



Introducing ethical theory to the triple helix model: Supererogatory acts in crisis innovation

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ARTICLE INFO

Handling Editor: Dr Stelvia Matos

Keywords:

Triple helix
Crisis
Ethics
Supererogation
Micro-relations

ABSTRACT

Triple Helix has been widely discussed as a means of enabling innovation and economic development. Yet, despite the presence of a considerable corpus of literature, little is known about its functioning during times of crisis and the ethical dimensions of the relationships between the individuals of which it is comprised. This study addresses this gap through examining the interoperation of university, industry and government to respond to a social and economic emergency.

Drawing upon the ethical theory of supererogation and evidence from three projects to innovate and develop medical devices, the paper makes important observations. First, the interoperation of Triple Helix appears perdurable under crisis conditions. Second, the micro-relations between individual actors enabled the ideation of new devices, the identification of resources and the minimisation of bureaucratic obstacles. Third, the micro-relational behaviours manifested as supererogatory acts between individuals. Collectively, these findings contribute to our understanding of Triple Helix beyond steady-state conditions and introduces an ethic-theoretical dimension to its examination that characterizes the nature of micro-relations between institutional actors.

1. Introduction

The Triple Helix model of innovation, along with its multi-Helix progeny (Bhattacharjya et al. 2023; Sumarto et al., 2020; Steenkamp 2019; Hoglund and Linton 2017; Miller et al., 2016; Lew et al., 2016), has emerged as a dominant concept within the literature. It has been widely promoted as a mechanism by which nations can build and maintain innovative economies and thereby generate greater economic benefits (Bartoloni et al., 2022; Zhang et al., 2019; Sá et al., 2019; Ranga and Etzkowitz 2010; Etzkowitz 2002, 2003, 2008; Johnson 2008; Razak and Saad 2007; Marques et al. 2006; Schartinger et al., 2001; Nieminen and Kaukonen, 2001; Martin 2000; Etzkowitz and Leydesdorff 1995). Meanwhile, among the Triple Helix innovation actors, it is believed that university is a leading innovator (Etzkowitz, 2008, 2012), and its capabilities provide an important foundation to the resource and coordination mechanism within a region (Liu and Huang 2018). Through the alignment and efficacious operation of university, industry and

government (the three strands of the Triple Helix) an innovative economic system may be engendered. Such strengthening of alignment and relationships between institutional structures is not only a unique requirement of the development of Triple Helix. It has been identified as an issue for other models of innovation (Cai and Lattu 2022; Belezas and Daniel 2023; Zhang et al., 2019; Linton 2018; Lundvall 2007; Etzkowitz and Leydesdorff 2000) and thereby remains a pressing concern for the ongoing research and practice of 'innovation'. However, much of this literature infers that Triple Helix is implemented and utilised in periods of relative stability in order to initiate and accelerate national development (Sá et al., 2019; Etzkowitz 2002, 2003, 2008; Etzkowitz and Leydesdorff 2000). In contrast, there is only a much smaller body of literature that discusses its application as a mechanism for dealing with pressing economic dilemmas and this is constrained to limited contexts (see Oksanen and Hautamaki [2014]; Etzkowitz [2012]; Rodrigues and Melo [2012]).

While the institutional structures of the Triple Helix are important to

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<https://doi.org/10.1016/j.technovation.2023.102832>

Received 1 March 2023; Received in revised form 24 July 2023; Accepted 28 July 2023

Available online 1 August 2023

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its functioning (Hou et al., 2021; Zhang et al., 2019; Linton 2018), it is increasingly recognised that it is the micro-relations between individuals that are vital for its successful operation (James et al., 2022; Liu et al., 2022; Fernandes and Ferreira 2022; White and Samuel 2019; Ryan et al. 2018; Champenois and Etzkowitz 2018; Winsor and Hall 2018; White et al., 2018; Mandrup and Jensen 2017; Razak and White 2015; Russell et al., 2015; Lundberg 2013). These individuals perform essential roles both within their own strand (Leisyte and Sigl 2018; Etzkowitz and Dzisah 2008) and in fostering connections between strands (Poppen and Decker 2018; Ryan and Hilliard 2018; Midgley and Lindhult 2021; Lee et al., 2015; Dooley and Kirk 2007; Audretsch and Belitski 2022). Garner and Ternouth (2011) conclude that effectual collaboration is the result of ‘personal, trusting and working relationships’ (362).

There is also some recognition within the literature of the potential ethical tensions that may arise between institutional and individual Triple Helix actors (Etzkowitz et al., 2022; Zhang et al., 2019; Amanatidou et al., 2016; Răceanu 2016) and the damage that may be caused by the unethical practices of a partner (Ankrah and Al-Tabbaa 2015). These have been explored, at least to some degree, in niche fields such as agriculture (Pant 2019) and substance abuse (Scheibin et al., 2022), and some suggestions have been made to address this through the development of appropriate university curricula (Grimaldi and Fernandez 2017; Vistisen et al., 2015). However, the Triple Helix model does not explicitly incorporate the dimension of ethics despite repeated calls for its inclusion (Cai and Etzkowitz 2020; Pant 2019; Etzkowitz 2011).

