards</i>	<i>Criteria governing resource allocation</i>
<i>Rapid Discovery Sciences</i>	High	High	High	High through peer review	High through peer review	Considerable through peer review; some sharing with state agencies
<i>Human Sciences</i>	Medium to low	Medium to low	Medium to low	Medium through peer review	Medium through peer review	Medium through peer review; some sharing with state agencies
<i>Technology and Policy relevant Sciences</i>	Considerable in highly codified sciences	Considerable in highly codified sciences	Considerable in highly codified sciences; includes audiences	Medium through peer review; shared with audiences	Medium through peer review; shared with audiences	Shared with state agencies and other audiences
<i>Performing Arts</i>	Considerable between complementary highly trained contributors, low otherwise	Considerable between complementary highly trained contributors, limited otherwise	Considerable between highly trained contributors; includes intermediaries and restricted audiences	Considerable when training is lengthy and standardised; shared with intermediaries and restricted audiences	Medium to low; shared with intermediaries and restricted audiences	Low, dominated by intermediaries and restricted audiences; subject to peer review of public support
<i>Single Product Arts</i>	Low	Medium to low	Medium to low; includes intermediaries	Limited; shared with intermediaries and restricted audiences		Low; dominated by intermediaries and restricted audiences
<i>Multiple reproduced Arts</i>	Low	Medium; includes intermediaries and reproducers	Low; includes intermediaries and reproducers	Limited; shared with intermediaries, reproducers and audiences		Dominated by intermediaries and reproducers; limited peer review of public funding allocation

Mutual Dependence, Authority Relations and Innovation

The level of mutual dependence of members of artistic fields and of researchers in the sciences coupled with the extent of their collective authority over standards and resource allocation criteria affect the ways in which the three kinds of innovations are developed in art worlds and scientific communities. In the sciences, high levels of both mutual dependence and collective authority over technical and significance standards pressure producers to respond to legitimate novelties because they affect what fellow practitioners can offer as their own contribution in the future. Although mixed individual responses may result in a period of community-level indecision (Pickering 1980), highly mutually dependent community members must quickly decide how to respond. Fast rejection in particular occurs where either new approaches show no clear promise of leading to new opportunities for novelty production (the 'colour' model in particle physics theory, Pickering 1980), or fail to meet established technical standards and/or challenge well-established theories as in the claims to the discovery of N-Rays (Nye 1980) and cold fusion (Lewenstein 1992), and the first claim to discovery of gravitational waves (Collins 1982, 1999).

New approaches can become accepted and change practitioners' priorities in such fields, however, if they promise to offer new directions and opportunities for colleagues to make highly valued contributions without requiring long term investments for uncertain outcomes. Novel research technologies in functionally mutually dependent fields that are seen to offer considerable potential for developing divergent but highly intellectually productive lines of research, for instance, can form the basis for establishing new areas despite needing extensive retraining and reorganising patterns of collaboration if researchers have sufficient long term institutional and financial support to undertake the necessary investments (Borck 2006; Whitley et al. 2018).

Additionally, we would expect complementary innovations to be more easily developed than displacement innovations in highly mutually dependent fields because they increase opportunities for novelty production without sharply challenging existing practices and authority hierarchies. Thus, novel approaches and technologies that deviate substantially from the dominant ones may eventually become accepted as complementary innovations in such fields, as in the case of monoclonal antibodies (Cambrosio and Keating 1995). Similarly, discoveries that open up new areas for novelty production are readily taken up as long as production processes in these areas adheres to fundamental technical standards, as was the case with radio astronomy (Edge and Mulkey 1976).

Establishing complementary innovations is, though, dependent on the overall availability of resources for novelty production by competent practitioners and the decentralised distribution of authority over technical and significance standards and criteria governing resource allocation. Developing such innovations in strongly mutually dependent fields becomes much more difficult when competition for resources and rewards is intense and authority over the standards used to distribute access to them is highly concentrated.

In fields where levels of mutual dependence and collective authority over technical and significance standards are much weaker, a wider variety of novel contributions to diverse goals are likely to be produced, but their adoption by others will tend to be relatively *ad hoc* and short lived with limited collective integration into coherent aesthetic or epistemic programmes. Weakly integrated artistic and scientific fields are often characterised by a variety of competing perspectives that are organised into separate schools of thought and practice. While innovations challenging a variety of ideals can be more easily developed and diffused amongst small groups of acolytes in these kinds of areas, as in many modernist movements in literature and painting in the early twentieth century, than in more integrated fields with unified authority structures, they are less likely to become widely accepted, incorporated into, and guide the activities of the field as a whole (Kovalevsky 2014; North 2013). They will struggle therefore to become the dominant approach for all competent practitioners pursuing careers in each field. This is especially so if they require learning new techniques and working on new kinds of problems for uncertain outcomes that are difficult to evaluate. Furthermore, as Crane (1976) has suggested, low levels of collective practitioner coordination and commitment to common standards and goals can often generate a succession of fads and fashions by fragmented and disconnected producers, especially when supported by ready access to material rewards and fickle consumer tastes.

