

# When Triple Helix unravels

## A multi-case analysis of failures in industry–university cooperative research centres

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**Abstract:** Cooperative research centres (CRCs) increasingly foster Triple Helix (industry–university–government) collaboration and represent significant vehicles for cooperation across sectors, the promotion of knowledge and technology transfer and ultimately the acceleration of innovation. A growing social science literature on CRCs focuses on their management and best practices, mainly through success stories and rarely by describing and analysing CRC failures. The literature on CRCs can benefit by learning from failures, as has been seen in other areas of social science. Here the authors present four mini-cases of CRC failures – centres that were successfully launched but later declined and closed – and, in contrast, one mini-case of a success story. The analysis identifies: (a) likely contributing factors in the failures, mainly environmental influences and mismanagement of centre transitions; (b) themes in the failures, notably a tendency for problems in one area to magnify the impact of problems in other areas; and (c) learning points for CRCs concerning leadership and succession. The implications for Triple Helix organizations are discussed.

**Keywords:** cooperative research centres; Triple Helix; outcomes; failure; leadership

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*‘There are no secrets to success. It is the result of preparation, hard work, and learning from failure.’*  
(Colin Powell, Retired Chairman, US Joint Chiefs of Staff and US Secretary of State)

Government-led industry–university cooperative – ‘Triple Helix’ – research organizations (Etzkowitz and

Leydesdorff, 1997) continue to spread (Etzkowitz, 2008). This trend has been particularly true for cooperative research centres (CRCs) – organized units or organizations that perform research and that also have an explicit mission to promote cross sector collaboration, knowledge and technology transfer and ultimately innovation (Boardman and Gray, 2010).

Cohen *et al* (1994) identified over 1,200 such centres in the USA in the late 1980s. While a more recent census is lacking, it is safe to assume a larger number of the 13,000 university-based or non-profit research centres listed in the *Research Centers and Services Directory* (2009) meet the definition of a cooperative research centre. Expansions of programmes to support such centres have recently been announced in Australia (Australia MIISR, 2009), Finland (Finland MTI, 2008) and throughout the EU (Government Monitor, 2009) and elsewhere in the world.

Public policy and related interest in these vehicles for promoting technological innovation and ultimately social and economic benefits have helped stimulate a relatively large, if uneven, body of social science research. According to a review of the evaluation literature on CRCs in the USA (Gray, 2000), this literature can be grouped into at least three categories: *ex ante* evaluations that focus on factors used to determine whether CRC programmes and/or individual centres should be funded; interim evaluations that involve data collection while the research centre is operating and focus on the effectiveness of CRC structure and processes; and evaluations of outcomes that examine the proximal and/or distal outcomes and impacts of centres. Not surprisingly, some evaluations use multi-level evaluation (Gray and Sundstrom, 2009) for continuous improvement and learning (Gray, 2008). A collection of papers reflecting all of these foci can be found in a recent special issue of the *Journal of Technology Transfer* (Gray and Boardman, 2010).

Unfortunately, from a practitioner's standpoint, most of these studies have been conducted at the programme level of analysis and provide little or no guidance on the factors that make individual centres successful. In general, this need has been met by a modest case-based literature describing 'best practices'. In these analyses, a series of cases highlights strategies and practices that have helped the centres produce valuable outcomes and beneficial results. Examples include Tornatzky *et al* (2002) university-level cases presented in *Innovation U*, Roessner and colleagues' centre-level examination of the Georgia Tech Packaging Research Center and subsequent analysis of several Engineering Research Centers (Roessner *et al*, 2004; Roessner, 2010), and Scott's project-level *Compendia of Technology Breakthroughs* (Scott, 2007). While useful, what all these studies have in common is an exclusive focus on successful universities, centres and projects.

This strategy is limited, for a number of reasons. First, as the case study literature suggests (for example, Yin, 2002; Ruegg and Feller, 2003), one can have much greater confidence in causal conclusions (for example, internal validity) with a multiple case analysis that

includes cases with varying rather than uniform levels of performance. In addition, considerable evidence suggests that valuable and unique lessons can be learned from failure. For instance, Coelho and McClure (2005) argue that, 'recognizing failure is essential to success because it implies that core competencies have been identified' (*ibid*, p 2). In addition, Petroski (1994) suggests that failures in our increasingly complex socio-technical systems lie hidden in the interdependencies of various system components and can only be detected when systems actually fail. Similar arguments come from analyses of both personal (Shepherd, 2009) and team failures (Kayes, 2004).