This paper addresses our lack of understanding of the ethical dimension of the micro-relations between Triple Helix actors during times of emergency. Drawing upon Heyd (1982) ethical theory of supererogation, the study characterizes the behaviours that manifest as a result of the ethical motivations to address pressing national needs. It contributes to innovation theory by introducing an explicit ethic-theoretical perspective to the study of Triple Helix and expands our understanding of its functioning beyond steady-state conditions. Since university is recognised as a leading innovation actor (Etzkowitz 2008, 2012) and micro-foundation of the Triple Helix model (Liu and Huang 2018), following the approach of Etzkowitz et al. (2022), this work focusses on the role of the university within this time of crisis and focusses on the ethical actions of its constituent individuals. We ask the following research question, ‘from a university’s position, how do innovation actors help each other during crisis?’

2. Virtue ethics and supererogation

Ethical theories may be considered to comprise three distinct forms; deontological theories that explain the behaviours of moral individuals according to rules and regulations, utilitarian theories that justify moral behaviours that are directed toward providing the ‘greatest good’, and virtue theories that regard moral behaviours as the result of the fundamental characteristics of agents (Gibert 2022; Taggart and Zenor 2022; Chakrabarty and Bass 2013).

Supererogation is a virtue-based ethical theory and supererogatory behaviours are those acts that ‘go above and beyond duty’ or are ‘more than what could be rightfully expected’ (Fernandez-Dols et al., 2010; Chisholm, 1963; Urmson 1958). Such acts are costly in terms of self-sacrifice, and are done without expectation of return, reward or recognition (Heyd 1982). There are a ‘*virtually infinite number*’ of ways that people and organisations can supererogate (Hurd, 1998, 67) and it is therefore impossible to compile a definitive list. Instead, supererogatory acts are classified according to the general forms that they may take. Heyd’s (1982) seminal work provides a taxonomy that comprises moral heroism, beneficence, volunteering, favour, forgiveness and forbearance. White et al. (2022) extend this taxonomy to include the category of sharing acts.

In summary, moral heroism refers to a determination to uphold

moral ideals when faced with contrary pressures. The ‘classical’ examples in the literature consist of Johnson and Johnson’s expensive media campaign and withdrawal of Tylenol from the marketplace after a consignment had been found to be laced with cyanide (Tencati et al. 2020; Mazutis 2014; Burton and Goldsby 2009), Malden Mills’ decision to continue to pay staff after the factory had been gutted by fire (Mazutis 2014), and the actions of institutional whistle-blowers (Grant, 2002).

Beneficent acts are usually represented by the donation of one’s ‘material goods’ (Heyd 1982, 146). Examples include the health and wellbeing services of organisations such as The Wellcome Foundation (Steinman et al., 2010; Ex Libris, 1967). Volunteering, which is similar to beneficence in many ways, is seen to comprise the ‘*offering of one’s services*’ (Heyd 1982, 150) or one’s facilities (White et al., 2022). Such acts are foundational to self-growth and the establishment and demonstration of moral integrity (Sekar 2022; Gill 2021; Clary et al., 1998). Favours are a culturally-embedded practice that occur between individuals or groups (Liu and Jia 2020; Thams et al., 2013). The degree of reciprocation of favours is also culturally-contingent and context-specific (Teagarden and Schotter 2013) as is the judgement of their (un)ethicity (Hyndman and Muller 2020). An act of forgiveness may be supererogatory if there would have been grounds for it not to be granted, such as in the enactment of a poorly-formulated law (Heyd 1982). Similar to acts of beneficence and favours, the nature and manifestation of forgiveness is culturally nuanced (Blanco 2016; Lacey and Pickard 2015).

Forbearance is predominantly a financial activity such as in the non-demand of repayment of a debt (Chang and Yu 2017) but may also be found in the non-competition arrangements between rival organisations (Guth et al., 2015). White et al. (2022) proffer the reduction of resource consumption as a form of ‘ecological forbearance’. Finally, sharing may comprise many acts such as knowledge-sharing (White et al. 2022) or profit-sharing (Cortez 2017).

While this taxonomy of the types of supererogatory acts is valuable in aiding the identification and characterisation of behaviours that go ‘above and beyond the call of duty’, it is not always feasible to distinguish between some classes of acts (Heyd 1982; White et al. 2022). For instance, some acts may be interpreted as either volunteering, beneficence or favours. Recognising this, Heyd (1982) stipulated that the taxonomy should neither be considered to be definitive nor should the classes be thought to be mutually exclusive. Consequently, the absolute identification of such acts is made through the examination of four necessary conditions (Heyd 1982): (i) supererogatory acts are neither obligatory nor forbidden, (ii) whose omissions are not wrong, and do not deserve sanction or criticism, (iii) are morally good, both by virtue of their (intended) consequences and by virtue of their intrinsic value, and (iv) are done voluntarily for the sake of someone else’s good, and are thus meritorious (See White, Samuel, and Thomas [2022] and Mazutis [2014] for ‘worked examples’ of each). Fundamentally, examining an act against the four necessary conditions tells us *if* it is supererogatory, whereas identifying the class to which an act belongs tells us *how* it is supererogatory.