Innovations that lead to more substantial changes in artistic and scientific conventions can, though, become established in fields with limited levels of mutual dependence when they are supported by collectively organised and directed social movements. To the extent that such movements seek to displace established authority relationships and ideals as well as changing working practices and norms governing the evaluation of artworks or scientific contributions, they sometimes follow similar strategies to social movements in politics (Accominotti 2009; Baumann 2007; Collins and Guillen 2012; Frickel and Gross 2005). Examples of intellectual movements in the sciences promoting innovations include the promotion of neural computing in the 1980s (Guice 1999) and the current movement promoting the sonification of scientific data (Supper 2011). Both cases illustrate their association with low levels of mutual dependence because they occur in a weakly integrated field (information technology in the case of neural computing) or across several disciplines (the sonification of scientific data).

These effects of differences in levels of mutual dependence and collective authority on innovation development are reinforced or weakened by the nature of practitioners' relationships with authoritative external actors. These connections are less epistemically important in sciences where such actors' influence on novelty production and direction mainly concerns technological innovations for commercial purposes, although they can be more significant in scientific fields where practitioners' authority over significance standards and the criteria for allocating resources is less strongly established. In the arts, on the other hand, different kinds of relationships with intermediaries and audiences that vary in their aesthetic commitments create contrasting conditions for developing different kinds of innovations.

In art worlds where non-practitioner intermediaries, such as dealers, critics, publishers, impresarios and managers of performing arts organisations, and aesthetically restricted audiences are involved in the framing of the meanings of art works and play an important role in the allocation of symbolic and material rewards, unusual and challenging novelties that promise to advance common purposes can become complementary or displacement innovations, even if they demand some further learning and appreciation of unconventional approaches over time. The growth of university music departments in the USA, for example, helped to support a number of innovative composers developing new musical languages in the mid-to late-twentieth century by expanding the size of knowledgeable audiences and providing student performers as well as some jobs (Dowd et al. 2002; Gilmore 1988; Meyer 1994: 323-324; Pasler 2008: 318-362; Ross 2012: 434-442).

In contrast, the more dependent artists become on non-practitioners controlling access to large and culturally diverse audiences, the more difficult it will be to gain acceptance for novel means of expression that deviate significantly from everyday language and conventions. This is especially so in fields where there are considerable economies of scale in the marketing and distribution of reproducible artworks to mass and culturally diverse audiences and commercial interests are likely to dominate those of artistic communities (Crane 1976; Menger 2014: 179-187). In such areas, innovations based on aesthetic ideals and performance standards that deviate substantially from and challenge existing modes of expression and conventions are unlikely to be supported or welcomed, particularly if vertically integrated oligopolies dominate access to audiences, as in the film and record industries for some decades in the 20th century (Parkinson 2012: 81-110; Peterson and Berger 1975; 1996). While a variety of new means of expression and aesthetic ideals remote from everyday experiences may be developed by a number of practitioners in new markets for novel reproducible works, such as Eisenstein, Pudovkin and other Russians, Dadaists and the surrealists in the early days of the cinema (Cousins 2011:103-112; Parkinson 2012: 50-80), they tend to remain relatively restricted to a small group once the field as a whole becomes, and remains, dominated by oligopolistic firms focused on reaching heterogeneous mass audiences.

The roles of mutual dependence and collective authority in the development of innovations in art worlds and scientific communities are further affected by how these connections to external actors are organised, particularly the extent to which they impinge upon their “protected space” i. e. the period of time for which practitioners have control over the use of human and material resources to pursue particular problems without suffering severe reputational and career consequences (Whitley and Gläser 2014: 8; Whitley et al. 2018). For example, in fields where authority over both the recognition of legitimate novelty and resource allocation is shared between diverse groups and organisations that have different priorities in addition to the overall level of resource provision not being tightly constrained, the strength of mutual dependence between practitioners is reduced, increasing opportunities for practitioners to develop a wider variety of innovations, some of which may deviate considerably from dominant standards and ideals.

Conversely, where authority over resource allocation, training and dissemination of cultural products is more concentrated, such heterodox challenges are unlikely to become institutionalised as legitimate forms of expression and the basis for future work, let alone widely communicated throughout the field. As Bourdieu (2017: 109-135) and others (e. g. White and White 1993) have emphasised, the academic regime governing painting in post-revolutionary France integrated the selection and training of legitimate artists with the display of their works in state organised salons and the award of prizes, commissions and other rewards around particular aesthetic standards in such a way that unorthodox paintings were simply denied any legitimacy as art works.

The diversity of resource providers’ interests and of authoritative actors able to legitimate different kinds of cultural contributions is additionally likely to facilitate the institutionalisation of unorthodox approaches and ideas as complementary innovations rather than their rejection as unproductive and incompetent novelties. It can also enable producers and their supporters to organise themselves as social movements promoting new kinds of practices and aesthetic or epistemic priorities, as in the cases of some changes in the environmental sciences, the support of DARPA for neural computing, and allies of the “salon” cubist artists in pre-WW1 Paris (Cottingham 2004; Cox 2000; Frickel and Gross 2005; Guice 1999; Sgourev 2013).