Given these circumstances, it can be instructive to examine the circumstances and factors that contributed to the failure of cooperative research centres. To this end, we present five mini-case studies from the US National Science Foundation (NSF) Industry/University Cooperative Research Centers (IUCRC) Program. Four of the cases represent failures: centres that closed, either shortly after opening or after sustained periods of operation. By way of contrast, we open with one brief case that demonstrates sustained operation and continued success.

Our goals are to identify: (1) *Likely factors* in the IUCRCs and their environments that contributed to the cases of failure; (2) *Common themes* in IUCRC failures; and (3) *Points of learning* for Triple Helix.

## NSF IUCRC Program

The IUCRC Program is one of the longest running Triple Helix-based centre programmes supported by the National Science Foundation. Its key features have been highlighted elsewhere:

'IUCRCs are university-based, industrial research consortia. The research performed in the centres tends to be strategic or pre-proprietary fundamental research and is carried out primarily by faculty and graduate students. IUCRCs follow a relatively standardized set of policies and procedures; members pay an annual fee (usually between \$30,000 and \$50,000 per year), and they get equal access to, and ownership of, all research and intellectual property; findings, know-how and technology are transmitted through a variety of means, including periodic reports and semi-annual meetings; and members get one vote on the centre's Industrial Advisory Board (IAB)'. (Gray 2008, p 81)

The IUCRC Program in 2010 supported about 45 Centers that involved about 100 universities, about 750 firms, over 600 faculty scientists, more than

1,000 graduate students and nearly 250 undergraduate students (Gray *et al.*, 2011). IUCRCs tend to be diverse in terms of annual budget (\$200,000 to \$7 million), number of research personnel (5 to 50) and number of industry members (8 to 90). These Centers also represent diverse areas of technology: manufacturing, nano- and microtechnology, chemical processing, biotechnology and advanced electronics, to name but a few. Importantly, because of their consortial format all research and IP is shared equally by all members.

At the programme-level of analysis, the IUCRC Program has had an enviable record of success. Programme-wide statistics indicate firms and faculty are very satisfied with their partnership, faculty continue to publish in high quality journals, students earn advanced degrees and develop skills that are in high demand, firms report a variety of direct and indirect benefits and centre research frequently results in commercialized technologies (Gray *et al.*, 2011). Not surprisingly, the picture at the centre-level is not as uniformly rosy. This is consistent with other studies on programme sustainability which have found that anywhere from 20% to 80% of programmes are able to survive a funding transition (Scheirer, 2005). In fact, a recent study by McGowen (2010) has revealed that 12 per cent of IUCRCs leave the programme before the end of their first five-year award and another 26 per cent do not complete a full ten years of funding. While a few centres leave the programme voluntarily to pursue other funding opportunities, we estimate that nearly one-third of all launched centres ceased operation prematurely because they failed to satisfy the needs and expectations of one or more of the stakeholder groups involved in their Triple Helix partnership. The literature on programme sustainability suggests that programmes that survived in the long run are more likely to have completed their grants than are those that do not survive (Goodman and Steckler, 1989; Scheirer, 1990). However, what else can the research literature tell us about the factors that contribute to the failure of these centres?

A small but growing body of literature focuses on what happens to programmes in the long term, after their initial funding ends. This concept of programme sustainability has been researched most heavily in the public health field (Scheirer, 2005). However, there has been very little research on the sustainability of science and technology Triple Helix based programmes.