3. Research context and methodology

3.1. Research context

Triple Helix has been used, implicitly and explicitly, as a model for economic development in South Wales. For instance, Marquand and Meara (1936) published ‘South Wales Needs A Plan’ that identified the need for universities to ‘*fulfil their natural function of conducting research and teaching based upon the institutions of the regions they serve*’ (168–169).

More recently, a well-publicised and much-criticised attempt at innovation through the Triple Helix model within the region were the ‘Techniums’, an initiative that constructed a network of buildings to act as incubators for indigenous technology companies. Pugh et al. (2018) found that the failure of the programme was, in part, due to government

ignoring the advice to focus upon building research capacity rather than property. Wales' finance minister at the time later wrote '*the concept was sound ... the management and roll-out was deficient*' (Davies 2012, 34).

The current model for innovation and economic development, published in 2022 (Welsh Government 2022) is based on the idea of 'innovation districts' described by Katz and Wagner (2014) that explicitly refers to the Triple Helix. Government documents recognise the need to adopt the Triple Helix framework because '*opportunities for innovation, and often also research, are increasingly requiring strong evidence of this "triple helix" of collaboration and Wales has some way to go before its institutions are delivering at the level that they and the nation will need to achieve in order to be successful*' (Delbridge et al., 2021, 46).

Consequently, the region in which this study was undertaken can be characterized as one in which the strands of the Triple Helix are in existence and have operated for some considerable period of time, and have achieved a level of stability. It is therefore an apposite environ in which to examine the interoperability of these strands in response to a crisis that threatens to impact upon all of its constituent actors and the nation as a whole.

This research was undertaken during the height of the Covid-19 pandemic, in 2020 and 2021, which perturbed most societal systems, including systems of innovation. The pandemic can be considered as a number of simultaneous crises - economic (Bashir et al., 2020), public health (Shi et al., 2020), leadership (Soluk 2022), society (Bartoloni et al., 2022), and environmental (Bashir et al., 2020). Whilst the Covid-19 pandemic is not the focus of this research, this context provides an opportunity to probe the actions of individuals in university, industry and government during a time of crisis. This study is based upon the endeavours of the staff of one university, located in South Wales, to develop three medical devices for Covid-19 protection, detection and treatment.

3.2. Methodology

This study adopts an interpretivist stance to explore the individual Triple Helix actors' everyday actions and interactions in response to a global public health crisis. A case study approach is utilised for its ability to garner rich insight (Davies 2009) and this has also been widely used for the examination of ethical behaviours (Jiang et al., 2021; Kourula and Delalieux 2016; Lamberti and Lettieri 2009; Gumeay and Humphreys 2006; Crane 1999; Brigley 1995). Multiple cases were used to enable the identification of '*common patterns and mitigate over-interpretation of case idiosyncrasies*' (Mitzinneck and Besharove, 2019, 383). Specifically, we focused on university-led projects and selected cases were based on the following criteria: 1) the innovation project provided medical innovation for Covid-19 pandemic; 2) the project was led by university either within a single department or across various departments; 3) the project involved collaboration among university, industry and government; 4) there was a sense of urgency in the project to meet deadlines, which required effort from the project team; 5) there was good access to data, including interviewing key people in charge of the project. These resulted in us exploring three cases, and their profile is illustrated in Table 1.

Table 1
Profile of the cases.

Case	Innovation Project	Key Actors	Interviewee	Interview Times
Case One	Oximeter design and development	University, Welsh and UK manufacturers, Welsh Government	Project manager	1 + Emails
Case Two	3D printed visor design and manufacture	University (various departments), Material suppliers, University-based manufacturer, Welsh Government, Local care homes	Project manager	1 + Emails
Case Three	Rapid-testing device development	University, Wales manufacturers, Local health board, Welsh Government	Project co-leader Project co-leader	1 + Emails 1 + Emails

Semi-structured interviews were chosen in order to gather rich narrative based data (Denscombe 2010; Seidman 1998) whilst also providing opportunities to probe deeper when interesting and emergent themes arose (Vinten 1994). The interview questions were operationalised according to Heyd (1982) and White, Samuel, Thomas's (2022) taxonomies of supererogation. The questions were open-ended to maximise the possibility of garnering rich contextualised data of the research participant's observations, experiences and actions (Fetterman 2010; Rabinow and Sullivan 1988; Charmaz 2006; Strauss and Corbin 1998). Question design was mindful of being able to allow the interviewee to reflect upon their experiences of operating in times of crisis and typically took the forms 'tell me' or 'what happened' (Strauss and Corbin 1998, 2005), 'could you describe,' 'how did' and 'what do you think' (Charmaz 2006). Table 2 shows our interview protocol with semi-structured questions.

Participant consent was gained prior to data collection (Van den Hoonaard 2003). Throughout the data capture and analysis the identity of all participants and host institutions remained anonymised (Duclos 2019). In the subsequent discussions, each of the case studies are referred to using the convention C1, C2 and C3. The interviews were conducted between 2020 and 2021, each lasting between 60 and 80 min, and generated 28,000 words of transcribed data. Data analysis was conducted via cyclic thematic indexing (Braun and Clarke 2006) and took place in three phases: during the process of data capture and the development of 'in-the-moment' interview questions, between interviews and the development of enhanced interview question schedules, and post-interviews upon the complete body of transcribed materials. The final analyses were performed independently by the researchers before cross-analysis comparisons were made in order to reach consensus.