The importance of being able to access resources and the necessary means of dissemination of outputs from a diversity of actors and organisations for the development of radically disparate forms of expression and their acceptance by sub groups of artists and associated supporters is illustrated by some changes in art music in the twentieth century, particularly after the end of the second world war (Glock 1991; Meyer 1994; Ross 2012; Rupprecht 2015: 94-109). Here, university music departments, public radio organisations such as the BBC, various public agencies and private supporters, amongst other groups and institutions in different countries, provided opportunities for composers and performers to develop new ways of writing and performing music and disseminating their results to

audiences, sometimes publicly celebrating their lack of appeal to traditional concert goers. In the development of the influential Darmstadt summer schools for new music, for instance, Ross (2012: 383) has suggested that:

”Darmstadt and similar organizations were wholly subsidized by the state, the city, and the Americans. They had no obligation to a paying public. Meanwhile, ‘classical music’, in the pejorative sense of performances of well-known opera and symphonic repertory, carried on as it had during the Nazi period with many of the same star conductors in charge.....So there was, on the one hand, a classical establishment that eluded denazification, and, on the other hand, an avant-garde establishment that opposed itself so determinedly to the aesthetics of the Nazi period that it came close to disavowing the idea of the public concert.”

This case highlights the important role of public subsidies and other forms of support for many cultural activities in enabling the development of radically novel approaches, skills and practices, especially in much of continental western Europe after 1945. In many fields the allocation and administration of these resources was influenced more by artists anxious to distinguish themselves by generating unorthodox approaches and aesthetic frameworks than by the need to appeal to paying audiences. While not usually displacing established aesthetic conventions, such practitioner-influenced support helped to expand and reinforce the authority of avant-garde artists and their allies over the direction of future work.

These connections between different kinds of fields, the diversity of influential external actors and interests and the development of different kinds of innovations are, of course, conditioned by the overall availability of human and material resources for producing and disseminating cultural artefacts. In general, expanding the of resources and rewards for innovators relative to the number of competent producers reduces the intensity of competition for recognition and opportunities to continue the production of novelty and so can be expected to increase the level of toleration of non-mainstream and disparate approaches and techniques.

The impact of such expansion on the development of unorthodox novelties into significant innovations is, though, ambivalent. On the one hand, it facilitates their establishment as legitimate complementary innovations rather than rejecting them totally as threats to dominant standards and practices. On the other hand, it reduces pressures to develop approaches that will be adopted by fellow practitioners and so the likelihood that any particular novelty will become a widely accepted innovation is reduced or left to popular demand. In the extreme case, where material rewards for cultural novelties become available for such a wide range of different kinds of outputs that they dominate the standards governing the allocation of symbolic rewards almost any novelty that attracts the attention of collectors and their

advisers seems to be able to become legitimated and rewarded as an innovation, as perhaps has happened in much of the contemporary art market (Crane 1987; 2009).

These relationships between levels of mutual dependence, collective practitioner authority and socio-economic conditions and the development of different kinds of innovations in cultural production fields are summarised in Table 2. Many novelties become drift innovations as long as they meet established aesthetic/epistemic standards and contribute to collective goals, but in fields with weak levels of mutual dependence these will tend to be limited in their diffusion and not adopted throughout the field. This is particularly likely when some authority is shared with external actors and a variety of non-practitioner audiences are influential in assessing the merits of contributions and allocating resources.

Table 2: *Mutual Dependence, Authority and Innovation*

<i>Kind of Innovation</i>	<i>Level of Mutual Dependence</i>	
	<i>Limited</i>	<i>Substantial</i>
<i>Drift</i>	Considerable, but with limited range of adoption	Considerable for novelties meeting established standards and contributing to collective goals
<i>Complementary</i>	Considerable if supported by aesthetic/epistemic movements with ready access to resources when collective practitioner authority is considerable and decentralised	Considerable if they offer high potential for valued novelty creation and collective practitioner authority is high and decentralised
<i>Displacement</i>	Limited but possible when supported by strong aesthetic/epistemic movements and by authoritative restricted audiences	Limited unless they offer clear potential for highly valued novelty production when there are sufficient resources to support the transformation of practices
<i>Likelihood of developing different kinds of innovations</i>		
<i>Likelihood of fads (short term enthusiasms)</i>	Considerable when practitioners have ready access to resources and material rewards and there are diverse sources of authority over standards	Limited unless some authority over significance standards and resource allocation criteria is shared with a diversity of external actors

The development of more deviant and unorthodox novelties as complementary innovations is more dependent on their supporters gaining access to the resources needed to demonstrate their merits and valuable contribution to widely shared priorities, especially their protected space. This depends in turn on collective practitioner authority over the standards governing resource allocation and the dissemination of contributions being considerable and decentralised to different groups pursuing a variety of goals, problems and approaches rather than being dominated by adherents to a single conception of the central problems, approaches and technical standards of the field.