The exception has been two studies on the NSF Engineering Research Centers (Ailes *et al.*, 2000; Mujumdar, 2005). These two studies are complementary in that the Ailes *et al.* (2000) study collected data on centres at the end of NSF support and the Mujumdar (2005) study collected data on those centres several years after the grant ended. However, these studies were

methodologically limited in terms of timing of data collection, attrition, sample size, and a lack of any inferential statistics. Nevertheless, they did identify the importance of some factors that may predict long term programme survival. In particular, Ailes *et al.* (2000) discuss the importance of centre management, adequate infrastructure, transition planning, faculty involvement, institutional support, the research area and industrial participation. Unfortunately, there have been no empirical studies on what predicts whether Triple Helix based programmes will survive in the long term. However, many of the conclusions drawn by Ailes *et al.* (2000) and Mujumdar (2005) are supported by the wider literature on programme sustainability. Scheirer (2005) conducted a meta-analysis of empirical programme sustainability studies and identified the 'Big 5' predictors of programme sustainability: programme adaptability, the presence of a programme champion and strong leadership, a fit with the host and stakeholder organizations, benefits to stakeholders, and support from the larger environment. The case studies described below will examine the importance of these and other factors for the long term success of Triple Helix based programmes and how their absence can lead to programme demise.

## Methodology

The IUCRC Program has adopted a customer-driven, decentralized evaluation approach that involves an on-site evaluator and observational and survey-feedback methodologies. The linchpin of the IUCRC evaluation system is the on-site, local evaluator. This individual is responsible for implementing a standardized assessment protocol on an annual basis, including collecting qualitative data via observation and interviews and quantitative data via the 'process/outcome' questionnaire (Gray, 2008). A more detailed description of the evaluation effort and results can be found at: [www.ncsu.edu/iucrc](http://www.ncsu.edu/iucrc).

The cases described below were prepared using annual case reports prepared by the on-site evaluator, archival records and interviews with centre directors. The first case highlights a centre that operated successfully with NSF funding and continued to prosper after NSF funding ended. The remaining four cases focus on IUCRCs that successfully launched, operated at least a few years with NSF funding, then failed. Organizational and operational information on the cases is summarized in Table 1.

### *Sustained centre success: Center Z*

A single-university IUCRC since its founding in 1984, Center Z continues as a scientifically robust,

**Table 1. Characteristics of formerly funded IUCRCs: Centers A, B, C, P (failures) and Z (success).**

	Center A	Center B	Center C	Center P	Center Z
Year founded	1981	1985	1986	1996	1984
Years operating	3	4	20	11	27
Years sustained	0	0	0	1	13
Number of sites	3	3	2	3	1
Starting number of members	7	5	7	19	7
Ending number of members	2	2	11	20	26*
Ending budget	\$200,000	\$320,000	\$735,000	\$1.7 M	\$1.8 M*

\*Current data, since the Center remains operational.

organizationally stable and industry-responsive Center today, in its 27th year of operation.

*Development and growth.* Foundations for Center Z developed years before its launch, through collaboration between Professor K and Professor M, the initial Center Director and eventual successor respectively. Both were endowed professors in advanced materials at the host institution, with decades of working together on research projects and day-to-day curricular and academic matters. The co-founders cooperated in leading Center Z, which expanded as industrial organizations and newly hired faculty scientists joined. When the original Director retired, the host University supported the Center by making new hires in the same technical area. The host university also provided continued fiscal support for the Center: for example, the university supported laboratory expansion and renovation.

Center Z followed the NSF guidelines for an IUCRC, by developing and implementing decision-making processes for selecting, managing, and funding its industry–university projects. As described in an early analysis by Yin (1981), the Center developed regular practices by addressing one-time problem-solving passages or transitions, with the solution replicated routinely through subsequent cycles of activity. For example, the Center developed and then replicated annually its cycle of research agenda-setting and funding in semi-annual Center meetings of the Industrial Advisory Board of member representatives. Member companies could allocate their fee among the three areas for new projects; and one novel feature was introduced, and continued, whereby a company could allocate a fraction of its fee to a small EDR (extra designated research) project in which results would be company-specific. These decision-making processes remain intact today. The leaders of the Center made sure that members saw benefits from the decision-making approach.