3.3. Case overview

Case one involved the design and development of a brand-new

Table 2
Interview protocol.

Project related questions:
- Could you describe when and how the project started?
- <i>What happened afterwards</i>
- <i>What is the ending point of the project?</i>
Triple Helix relation related questions:
- <i>What support did the government provide?</i>
- <i>How did you work with in industry for this project?</i>
Ethical behaviour related questions:
- <i>What were the motivations?</i>
- <i>How would the project benefit to whom?</i>
- <i>Were there any voluntary activities?</i>
- <i>What else helped the innovation?</i>
- <i>What hindered the innovation, and how did you cope with that?</i>
- <i>Who funded the project?</i>
- <i>How did you share resource with others?</i>
Other questions:
- <i>What do you think are the differences of innovation before and during the pandemic?</i>
- <i>Questions tailored to each project</i>

oximeter. The Welsh government initiated and sponsored the project in March 2020, which was directed by a member of the academic staff from the Engineering Department. The objective was to satisfy the demand for a CPAP (continuous positive airway pressure) machine that could treat patients with Covid-19 infection early and employ oximeters to monitor blood oxygen levels. With the global supply chain disrupted, the project team designed a practical product at a lower cost, using an alternative local supply chain in the South Wales region.

Case two concerned the design and manufacture of 3D printed visors to prevent the spread of Covid-19. The project, which was led by a member of the academic staff from the Engineering Department, started in March 2020 and was completed in May 2020. The project leader identified the shortage of PPE supplies in the UK and saw the opportunity of using a university 3D printer. The project team reverse-engineered the design from existing products and began production inside the university. The project was assisted by Aircraft Maintenance Department staff and Mechanical Engineering Technicians from other departments. The university provided support in terms of funding, expertise and skills, security and logistics. The products were delivered to local institutions including care homes.

Case three comprised the development of a rapid-testing device for Covid-19. The project was led by two academic staff with a background in microbiology and molecular technology. In early 2020, the two researchers identified the potential to adjust existing technology for the detection of bacterial pathogens for the rapid testing for Covid-19. The team worked with the Local Health Board to obtain samples for validation testing, which was a critical step in the development of the technique. In October 2020, the team conducted a clinical study to evaluate the performance of the prototype diagnostic device and received a grant from the Welsh Government to scale-up the production.

4. Findings

The seven types of supererogation defined by Heyd (1982) and White et al. (2022) are evident in the actions of those involved in all three case studies, as described in the participants' interviews. The following section highlights examples of each type of supererogatory act and examines each act to identify the four necessary conditions (Heyd 1982).

- (i) supererogatory acts are neither obligatory nor forbidden,
- (ii) whose omissions are not wrong, and do not deserve sanction or criticism,
- (iii) are morally good, both by virtue of their (intended) consequences and by virtue of their intrinsic value
- (iv) are done voluntarily for the sake of someone else's good, and are thus meritorious

In each case, these four conditions were met, thereby satisfying the definition of a supererogatory act. Many of the following examples could be interpreted as more than one type of supererogation, particularly those of beneficence, volunteering and favours, and this is a feature of attempting to classify supererogatory acts that has been noted in the literature. Therefore, the subsequent analyses present the researchers' consensus of examples that are most pertinent to each type of supererogatory act.

4.1. Moral heroism

The interviews highlighted acts of moral heroism which occurred during the innovation projects. Members of the research team were clinically vulnerable and coming into work and into contact with others was a known risk. Despite this, they came to work:

'I'm asthmatic, so I'm on the inhaler, and there was another colleague ... he's asthmatic as well ... according to NHS, we should be very careful, even right now ... So we both had that risk when we

leave the house and coming back because we should have actually stayed home.' [C2]

Similarly, this willingness to risk their health was shown in many cases and others who displayed similar moral heroism were listed by the interviewee:

'One guy, they had a baby recently, the other guy, also had some difficulties and so on, but they all came to the university ... all the other colleagues working from home, they should have simply said, "sorry, we can't do that one" and they all get paid and so on. But they stayed voluntary.' [C2]

Moreover, it was known that the virus was, potentially, lethal and that it was easily spread. Despite this, project leaders and team members willingly came into contact with others who had the virus in order to carry out their work:

'you were in full PPE and you were dropping loads of things off at the doorstep of this person who we knew he had Covid ... so coming into contact with this deadly virus we felt like ... we knew the risk we were taking. We knew that we were putting ourselves more at risk of picking up the virus than if we were staying at home. And we were happy to do that.' [C3]

Beyond health risks, moral heroism was apparent in individuals' professional acts too. Project leaders upheld moral ideals that the societal benefits of health research are worth performing when faced with contrary bureaucratic pressures in needing to complete paperwork. Researching without completing ethical forms was a choice made because it could save more lives and was morally good:

'And then I think the university was happy to let us do that and to ... and so there was ... I think the key thing was about, yeah, about risk and about not having necessarily huge bureaucratic processes to go through, just people going "okay on my head, be it let's say yes to this." And ... and that really helped.' [C3]

Most pertinently, the interviewees highlighted their belief that inaction could be immoral:

'I'm not against ... all the ethical stuff that's in place is there for a reason and it's there to protect patients, but sometimes it feels like people forget that there's an ethical implication of NOT [emphasis added] doing a piece of research.' [C3]

4.2. Beneficence

Beneficence is another predominant theme according to the interview data. The use of equipment and the supply of materials was all donated by the university for the use of researchers. Donating materials was morally good and for the benefit of others over themselves. This beneficent act enables innovation with the required resource, especially when the supply chain is disrupted:

'it was fully funded by the school ... so all the expenses came out from school budget. But there was no problem, everybody approved that ... up till now nobody asked any questions about any spendings.' [C2]

Acts of beneficence were not only to supply the main equipment but also to keep morale high. The university paid for food during working hours for the project team, which was unusual in normal conditions. Supplying food was for the benefit of others and not themselves:

'I have ordered food for them and the university actually paid for them. Under normal circumstances, I know it's not possible to pay for somebody's food while they're working on site, but this case, they have agreed with other things.' [C2]

The recipients of this benevolent act were then the instigators of a

benevolent act themselves in donating the finished visors to those who needed them free of charge. This act also helps disseminate the innovation product quickly to the users:

'They were struggling to get the stuff. They're not capable with the technology knowhow, how to place the orders and so on. So then we decided, at that point, rather than focussing on NHS, we can focus on people who actually, are not under the spotlight, so that's why we have decided to approach the care homes.' [C3]

4.3. Volunteering

Volunteering is another enabler of the innovation projects, which was observed across university and government. People were volunteering to help researchers, even taking risks in doing so. Wanting to do something to help was for the benefit of others over themselves. Interviewees described how these voluntary acts enabled their work:

'in the beginning, we were lucky that we were surrounded by people who just wanted to do something and they were happy to take some risk. And that's both internally and externally. I guess the external, especially the commercial partners, they will see an opportunity, so I get that, but more internally, just by freeing up money quickly ... made a huge difference.' [C3]

Individuals in government were willing to assist individuals in academia outside their normal working hours and days. Working on weekends and providing such assistance was supererogatory:

'I've got to say, you know, [anonymised individual] was absolutely fantastic, right? ... he was there all the time, yeah?..Saturday. Sunday. Any issues ... he was always there, supporting, yeah? Absolutely phenomenal support.' [C1]

It was recognised that these acts were going above and beyond what was expected:

'I've got to be honest, that was, that was impressive, the way those guys come forward to actually, you know, when you got a problem.' [C1]

4.4. Favour

The concept of favours emerged during interviews. This is seen from the university and supporting infrastructure for the core innovation teams. University colleagues from the print shop made a specific trip to the shop to get equipment to help researchers. Not opening the shop whilst under 'work from home' directives would not have been wrong or deserve sanction or criticism:

'So I have contacted the print room manager and they all were ... working off campus. But then, when I contacted him, within an hour, they have arranged one of their colleagues to travel from his home to our print shop, open the print shop, get all the stuff I need and deliver it to the room where I was. So from call to receiving items from a locked building and all, it took less than one hour.' [C2]

The project leader highlighted the significant support from university. The head of school provide funding quickly to help start the project. All supporting staff responded to emails quickly which was unusual in normal conditions. Removing these barriers was done for the benefit of others over themselves:

'it's not there was no barriers. There were lots of barriers, LOTS of barriers. But all the barriers were lifted purposely by everybody in order to get this work done. I mean, I think that that's what SHOULD happen.' [C2]

An example was highlighted of a security guard bringing mail and parcels to an individual instead of making the individual collect from

another location, which would have been required before the pandemic. These acts clearly stayed with the interviewees as they were eager to praise individuals in the interview:

'Especially I like to mention our security colleagues and the post room staff. They were brilliant, right?' [C2]

It was apparent from the interviews that favours were being performed by individuals at all levels of seniority across all function:

'they used to pop in and say, "hi guys are you ... you all ok? Do you want us to do anything? Do you want us to take boxes here and there," and so on ... I mean, the attitude and the support had from people like from security, post room, all the way up to the highest level, was amazing. Amazing.' [C1]

Case one also highlighted favours performed by other actors within the Triple Helix. An example of this was an individual from the public sector who confirmed whether the technology developed was patentable and could be used in a medical setting. It was explained how the public sector:

'support us all way through that and as a way of getting that double checked out by one of the guys in the Welsh government, who checked out the patent and it looked like it's pretty clean.' [C1]

4.5. Forgiveness

Acts of forgiveness were evident in the interviewees' accounts of their work. In case one, when the project started, there was no official grant confirmation or letter of support from the public sector:

'when we started in March, we were told that [anonymised public body] would fund it. Right?' [C1]

However, the team still went ahead with the project, while waiting for the grant to be allocated after 6 weeks. The intention of forgiving the minor rule break was morally good:

'if we didn't get a grant allocated, I would be in a difficult spot ... but we started because obviously we trusted each other and said, look, we know there's a common problem here. We just got to do it. So we started without any contract in place.' [C1]

Forgiveness is not only shown in university, but also in industry. Managers were allowing, or encouraging, employees to continue with work which may not have been allowed, forgiving their discretions and offering to take the blame for any consequences. The act of forgiveness was done for the sake of employees, and for the benefit of society as a whole:

'he was basically saying, "let's go for this, if there's any flack, I will ... I'll pick it up," and that's what we needed.' [C3]

4.6. Forbearance

Different types of forbearance were evident, especially at university and industry levels. For example, the money to fund exploratory work in case two was provided by the university with no expectation of repayment:

'so all the expenses came out from school budget. But there was no problem, everybody approved that.' [C2]

Further, there were acts of forbearance between different actors in the triple helix. A private manufacturing company provided their services for no charge and worked throughout the weekend. Demanding payment would not have been wrong or deserve sanction or criticism and is expected of any private company:

'Testing was done by [anonymised company] and there was no charge.' [C1]

The act was intertwined with other supererogatory acts such as volunteering:

'The guys down there did the AMC testing over the weekend. They knew the time urgency of it. And there was no cost. They just pulled their sleeves up and they got on and just did it.' [C1]

As with previous acts of supererogation, interviewees were keen to praise and recognise the acts of others:

'Companies like that really need to be recognised for what they, you know, for what they did there, because there was no payment made. They just got stuck in.' [C1]

Furthermore, a different type of forbearance was displayed by the public in recommending that the researchers use companies outside of Wales, despite their remit being economic development within Wales. This displays a type of non-competition arrangements between rivals for the benefit of society at large:

'not always in Wales, there's one company actually in Reading which came back, and one in Kent, yeah? "Talk to these guys, they might be able to help you.' [C1]

4.7. Sharing

Sharing is another theme, identified across all Triple Helix innovation actors. Equipment and knowledge, in the form of relationships, were shared in examples given by the interviewees. In case two, the realities of the context were explained:

'So we have seen all the news around UK and across the world saying there is a huge PPE shortage, which, errr, of course, put the ... the life into risk of medical staff and so on.' [C2]

It was explained how this led to the university facilities and machinery being shared. This was done solely for the benefit of others:

'And then, of course, there was no way that they could find whatever they needed starting from face visors, masks, glasses and so on. Right? So then what we thought is because we got a ... a variety of machineries and facilities available within the university.' [C2].

Apart from sharing tangible resource such as equipment and knowledge, relationship and social network are also shared for the purpose of innovation. In case one, the government actively shared relationships with the project team to assist the medical approval process and help establish the new supply chain. Industry partners continuously bring more partners on board based on their previous collaboration relationship:

'you could ring them up at any time and say, "look, we ... we are getting a problem here, any ideas guys?" and you'd get a response, even Saturday or Sunday. Errr ... it was really good support. It really was ... one of the key things here is getting the right team.' [C1]

The findings highlight supererogatory acts experienced by individuals within academia from, and towards, individuals in academia, industry, and government. There are examples of all seven types of supererogation described within the interviews.

5. Discussion

Our examination of several innovation initiatives has provided some valuable insight into the operation of the three strands of the Triple Helix during a time of crisis.

The first, and perhaps most significant finding, is the observation that the operation and structures of the Triple Helix are perdurable even

under the conditions of a crisis that is global in extent. This is an important observation and extends our currently limited understanding of the functioning of Triple Helix beyond conditions of relative stability (Cai and Lattu 2022; Oksanen and Hautamaki 2014; Etzkowitz 2012; Rodrigues and Melo 2012). 'University' was the site of ideation of the three medical devices, either in the form of the repurposing of an existing stream of technological development, the utilisation of facilities, or the invention of a more efficacious device than was currently available. 'Industry' was the source of manufacturing and testing capability and capacity, as well as materials and expertise. 'Government' proved to be an essential nexus between University and Industry, providing links, funding and aiding the amelioration of procedural barriers.

The second pertinent finding confirms the vital importance that is played by individuals within each of the three strands of the Triple Helix. Not only were some individuals notable for their 'eureka' moments, but these moments were often catalysed by their relationships with other individuals. The ability of government, and the individuals of which it is comprised, to act as 'relationship broker' was indispensable in introducing individuals in University to individuals in Industry and in other Government sections. These new relationships were of paramount importance in enabling the design, development, testing, approval and distribution of the new medical devices. Together, these add further weight to the recognition of the importance of individuals and their 'micro-relations' that is emerging in the literature (James et al., 2022; Ryan et al. 2018; Champenois and Etzkowitz 2018; White and Samuel 2019; Mandrup and Jensen 2017; Razak and White 2015; Russell et al., 2015; Lundberg 2013). These micro-relations operate both intra-strand, between individuals in the same institution or sector, and inter-strand between individuals in different institutions or sectors (Poppen and Decker 2018; Ryan and Hilliard 2018; Midgley and Lindhult 2021; Lee et al., 2015; Dooley and Kirk 2007; Garner and Ternouth 2011).