While in strongly mutually dependent fields the main criterion for establishing complementary innovations concerns their expected potential for enabling practitioners to make highly valued contributions to collective goals, the support of strong aesthetic/epistemic movements is often an important factor in establishing unconventional approaches as valid innovations in less mutually dependent fields. Highly authoritative and closely allied non-practitioner audiences are also significant sources of support in the development of complementary innovations in these kinds of fields, especially when they include powerful intermediaries.

Establishing displacement innovations is more difficult but is possible in fields with limited degrees of mutual dependence if they are supported by strong aesthetic/epistemic movements with access to substantial human and material resources and by non-practitioner intermediaries and closely linked restricted audiences that collectively play an important role in determining and applying aesthetic/epistemic standards. In a number of cases, technological and broader socio-economic changes have also helped to institutionalise displacement innovations by aiding the construction of new kinds of influential audiences for their outputs, as in the cases of modern finance theory in financial economics and bebop music in the development of modern jazz (Gioia 2011; Myers 2103; Whitley 1986a, 1986b).

In more mutually dependent fields, displacement innovations are unlikely to become established unless they are widely seen to offer high potential for producing valued novelties that make significant contributions to dominant collective goals. Their development also depends on practitioners being able to access the necessary resources to invest in learning new knowledge and skills, especially their own time and protected space to acquire the new competences needed to continue as recognised practitioners. Additionally, it is important that collective practitioner authority over aesthetic/epistemic standards and dissemination channels is high and not monopolised by a single approach and set of technical competences.

The Impact of Changing Conditions Supporting the Arts and Sciences on Patterns of Innovation

Many of the conditions that supported the expansion of artistic and scientific activities in OECD countries since the 1940s have changed considerably over the past three or so decades, albeit to different degrees and in different ways in different political economies. As well as the rate of growth of public support of the arts and sciences levelling off or reducing relative to the number of competent practitioners, there have been substantial changes to the ways that such support has been provided and the nature of the dominant institutions governing the organisation and assessment of these activities, especially those conducted largely in universities.

Changing Conditions in the Sciences

Considering first the major changes in the funding and governance of research undertaken primarily for published contributions to scientific knowledge, these can be summarised as four main shifts (Whitley, 2014). First, the ability to conduct academic research has become highly dependent on researchers' gaining extra-mural project funding that is allocated through peer review in an increasingly competitive environment. This competition for project finance is reinforced in some countries by universities and other public research organizations using the amount of money thus raised as an indicator of employee quality and high performance, and so affecting their reward and promotion policies. As a result, researchers' priorities are becoming more and more subject to the preferences of scientific colleagues who advise funding councils and help to set their intellectual priorities. These peer reviewers' growing authority over resource allocation and reputations is often further enhanced by their involvement in the *post facto* evaluations of the research performance of groups and institutes that many states have established in recent years, especially where these are organised on a disciplinary basis (Martin and Whitley 2010; Morris 2010; Whitley and Gläser 2007), as well as by the increasingly common institutionalisation of regular performance reviews within universities and institutes.

Second, the selection of publicly funded projects is also being increasingly overtly steered by state ministries and agencies towards contributing to governments' goals that may well conflict with disciplinary priorities. At the same time, then, as peer-reviewed project financing of research by state agencies is increasing the direct influence of scientific community priorities, it also enables ministries and agencies to affect - at least in principle - the kinds of work that are supported and thus their authority over research priorities. Additionally, many governments are pressing universities and state research institutes to contribute more directly to their socio-political goals as they establish targets and key performance indicators for evaluating their efficiency and effectiveness, as well as mission-based

contracts and similar steering mechanisms (Jongbloed et al. 2018; Regini 2011b; Wright and Orberg 2009).

Third, many governments have both reformed the governance of universities and state research institutes to increase the authority and responsibilities of central managerial roles and compelled them to compete more intensively for public and private resources and scientific reputations as distinct organisations. Deans, presidents and rectors have become more influential over resource allocation, the direction of research programmes and personnel decisions, usually at the expense of the senior academics directly involved in leading research institutes (Bleiklie and Michelsen 2013; de Boer et al. 2007; Meier and Schimank 2010; Muller-Camen and Salzgeber 2005). Senior managers sometimes initiate *ad hoc* peer reviews to inform and legitimise their decisions, which further strengthens the influence of scientific communities on research content.

Finally, commercial interests, broadly understood, have gained increasing legitimacy and authority over research priorities and programmes. While some of the growth of technology transfer offices may have been more a response to public incentives for them than derived from business demand (Kruecken 2003; Kruecken and Meier 2006), and much research commercialisation through patents and new firm formation has generated limited financial returns for universities (Mowery et al. 2004; Regini 2011a), pressures to increase the direct economic benefits generated by academic research have increased the authority of those representing commercial interests in the setting of research priorities and guiding academic careers.