*Coping with a challenge to survival.* About 10 years after the Center opened, major changes in the technical and business environment threatened its survival. When founded, Center Z’s member companies consisted almost entirely of large, historically prominent firms based in North America. However, subsequent globalization and changing markets introduced turbulence in the industry. Many member firms were acquired or merged. Market-leading firms in the relevant technologies were increasingly based in Europe and Asia. As one indication of the impact of this environmental turbulence for the Center, it had an average of about 20 member organizations during any one year, but over its history had about 60 companies as members. Some members left the consortium while others disappeared or merged with other firms. Some new member companies were unaccustomed to, or even suspicious of, a consortium approach to R&D with universities.

Center Z responded to the changes in its industry and markets by developing and executing a new, more proactive approach to marketing the Center and recruiting members. The Director and Center scientists consulted with member companies, conducted seminars and visits with member organizations, visited prospective member firms and made research presentations at international conferences that enabled contacts to be made in the emerging industry. At the same time, the Center maintained the basic decision making processes, policies and practices that had developed in its first 10 years.

*Success factors.* Arguably, five factors contributed to the sustained success of Center Z. First, the Center had an effective, committed leadership team with a shared intellectual history and vision. Second, the Center’s host university has provided consistent organizational support throughout the Center’s operation, including staffing and updating the Center’s facilities. Third, Center Z’s leaders developed a comprehensive business

model, based on the practices of the IUCRC Program, a defined mission and customer-focused processes, and maintained a disciplined adherence to that business model through periods of turbulence in the industry and environment. Fourth, the Center's co-founders managed an orderly transition in the role of director, ensuring leadership continuity. Fifth, the Center managed a nimble, flexible and rapid response to major changes in its international technical and industry environment.

## Case studies of early failure

### Center A

Center A was a multi-university IUCRC based in a US commonwealth territory during the early 1980s that focused on pharmaceutical manufacturing. The managing site was at a moderate-sized public university with partner sites at two small nearby private universities. The Center began operations with seven industrial members and about \$500,000 in total funding.

*Development and growth.* At launch the Center appeared to have a number of strengths. It was located in an area that had a large concentration of pharmaceutical manufacturing firms. In addition, the participating universities had a long track record of performing contract research for those firms. Furthermore, Center A was the brainchild of the managing university's dean so it had strong support from this primary university. On the negative side, the participating universities only had Masters degree-level chemical engineering and pharmaceutical science programmes. The memberships came from local units of the participating firms, none of which had on-site R&D capabilities. Finally, Center leadership was assumed by a senior but non-tenure track faculty member.

*Decline and dissolution.* While Center A operated for a couple of years, it never really reached the level of research performance and cohesiveness demonstrated by most successful IUCRCs. Within three years of start-up the Center began to close its operations and it is clear that a number of deficiencies contributed to its demise. While the university scientists and local firms were very comfortable engaging in one-on-one research, moving to a consortial form of collaboration created a number of problems. For example, firms were reluctant to discuss and share with their competitors the more applied problem-solving research they had been doing with the local universities. While the Center tried to move toward a more fundamental precompetitive research programme, this caused its own problems. It became clear that the participating Masters-degree granting universities did not have capabilities to

perform this kind of research; and the units of the sponsoring firms, lacking an R&D function, did not have the absorptive capacity both to define and exploit these types of studies (Zahra and George, 2002). Finally, as the Center began to unravel, it became clear that the non-tenure track Director did not have credibility with the participating faculty nor the political strength and authority necessary to hold the Center together. In the final analysis, it became clear that Center A lacked the ingredients necessary to become a successful IUCRC and was forced to close down.

### Center B

Center B was launched in the mid-1980s. It focused on topics related to molecular biology and it was novel in a number of respects. It was the first IUCRC to conduct research targeted at the quickly maturing biotechnology-based pharmaceutical industry (Blumenthal *et al*, 1996). It adopted what was then – and still is – a very high annual membership fee of \$75,000. It was also one of the first multi-university IUCRCs supported by NSF. It began with two universities and eventually added a third, all in relatively close proximity. It is worth noting that each participating university was considered nationally, if not internationally, prominent in one or more biotechnology-related areas. Finally, the Center adopted a novel management structure wherein a state-funded science and technology agency served as the organizational home for the Center and provided its management support.