Third, identifying suitable partners in a Triple Helix arrangement is usually considered under stable conditions, but in situations that create a 'pressure to innovate' the time that is available to rationally select a partner is greatly reduced. As Gillier et al. (2010) also note, the challenge of identifying suitable partners in the context of innovation is greater since the scope and nature of the challenge and possible future requirements are less well-known. There is a great deal of literature that explores and categorises the desirable features of an effective partnering arrangement, but Borch and Solesvik (2016) reveal that there '*are no universally established criteria for choosing a partner for inter-firm collaboration*' (424). Much of this literature focuses upon the 'hard' capabilities of partnering organisations such as their 'research expertise' and 'agreements on IP management' (Manotungvorapun and Gerd Sri 2016). Some of this recognises the 'softer' aspects of the relationship such as the 'compatibility of strategic goals', 'compatibility of innovation strategy' and 'previous working relationships' (Na et al., 2021; Manotungvorapun and Gerd Sri 2016; Vom Brocke and Lippe 2015). Even less recognises the need to take account of the 'fundamental nature' of the organisations such as their '*cultural compatibility*' (Vom Brocke and Lippe 2015, 1027) and their '*working styles*' (Manotungvorapun and Gerd Sri 2016, 422).

It is known that there are potentially severe consequences from the unethical behaviour of partnering organisations (Amanatidou et al., 2016; Raceanu 2016; Ankrah and Al-Tabbaa 2015) but the Triple Helix model of innovation lacks an explicit ethical dimension (Cai and Etzkowitz 2020; Pant 2019; Etzkowitz 2011). This study has identified the efficacious alignment of Triple Helix actors' actions toward the common goal of developing medical devices to tackle the consequences of a global pandemic that were predicated upon virtuous, supererogatory acts. Consequently, we proffer that the partnering of organisations within and between each of the strands of the Triple Helix needs to take account of their ethical dimensions, in addition to their 'hard' and 'soft' knowledge and technical capabilities. This is not a trivial undertaking, but tools such as the Ethical Climate Questionnaire (ECQ) exist that could be employed and, if necessary, further developed in order to

provide insight into the ethical alignment of partnering organisations and individuals (Victor and Cullen 1987).

At this juncture it is pertinent to reflect upon Heyd's (1982) assertion that occasions during which supererogatory acts such as moral heroism may be observed are atypical since the conditions that bring them about arise infrequently. The Covid-19 pandemic has been one such occasion and has thus afforded a rare opportunity to observe the ethical actions of individuals that are motivated by a significant common cause. Undoubtedly, the magnitude of the pressing needs for medical device innovation have been an exceptionally unifying force. While such extreme circumstances are useful in fostering the manifestation of such behaviours one could infer that those behaviours may not be present in times of normality. However, while the literature does suggest that extreme conditions promote the magnification of both 'good' and 'bad' ethical behaviours, it also clearly shows that supererogatory behaviours are manifest during everyday life. For instance, consider the prevalence of favour-exchange, volunteering and forgiveness that are present in most if not all societies (Liu and Jia 2020; Thams et al., 2013; Teagarden and Schotter 2013; Sekar 2022; Gill 2021; Clary et al., 1998; Blanco, 2016; Lacey and Pickard 2015). Consequently, while this examination took place during a period of unprecedented global turmoil, there is good reason to expect the ethically-motivated behaviours that were observed to persist, at least to some degree, among Triple Helix actors during more stable times.

6. Conclusion

6.1. Conclusion

Triple Helix has emerged as a dominant means of understanding and precipitating innovation within national economies through aligning the endeavours of university, industry and government. So far, research has tended to explore this system of innovation in times of relative stability and little work has been done to understand its functioning during times of crisis. Furthermore, while it gives primacy to the three institutional structures it is increasingly recognised that it is the micro-relations between individuals within these structures that enable its operability. These institutional and inter-personal interactions have the potential to give rise to ethical issues, yet Triple Helix lacks an explicit ethical dimension. In order to address these shortcomings, this study sought to address the question, 'from a university's position, how do innovation actors help each other during crisis?'

Drawing upon Heyd's (1982) ethical theory of supererogation, this paper explores the behaviours that arise between university, industry and government actors in response to the pressing need to develop medical innovations to address a global public health crisis. The findings underpin three important contributions:

First, the interoperation of university, industry and government was found to be efficacious during a period of considerable social and economic instability. This extends our limited understanding of Triple Helix beyond 'steady state' conditions. It also broadens our understanding of its operability beyond the limited contexts that are covered by the few extant studies, and provides insight into its functioning in response to crises that are not merely economically grounded.

Second, the micro-relations between individual actors, both within (intra-strand) and between (inter-strand) university, industry and government, enabled the 'eureka' moments of discovery, the identification of skills and resources, and the minimisation of bureaucratic obstacles. Some of these relationships existed pre-crisis whereas others emerged during the process of innovation. While the institutional structures of Triple Helix are undoubtedly elemental to the foundation of valuable relationships between institutions and individuals, it would appear that much can be gained by the deliberate fostering of relationships at a more granular level. Such deliberate relationship-forging is beneficial in and of itself, but it is also instrumental in enabling the emergence of serendipitous and context-specific relationships in the future (James et al.,

2022). Consequently, Triple Helix arrangements should not be content to rely upon the passive generation of inter- and intra-strand relationships but should actively seek their creation.