As a result of these changes, many researchers are confronted by conflicting pressures and opportunities. On the one hand, they increasingly have to share their authority over research goals with a range of actors pursuing a variety of interests, many of which have developed strong expectations concerning research goals and are using their control of funding to exercise authority accordingly. On the other hand, the diversity of actors and organisations providing financial support may enable scientists to circumvent the priorities and judgements of established scientific elites and so pursue research strategies that deviate from mainstream intellectual goals as understood by those elites. Additionally, of course, extra-mural authoritative actors may well pursue contradictory objectives, as when governments encourage universities to become “excellent” in terms of their intellectual reputations and rankings at the same time as urging them to contribute to policy goals that may conflict with current international scientific elites’ priorities.

Limiting the rate of growth of public funding for research, and/or reducing it relative to the number of competent researchers bidding for project finance, increases the intensity of competition for the resources necessary for continuing to pursue a scientific career. While this is especially so for the experimental sciences, it is also the case for many fields that rely on university facilities as these become

scarcer or inadequate as a result of reduced state funding of universities' recurrent budgets in periods of high student recruitment. Such increased competition heightens scientists' dependence on peer reviewers' evaluations of their contributions to collective intellectual goals and the importance of proposed projects for the advancement of the field in terms of current priorities and epistemic standards.

Particularly in the more mutually dependent sciences, this seems likely to narrow the scope of new projects to those that can reliably be expected to produce publishable results in the usual two to four year project cycles and to limit the level of support for wider ranging projects with more uncertain outcomes, especially if these require major resources and the development of new skills and techniques. This makes displacement innovations less likely because projects establishing radically novel approaches with early adopters would only gain support if there is a strong promise of new opportunities for novelty production in the very near future. The same applies to complementary innovations that could form the basis of new scientific specialties or sub disciplines that involve the development of novel research technologies, skills and the creation of new posts.

The impact of growing dependence on short term project finance on scientists' willingness and ability to investigate complex problems that require long term investment in developing new skills and technologies with uncertain outcomes is being reinforced by the institutionalisation of research evaluation systems in many countries, together with the introduction of performance based funding of universities (EUA 2017; Whitley and Gläser 2007). Particularly in sciences where major contributions depend on the continuing involvement of senior researchers and long stretches of uninterrupted research time, these pressures from funding bodies, employers and state agencies for generating publishable results in the short term can be expected to discourage many from undertaking such projects. While this effect may be most noticeable in the humanities and social sciences, it can also appear in parts of experimental physics and mathematics (Gläser et al. 2010; Laudel et al. 2014a), while being less marked in fields where problems are more readily modularised into 'doable' subunits that can be undertaken by groups of less experienced scientists (Fujimura 1988; Laudel et al. 2014b).

To some extent, the growing willingness of governments to pressure researchers to contribute to public policy goals and steer the allocation of project grants accordingly can be expected to broaden the range of problems studied beyond current disciplinary priorities, especially if substantial amounts of money are committed over the medium to long term, and projects involve the use of skills and knowledge from a variety of different fields. Similarly, the combination of closer and more formalised involvement of private companies in developing research programmes and the institutionalisation of novel modes of technology transfer between scientists and business interests, as in many biomedical fields, is likely to constrain the level of mutual dependence between researchers within established disciplines and support the development of innovations that contribute to extra-disciplinary epistemic objectives.

Such initiatives may well increase the diversity of intellectual objectives and support for complementary innovations when they provide substantial resources over long enough periods to constitute viable career paths for scientists contributing to novel goals, as has been the case with international large-scale student assessments in Germany (Gläser et al. 2014). However, while some researchers may use policy focused funding that is not seen as supporting epistemically valued research programmes to complement their current activities in the short term, such support is unlikely on its own to lead to the establishment of new specialisms and careers focused on governmental priorities.

Overall, the combination of increasing reliance on highly competitive project funding, growing financial pressures on universities, active state steering of publicly funded research projects towards public policy priority areas and strong research evaluation systems that regularly assess individual and university performance and affect the distribution of resources, is likely to shorten and standardise production cycles for novelties and to increase mutual dependence in the sciences. Since this trend is unlikely to be compensated by an increasing diversity of financially backed external epistemic interests, it is likely to discourage researchers from studying problems that involve long term commitments, costly apparatus and developing new kinds of skills that do not appear to contribute to current priorities and may in fact conflict with them. In recent years this seems to have occurred in the Netherlands where experimental research in evolutionary developmental biology has largely ceased, especially that involving new model organisms, and the number of groups pursuing projects on Bose-Einstein Condensates in atomic and molecular optics has greatly reduced (Laudel et al. 2014a; Laudel and Weyer 2014).