*Development and growth.* Center B got off to a very good start from both a financial and technical standpoint. By its second year of operation the Center had grown to five members and had an operating budget from all sources that approached \$750,000. The Center attracted proposals from some of the participating university's strongest faculty. Members seemed very pleased with the quality of the research proposals submitted by the participating faculty as well as the early results that were produced. Concurrently, about five additional firms were evaluating the Center's research programme and were actively considering membership.

*Decline and dissolution.* Unfortunately, within two years the Center's membership had declined to two firms and total Center funding had declined to about \$300,000. Not surprisingly, interest in submitting proposals, especially by high profile investigators, had already begun to diminish. One year later, the Center's leadership decided not to submit a renewal proposal to NSF (which would have provided a second five-year award) and began closing down the Center.

What caused the demise of Center B? It had a number of things going for it. First, it possessed a capable and highly motivated leadership team including individuals who had worked in the bio-pharma industry. Collectively, the three universities had one of the most well-respected groups of faculty (academic staff) in the country, if not the world. In addition, Center B was partnering with a fast growing industry that had 'deep pockets' and was not reluctant to invest large sums of money into university research (Blumental, 1996). Interestingly, it was not the Center's very high fee nor its novel multi-university structure and external management structure that led to its downfall. In our opinion, two factors were critical in the decline and eventual demise of this Center: the biotechnology industry's desire for strong, exclusive intellectual property (IP) rights and the large amount of funding readily available to faculty from other federal sources.

Most significantly, it gradually became clear that firms involved in the highly competitive and proprietary-focused biotechnology industry were not comfortable with a consortial centre model wherein firms shared what was supposed to be pre-competitive research. Two failed attempts to recruit members during this period illustrate this vividly. In one case, scientists employed by a firm favourably reviewed the Center's operations and research programme and recommended joining the Center, only to be overruled by the company's corporate lawyers. The lawyers argued that even if the Center pursued a relevant and relatively novel pre-competitive research programme there was a chance that the programme might accidentally coincide with internal research that would be used to support exclusive patent claims within their firm. The lawyers successfully argued that the potential risk to the firm's IP claims posed by participating in Center B was too great to justify membership. In another case, a firm enthusiastically reviewed Center B's research capabilities and gave every indication they would join; but they did not. One month later that firm signed a \$500,000 exclusive research agreement with one university site that gave it first-refusal rights to all IP created under the agreement. Gradually, Center B's fee-paying members appeared also to conclude that the risk versus reward involved in consortial research did not justify their continuing involvement in the Center. One-by-one the Center's founding members decided to discontinue their participation.

Although the biotechnology industry's aversion to consortial research would have eventually doomed Center B, another factor, the government funding environment faculty scientists experienced, helped weaken the university side of Center B's partnership. During this time period, the National Institute of Health

(NIH) was beginning to experience the budget increases that would eventually lead to a commitment to double its budget beginning in 2003 (Korn *et al.*, 2001). In spite of the fact that Center B faculty appeared to enjoy and benefit from interacting with industrial members, as soon as it became clear to faculty that a well conceived Center proposal might result in a \$50–100,000 two-year award while a successful NIH proposal might yield a four-year \$2–3 million award, faculty interest in submitting their research to Center B began to wane.

It is worth noting that these two factors, a desire for exclusivity in IP and ample government funding opportunities, appear to continue to work against the development of successful biotechnology-focused IUCRCs. While NSF has developed numerous successful IUCRCs in a variety of scientific and technical fields, with the exception of centres focused on the processing side of bio-pharma manufacturing (something firms are willing to collaborate on) few IUCRCs focused on biotechnology-related issues have been launched and fewer have passed the test of time.

## Cases of late failure

*Center P: successful, three-university Center that failed in year 11*

Center P successfully launched and operated for five years as a single-university IUCRC, evolved smoothly to become a three-university IUCRC, expanded to become a model IUCRC with more than 50 member organizations in its seventh year, and operated through its tenth year. In its 11th year the Center dissolved and ceased to operate at its lead site. However, one of the three university sites continued to operate its component of the IUCRC as a self-sufficient CRC with essentially the same research programme and sponsoring members – mainly in defence-related industries – as it had when it operated a site of the larger IUCRC. This example of what might be described as a spin-out CRC is still operating today.