Third, the micro-relations between individuals manifested as supererogatory acts that went 'above and beyond duty', comprising moral heroism, beneficence, volunteering, favour, forgiveness, forbearance and sharing. This confirms that micro-relations within the Triple Helix are underpinned by an ethical dimension. While this study took place during a period of instability and supererogatory acts may therefore be unusually magnified, similar ethical acts should persist during times of stability. The ethical alignment of actors is necessary not only for the security of the partnering institutions but also for the wider issues of the ethical governance of research, product development and their future consequences (Cai and Lattu, 2022). Not only is there a temporal dimension to the future consequences of innovation but there is also a temporal aspect to supererogation. Behaviours that are perceived to be morally praiseworthy in the present, may become the expected norm over time (Heyd 1982; White et al., 2022). Consequently, Triple Helix institutions and actors should be mindful of the possibility of incongruity between the behaviours that may expect from others and that others may expect from them as a result of previous relationships. This 'ethical creep' may serve to drive effective collaboration during the early stages of relationship development as reciprocal assistance is given, but it may eventually become perceived to be a burden that cannot be maintained by some partners. This may also be exacerbated by other factors such as the actual material benefits of pursuing the partnership and by the influence of the sociocultural expectations of the degree of reciprocity.

Collectively, these contributions add weight to the considerable corpus of literature that identifies Triple Helix as an efficacious means of arranging institutional structures to foster innovation (Bartoloni et al., 2022; Zhang et al., 2019; Sá et al., 2019; Ranga and Etzkowitz 2010; Etzkowitz 2002, 2003, 2008; Johnson 2008; Razak and Saad 2007; Marques et al. 2006; Schartinger et al., 2001; Nieminen and Kaukonen, 2001; Martin 2000; Etzkowitz and Leydesdorff 1995). They identify that Triple Helix arrangements can be effective in enabling innovations in response to global socio-economic crises (James et al., 2022; Oksanen and Hautamaki 2014; Etzkowitz 2012; Rodrigues and Melo 2012). They also confirm that micro-relations between institutional actors are paramount in effecting the creation and realization of innovations (James et al., 2022; Liu et al., 2022; Fernandes and Ferreira 2022; White and Samuel 2019; Ryan et al. 2018; Champenois and Etzkowitz 2018; Winsor and Hall 2018; White et al., 2018; Mandrup and Jensen 2017; Razak and White 2015; Russell et al., 2015; Lundberg 2013). Finally, the study responds to the continued call for the introduction of an ethical dimension to the study of Triple Helix through the identification that the micro-relations between institutional actors may be characterized by their supererogatory exchanges (White et al. 2022; James et al., 2022). In doing so, the study integrates an ethic-theoretical dimension to Triple Helix.

The research has implications for both policy and practice. The triple helix is a widely adopted model for regional innovation which has developed over the decades to consider nuances which may improve the effectiveness of collaborations. Whereas currently geography and industry are the main considerations in partnering institutions from different strands of the Triple Helix, this work shows that consideration should be given to ethical considerations and the actions of individuals within institutions. Similarly, for academic, industrial, or governmental actors looking to collaborate with other strands of the helix, consideration should be given to the culture, ethics, and individual relations of institutions as these will impact how innovation projects occur in practice. Our study was conducted during the Covid-19 pandemic, an extreme national and global crisis. However, in the long term, university, industry and government can still utilise wider micro-relations (James et al., 2022), ecosystem resources and network (Fernandes and Ferreira 2022) to tackle future crisis such as the climate change. Such

innovation requires collaboration (Sá et al., 2019), volunteering acts, sharing of knowledge and relations (White et al. 2022), and indeed the consideration of ethics (White et al. 2022).

6.2. Limitations

This study is based upon a collection of innovation projects that were conducted under the exceptional circumstances of a global pandemic. Consequently, the observations may well have been made of behaviours that were magnified by the prevailing conditions. However, there is reason to believe that such behaviours ought to manifest under 'normal' conditions and future research should seek to confirm this proposition.

6.3. Future research

Useful insight could be gained by operationalising and studying devices such as the Ethical Climate Questionnaire for the identification of efficacious partnerships between institutions in Triple Helix arrangements and other contexts. Our study is among the first attempts to introduce ethical dimension to Triple Helix framework, and thus lay a foundation for future research areas. First, more studies can explore the connection between supererogatory acts and Triple Helix actors in stable conditions, for instance, in the context of sustainable innovation after the Covid-19 pandemic. Second, as our research focuses on innovation projects led by university, the data reflect micro relations inside the university, or between university and other Triple Helix actors. Whilst university plays a leading role in innovation, more empirical studies can investigate innovation from other Triple Helix actor perspective, including industry and government. Thus, it can provide more holistic view of the ethical dimensions across the Triple Helix model. Third, further work could explore alternative ethic-theoretical stances for ascertaining the ethical alignment between partnering organisations. For instance, such research could seek to understand the differences between adopting deontic, utilitarian or other virtue-based ethical frameworks.

Declaration of conflicting interests

The authors declare that there is no potential conflict of interest with respect to the research, authorship and/or publication of this article.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability

Data will be made available on request.

Acknowledgement

The authors would like to acknowledge all interviewees from the above three case projects. The authors would also like to thank Karen Young for her kind help on with interview transcription.

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2023-08-01

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James S, Liu Z, White GRT, Samuel A. (2023) Introducing ethical theory to the triple helix model: supererogatory acts in crisis innovation. *Technovation*, Volume 126, August 2023, Article number 102832

<https://doi.org/10.1016/j.technovation.2023.102832>

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