Changing Conditions in the Arts

Turning next to consider the nature of recent changes in the socio-economic context of the arts and their likely impact on the development of different kinds of innovations in different fields, while some of the shifts in state cultural policies have been similar to those implemented in the sciences and higher education, and can be expected to have some similar consequences, they have been accompanied by other changes that have variously affected innovation processes in different political economies. These include shifts in the size and nature of audiences for new artworks, changes in the ways that artworks are acquired by intermediaries and distributed to audiences, and the increasing significance of formal training programmes for neophyte artists in many fields and countries.

Considering first changes in the level of public support for the arts over the past half century, it is important to note that the amount provided has typically been considerably lower than that for the sciences, has varied greatly in how it has been allocated to different actors, such as active artists and

cultural institutions, has variously involved artists' associations and individual producers, and been granted for different periods and under different conditions in different countries (Cummings and Katz 1987). The size of the reductions in this support since the 1980s has also varied considerably, particularly between many Anglophone societies and those in western and Nordic continental Europe, although since the 2007-8 financial crisis some more substantial cuts have been made in a few continental states (Sevanen and Hayrynen 2018).

Similarly, despite the widespread adoption of much New Public Management rhetoric, the extent to which shifts in state cultural policies have led to substantial changes in how public support is provided for the arts and in the organisation, priorities and activities of cultural institutions continues to vary considerably between nation states (Belfiore 2004; Burns and van der Will 2003; Gray 2007; Jenkins 2009, Shin et al. 2014; Zahner 2018). In particular, the scale of reductions in public support and the effects of neo-liberal policies and priorities on artists' activities and institutions have been more marked in Anglophone societies where market forms of socio-economic coordination and resource allocation have been preferred for some time (Alexander and Rueschemeyer 2005; Kleppe 2018; Zolberg 2000).

To the extent that substantial cuts in state support for the arts have been accompanied by continuing demands for them to contribute to public policy priorities, to attract larger and more diverse audiences, to gain more private funding, and by allocating funding on a more contingent, performance-based set of rules focused on short term projects, we would expect the collective authority of artists and their art world allies to decline (Alexander and Bowler 2014). In particular, their ability to establish and implement the dominant standards governing the allocation of resources and assessment of the aesthetic value of new innovations seems likely to weaken relative to that of traditional intermediaries and/or emerging actors such as marketing consultants, administrators and fund raisers. As a consequence, these changes are also likely to reduce the level of mutual interdependence between artistic producers as well as the rate at which, and extent to which, new innovations become recognised and adopted throughout artistic fields.

In addition to state cultural policies changing in a number of countries, the size and characteristics of audiences for many art forms have shifted considerably over recent decades as higher education systems expanded rapidly, more artistic fields have become entrenched in universities and other higher education institutions – both as objects of study and as training programmes for producers – and as distribution systems for new art works have enabled multiple copies to be disseminated more quickly and more widely (Ake 2002; Fine 2018; Freeman 2014; Pasler 2008; Thompson 2012). The increasing demand for cultural products has been accompanied by the increasing expansion of producers, often certified by tertiary education institutions, and the weakening of traditional distinctions between the “fine” arts, their controlling elites and aesthetically restricted audiences, on the one hand, and mass

produced entertainment products distributed to large scale heterocultural audiences across the world by oligopolistic companies, on the other hand. Just as audiences for mass entertainment products have become more differentiated with the development of sub-markets for more complex and demanding works, so too audiences for artworks have become more varied in their tastes, competences and aesthetic ideals, and less dominated by established art world elites (Schmutz and Dowd 2018; Shiner 2001; van Venrooij and Schmutz 2010).

This weakening of aesthetic authority exercised by leading artists and their art world allies has become especially marked in markets for unique art works, such as paintings and sculptures. Here, the combination of long periods of economic growth in many countries and regions and consequent increase in the number of highly wealthy people, expansion of contemporary art museums across the world, and of newly trained and certified artists created by an increasing number of institutions offering programmes and qualifications in art work production (Crane 1987: 2-9; Fine 2018; Singerman 1999) has intensified the pursuit of novelty as more and more artists seek to distinguish their work and gain recognition from increasingly commercialised audiences, gatekeepers and collectors (Cottingham 2013: 87-96; Robertson 2016: 125-152; Shiner 2001: 269ff). It has also generated a corresponding efflorescence of new curatorial, interpretative and consecrational roles for ordering and disseminating the mass of new works – often populated by academically certified experts including academic staff seeking to differentiate themselves by identifying the next new thing - reducing the collective authority and mutual dependence of artists while enhancing the influence of the increasing number of intermediary roles.

In particular, the expansion of the international market for both artists and collectors in Asia, the growing importance of very rich mega-collectors in the market for contemporary art, the establishment of new locations and formats for displaying and selling works and the rise of art funds as collective investment vehicles for acquiring and trading art works purely as financial assets have both altered the distribution of authority over aesthetic standards and reputations between variously informed actors and increased the overall influence of market actors on evaluations of aesthetic merit and artists' priorities (Crane 2009; Lee 2018). Whereas galleries, critics, museum curators and fellow practitioners were the major actors influencing the primary market for new works and constituted the most important audience for artists in the postwar New York art world (Crane 1987), over the past three decades or so art fair organisers, auction houses, art fund managers and very rich collectors have become much more significant actors in the “globalised” market for contemporary art and come to form a more significant audience for many artists.