*Development and growth.* Center P began in the late 1990s as a single-university IUCRC, operating from a large, research-oriented, state university for five years, serving mainly the chemical industry and a few manufacturers. By its fourth year the Center had 25 member organizations, a research laboratory with \$4 M worth of testing equipment and a research budget of over \$1 M per year, with IUCRC funding supplemented by state grants, NSF research grants and industry contracts. Center P had a half-time Director, a half-time administrator, and affiliated faculty scientists in three departments. The Center produced an

impressive flow of scientific publications and graduate degrees and represented a model NSF IUCRC.

After its first 5 years, Center P joined with two state universities in other regions of the USA to form a multi-university IUCRC. Both partner universities ran independent, industry-funded research consortia with complementary research programmes. The new Center added research initiatives at the new sites that attracted sponsors among defence contractors, aerospace firms and the auto-makers, in addition to charter members in the chemical industry.

The new, three-university Center received its second 5-year NSF IUCRC award in the early 2000s, during an economic downturn, and still retained a total of 34 member organizations. Of these, half consisted of non-voting 'affiliate' members that paid 40% of the regular member dues, had access to the Center's research but had no rights to commercialize it. Although affiliate members had no vote, the Director negotiated one-to-one with them to design research projects that met their needs, often in exchange for in-kind contributions of equipment and testing materials.

Center P grew rapidly, despite losing a few memberships in the chemical industry when member companies merged. After two years as a multi-university IUCRC it had 34 voting member organizations and 19 affiliate members. Its sites at all three universities had half-time administrators who managed relationships with the member organizations affiliated through their sites. Each university had four or more Center projects specifically designed for, and primarily funded by, one or two member organizations. Affiliate members continued to negotiate privately for projects on the Center's research agenda. The Center had few projects involving cooperation among industry member organizations and practically none involving cooperation by scientists across the three sites.

*Decline and dissolution.* Seven years after opening, and two years after Center P expanded to become a multi-university IUCRC, the founding Director left. A scientist at the lead university who had worked with the Center since it had opened reluctantly took over the post. Unfortunately, the lead university did not appear to appreciate the workload and responsibility involved in managing the Center and did not give the new Director release time for the role. The new Director continued to work as a full-time academic and delegated leadership of the Center to the half-time administrator.

Two years later the Center lost its long-time administrator. The lead university named a replacement with a nominal commitment of 20% to Center P, in addition to another, full-time job on campus. Until then the Center had maintained relatively stable operations.

At the end of the fourth year as a multi-university IUCRC, Center P had 26 voting members, 15 affiliate, and 8 in-kind-only members.

Center P approached the end of its second, 5-year renewable NSF IUCRC award with a leadership vacuum. Neither the new Director nor site Directors at the two other universities took the lead on writing the renewal proposal. Even after a year's extension from NSF, the Center still had no Director willing to lead its next five years as a multi-university IUCRC. The Center had 20 voting members when it dissolved after slightly more than 11 years of operation.

Despite the failure of the multi-university IUCRC, many of the research projects continued at the three university sites. At the lead university, scientists continued to conduct contract research for several of the member organizations. Each of the two partner universities re-opened the industry consortia they had started before joining the IUCRC. At least one is prospering today, re-constituted as a self-sufficient, single-university CRC, not affiliated with NSF. This spin-out CRC retained about half of the member organizations from the former IUCRC – mainly in the relatively prosperous defence-related industries.

One obvious factor in the failure of Center P as an IUCRC was the lack of an effective succession planning process at the host university, resulting in an unfilled leadership vacancy that arose when the founding Director departed after seven years in the job. The reluctant replacement Director did not exercise leadership and realistically could only have done so with some release time from academic duties. Nevertheless, the Center's research programme continued largely as before, with most of its industry support, for another three years. The Center's part-time site administrators managed day-to-day operations and faculty scientists managed relations with industry members, including some recruiting. In effect, members of the Center's leadership teams and faculty scientists compensated by taking on parts of many of the leadership tasks left undone by an inactive executive Director. Unfortunately, the task of leading and drafting the proposal for renewal of the NSF IUCRC award required a single, Principal Investigator to take responsibility.

A second, contributing factor in the Center's failure involved a management vacuum resulting from the departure of the Center's half-time administrator. The nominal replacement, an already overloaded employee, had no time for the job. For all practical purposes, the Center had no staff at its main office in its ninth year, when it should have been preparing to renew its NSF award. Although the faculty scientists at the lead site continued their research and the two other sites operated

as usual, the day-to-day work at the lead site fell behind, notably in billing members for their fees.

A third, less obvious but perhaps more fundamental factor in the failure concerned the lack of institutional commitment by the lead university. The dean of the college that launched the Center and campus research officers declined to arrange release-time for a faculty member as replacement Director, did not support hiring a replacement for the departing half-time administrator and opposed a bid by one of the partner universities to take over as lead site of the multi-university Center. A difference in any of these decisions might have led to a different outcome.

Another non-obvious factor in the failure of this IUCRC concerns the lack of a cohesive group of industry stake-holders actively engaged with the university on behalf of the Center. Under similar circumstances at other IUCRCs a very dedicated and cohesive industry group might have lobbied the university for more resources and commitment as a group. Instead, the industry members maintained relationships mainly with individual faculty scientists, especially at the lead university.

Center P's one-to-one research funding approach contrasted with the collective approach in other IUCRCs. Ideally the IAB cooperates to define a shared research agenda of projects of interest to many of the member organizations. At Center P, the IAB had little input into the research agenda, because decisions had been made one-to-one. Many member representatives did not even attend IAB meetings; and many of the member organizations sent different individuals to IAB meetings. As a result, the IAB had no appreciable continuity and developed no cohesion as a group. The IAB chairperson for most of Center P's history was the CEO of a small, local firm – one of very few individual, industry representatives who came to more than two or three IAB meetings. In a Center with a more engaged IAB, multiple industry representatives can act as advocates for their Center in dealings with the host universities. At Center P the IAB never operated as a Board and took no advocacy role.

*Center C: successful two-university IUCRC that failed in year 20*

Center C developed and prospered for ten years as a single-university IUCRC, expanded to a two-university IUCRC, continued an expanded research programme through its 20th year, then closed.

*Development and growth.* Center C opened in the late 1980s as an inter-disciplinary, industry–university research consortium at a research-oriented, state university in cooperation with one of the US National

Laboratories. It received an NSF award as a single-university IUCRC in its first year, funded mainly by member organizations in the chemical and pharmaceutical industries. The Center operated with about a dozen members for its first five years under the leadership of its full-time, founding Director, who then retired.

In the early 1990s a second, full-time Director actively led Center C in obtaining a second, five-year IUCRC renewal award from NSF at a single site, a large state university. The staff included a full-time administrative assistant and a full-time book-keeper. The Center had a budget of about \$500k and a dozen member organizations eventually supporting research by 9 scientists at 3 university campuses and a National Laboratory.

Center C became a model IUCRC in the early 1990s, serving primarily the chemical industry – which was relatively stable and profitable at the time. Representatives of Center C's member organizations cooperated in a cohesive IAB to guide its research agenda. The 12-member Board selected 9 to 11 projects for funding, based on collective deliberation, and supported the research programme with contributions of testing equipment, supplies and use of their facilities. Center C produced a steady stream of scientific publications and graduates and, around its tenth year, invention disclosures and patent applications.

After ten years, Center C's funding as an NSF single-university IUCRC ended. The Director had planned to expand Center C to a multi-university IUCRC with a broader research programme with some new specialties. Negotiations with two potential university partners took longer than expected. Proposals by faculty scientists for a new research initiative at one prospective partner site did not interest the current IAB and the partner site did not have enough industry sponsors to support the new research area. At another state university, the prospective site Director was an untenured faculty scientist who struggled to find sufficient committed industry support. The first proposal to NSF for a multi-university IUCRC was rejected.

In Center C's 13th year, a second proposal to NSF for a two-university IUCRC succeeded, with a site at another state university and a total of 20 member organizations through the two universities. The Center had operated for three years without an IUCRC grant, relying on its industry support and individually funded research by its scientists, including NSF project grants. During the transition the Director reduced to half-time to cut costs. The site Director at the second university tried, with little success, to take over some leadership

tasks, including member liaison. Within a year the Center hired a 15%-time co-Director of industrial relations.