According to Crane (2009), this shift is associated with the rise of artist-entrepreneurs such as Damien Hirst, Jeff Koons and Takashi Murakami who are more concerned to establish their unique “brands” as conceptual artists directing the activities of many assistants constructing their works than to personally

create aesthetically innovative products primarily for the appreciation of fellow artists and their art world allies. Many of their works draw on images and themes prevalent in the mass media and popular cultures and are relatively easy to appreciate by large audiences who are unfamiliar with, and uninterested in, the aesthetic judgements and conventions of established art worlds. As a result, art world rankings of artists' aesthetic statuses have come to diverge substantially from their financial success at auctions and other trading venues (Lee 2018; Quemin 2018; Shin et al. 2014).

In artistic fields where multiple copies of artworks are reproduced and distributed to large audiences, such as literature, a significant change in their production, distribution and evaluation has been the rapid increase in the size and heterogeneity of audiences for new works and the rise of large conglomerate firms dominating the publishing industry (Thompson 2012). At least in the Anglophone world, new books have become produced, marketed and distributed in both hardback and paperback editions to large numbers of readers much faster since the 1970s, using techniques and strategies adapted from mass retailing sectors. The effective merging of hardback and paperback editions and massification of initial markets for new books has reduced the length of their product life cycle, stimulated an enormous growth in the number of books published and greatly enhanced the rewards gained by the relatively few authors producing best sellers.

It has also weakened the cohesion and aesthetic authority of established networks linking authors with publishers, critics and aesthetically informed readers as editors and owner/managers of small to medium sized publishing businesses have had to share decision making authority with both the executives of large conglomerate firms owning several brands and the increasingly important literary agents. Agents in particular have become much more central actors in the selection and promotion of authors and their works as influential gatekeepers connecting writers to publishers. Just as the large conglomerates controlling the acquisition and dissemination of large numbers of new books to large audiences have become focused on finding and selling "big books" that attract the largest number of buyers in the short term, so too the dominant firms of agents devote most attention to authors and books that promise to reach mass sales relatively early and can gain the largest advances from publishers (Thompson 2012: 62-140).

Although backlists of books published in previous years remain important sources of income for both publishers and authors, they have become less significant in recent decades and publishers' willingness to invest in innovative new works that seem likely to take some years to become appreciated by a large readership is less than it used to be. While not necessarily discouraging the publication of books that deviate significantly from established forms of expression and dominant literary conventions, then, these changes are likely to restrict the enthusiasm of agents and publishers for works that are expected to be slow to achieve widespread acclaim. Additionally, it has become more difficult for editors to justify

investing in aesthetically interesting books that are unlikely to gain significant marketing and sales support from their employers.

In the performing arts, reductions in public subsidies of performances and new works directly impinge upon artists' independence from commercial pressures and ability to develop radically unconventional innovations that are not appreciated by lay audiences. While private sponsorship and support can substitute to some extent, especially where it is encouraged by tax incentives, this is often difficult to rely upon over long periods and tends to prefer works that appeal to wide audiences, as was shown by General Motors' withdrawal of support for radio concerts by Stokowski and the NBC orchestra that included new works by Schoenberg and other contemporary composers (Ross 2012: 288-290). Even when new works are commissioned by performers, radio stations and music societies, it is often difficult for composers to gain subsequent performances and so wider acceptance of their merits, particularly if they are seen as stylistically "foreign" and deviant as in the case of Lutyens' *Motet* with words from Wittgenstein's *Tractatus* (Rupprecht 2015:39-45).

Because of the costs involved in performing new works, especially in fields such as art music where performers are highly trained, increasing dependence on box office receipts is likely to inhibit frequent performances of highly novel and unconventional contributions, not least because of the extra rehearsal time usually required. Since the lack of continuing exposure to such works means that audiences have fewer opportunities to learn more about them and perhaps come to appreciate their novel qualities, particularly at times when more music was experienced live than from recordings (Rosen 2000: 306-318; Rupprecht 2015), artists are not likely to devote a great deal of time and effort to creating them without commissions and/or subsidies. Many new works produced for a particular occasion or private commission can fail to become widely disseminated simply because they are insufficiently attractive to performers and audiences to gain repeated performances. This is even more so for the more innovative ones that demand more rehearsal time and exposure to audiences, as in the case of some of Elliott Carter's orchestral works (Rosen 2000: 283-293).

The development of the Internet, satellite broadcasting and similar technological changes have enabled the establishment of new distribution channels for many arts organisations to reach much larger audiences and potentially raise additional funds through ticket sales, subscriptions and other means. However, this will not necessarily encourage them to commission and perform unconventional new works that could deviate substantially from that audiences' expectations, not least because those expectations are likely to be more varied and changeable than their regular audiences' tastes and commitments. Depending on income from such distribution channels to pay for substantial investments in learning and performing, commissioning radically different kinds of works would be regarded as unnecessarily risky for many organisations.

The large-scale streaming of recorded music, such as popular songs, that is mostly paid for by advertisers also seems unlikely to encourage aesthetic diversity and innovation. Most such firms are more concerned to attract listeners by providing music that appeals to their current tastes and keeps them connected to the service than challenges them with unusual innovations. Where record companies and performers are paid according to the number of people listening to the first 30 seconds of each track, as apparently is the practice at Spotify (Eriksson et al. 2019), they will be more encouraged to produce numerous short, intense and immediately attractive material than to create longer and more unconventional pieces that require sustained attention to become appreciated (Krukowski 2019).

The more that states make their support of the arts dependent on artists and organisations achieving short term performance targets, involving private organisations and diverse audiences and allocating resources to specific projects rather than longer term funding, and the stronger the influence of markets that value novelty above all becomes, the less likely innovations of all three kinds will develop. Shortening cycles of novelty production and sales-oriented markets constrain opportunities for artists to develop radically novel artworks that require audiences to invest considerable amounts of time and other resources in learning new aesthetic conventions and forms of expression. This is especially so in the performing arts where both performers and audiences often need to perform and experience unorthodox new works repeatedly if they are to become accepted as worthwhile innovations. At the same time, the increasing demand for art works and the shift of authority over what counts as art to intermediaries constrains the collective authority of practitioners over aesthetic standards and thus their interest in collectively changing their practices.

Concluding Remarks

This discussion of relationships between socio-economic conditions, levels and modes of mutual interdependence between cultural producers in artistic and scientific fields and the development of different kinds of innovations has highlighted a number of points about how changes in the socio-economic contexts of these fields can affect innovation development in different arts and sciences. First, it is important to distinguish between the production of novelties in cultural production systems that simply differ from what has gone before from developing innovations that alter the ways artists and scientists work and/or their collective technical standards and/or their aesthetic/epistemic priorities and ideals. As novelty-driven fields of cultural production, the modern arts and sciences generate a continuous stream of novel contributions but many, if not most, do not become innovations that affect established practices, problems or purposes. Such innovations differ not only in how they deviate from established practices and purposes but also in the degree to which they change practices and competences of practitioners throughout entire fields.

Second, the ways that novel contributions can become innovations varies between artistic and scientific fields with different levels and modes of mutual dependence and distributions of authority. High levels of functional mutual dependence between practitioners imply the direct incorporation of productive new results, ideas and approaches into each others' practices and so their relatively swift and significant adoption. However, this depends on novelties fitting into established programmes and conforming to dominant standards such that they are widely expected to enable the production of further highly valued contributions by solving important problems and providing new opportunities for aesthetic/epistemic success. Weaker degrees of mutual dependence may be less restrictive of unorthodox and diverse novelties, but the impact of such contributions will be less direct and transformational.

Third, such mutual dependence depends on each artistic and scientific field developing some autonomy from external authoritative actors and establishing some collective authority over aesthetic/epistemic standards and priorities. This in turn reflects broader conditions governing the production and evaluation of cultural products, particularly the overall level of prestige of, and support for, the arts and sciences in a society. The greater these are, the more fellow artists and scientists constitute the primary audience for contributions and the more novelties have to follow their collective standards and advance their goals to become significant innovations.

Fourth, increasing the diversity of authoritative actors and interests influencing aesthetic or epistemic standards and the priorities governing resource allocation can encourage a greater variety of contributions and support the development of unorthodox innovations that deviate significantly from established community purposes. However, such support would have to be both substantial enough and last for at least a generation of researchers to become a credible basis for successful careers if it is to lead to significant complementary innovations being established. Where, on the other hand, such diversity of interests becomes so extensive and substantial that it significantly reduces the collective aesthetic or epistemic authority of artistic/scientific communities over standards and goals, mutual dependence within fields can be expected to decline and contributions become more developed by fragmented and shifting subgroups oriented towards a variety of separate actors and interests.

Finally, the more that such changes prioritise short term success in gaining attention and support, the less likely highly complex and unusual outputs will be developed and become recognised as significant innovations if they require extensive and repeated experiencing to be understood and appreciated. Whether because of shifts in public funding policies, intensified competition for prestige and resources, increased frequency of consequential evaluation cycles for individuals and organisations, and shortening of product life cycles for market-dependent contributions, the acceleration of novelty production in the arts and sciences can be expected to favour incremental innovations over more unusual ones requiring longer periods of time to be developed and appreciated by both practitioners

and non-practitioners. The creation of substantial innovations in novelty-producing fields seems to be turning into the privilege of a relatively small elite that is secure in its career and reputation, thereby diminishing the diversity of sources of innovation. While policy makers, funding agencies and community elites may endeavour to encourage longer term investments of time and costly resources to deal with complex problems that have highly uncertain outcomes in the sciences, it is unclear whether such coordinated efforts are feasible in many of the arts.

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