*Decline and dissolution.* Center C struggled after making the transition to a two-university IUCRC, partly because the lead university site discontinued cost-sharing support. Through the Center's first decade the lead university contributed a full-time administrative assistant, an accountant and at least part of the Director's salary. This support ended at the lead university at around the time the dean of engineering who had served as the Center's institutional champion departed unexpectedly and the Center's first multi-university IUCRC proposal went unfunded. The Center then had to use external funds to support its administrative assistant and other staff. The executive Director took another job, reduced to 10%-time long enough to hire a part-time, interim Director, and then resigned.

Meanwhile, companies in the Center's primary constituency, the chemical industry, experienced budget pressures as global competition increased, and some consolidation. Two of the Center's member companies in the chemical industry merged and retained just one membership; another large chemical company downgraded to non-voting membership; others were acquired and departed. To adapt to changing economic conditions, the Center recruited member companies in the pharmaceutical industry, for whom the Center's current research programme represented a good fit with their R&D priorities.

Two years and two interim Directors later, one of the Center's founding research scientists at the lead university took over as Center Director. Meanwhile, at the second university the site Director had resigned, a second Director had taken over and resigned and an associate dean had been appointed as Director. The new site Director suffered an extended illness and Center C's faculty scientists at the site cooperated to manage relationships with the remaining 3 member organizations there.

By the end of the Center's 15th year the Center still retained 19 member organizations. This reflected both the loss of one or two members each year and compensating gains through recruitment which resulted in expansion into the automotive and other industries, including equipment manufacturing. The second university site continued to retain only 2 to 3 members. Unfortunately, when the new Director took over, several current member representatives expressed dissatisfaction with the Center's management and/or research programme during the preceding years of interim Directors.

The new Director's tenure coincided with the economic decline of 2001, which adversely affected Center C's member organizations in the chemical and pharmaceutical industries with particular severity: that year, Center C lost five members. The next year another four members withdrew.

By the end of its 19th year of operation, Center C had only eight members, including two non-voting members (allowed when the Board agreed to a second category of membership). Center C had fallen below the minimum level of membership support needed for renewal of the NSF multi-university IUCRC award. The Center sent a renewal proposal anyway, including letters of interest (not commitment) from some prospective members. It was returned for clarification; and NSF funding expired.

Center C's Director, with another, newly appointed Director at the second university, conducted energetic (some said 'heroic') campaigns to recruit enough new members to achieve the minimum required for a continuing IUCRC proposal. These efforts proved unsuccessful. Center C's Director and site Director both announced their resignations after the Center's 19th year. An assigned, interim Director closed the Center a year later, after overseeing completion of projects for the remaining industry members.

At Center C, as in the other case of failure at Center P, a contributing factor involved turnover in the role of Center Director. At Center C, however, the highly effective Director wanted to stay, but departed because the host university withdrew financial support for the Center and, specifically and critically, for the Director's salary. Appeals to the lead university by members of Center C's active and supportive Industry Advisory Board failed to regain even limited, financial support from the host college.

Turnover and inexperience in the role of site Director at the second university site probably contributed to the failure of Center C as a multi-university IUCRC. The initial site Director at the second university site, an un-tenured faculty member, had little experience with industry and had little success in recruiting member organizations, even on a sabbatical leave from teaching. The first Director was replaced after less than two years: the role then had three more incumbents in the subsequent five years, all with full-time academic jobs. The second university site struggled the whole time to attract even the minimum membership support required for the site to qualify for the NSF award.

The economic downturn of 2001 probably contributed to the loss of at least nine of Center C's member organizations in the chemical and pharmaceutical industries in a period of just two years. Contributing factors may also have included

mismanagement of the Center's research portfolio, as it replaced topics important to the chemical and pharmaceutical industries with topics designed to attract new members in the automotive and other industries. However, the reasons mentioned most often by member representatives in explaining their decisions to leave involved chaos in the Center's management and/or problems with leadership. The Center never recovered from the setback of losing nine members, which amounted to the loss of its critical mass.

## Discussion

Our four cases of failure suggest that a variety of factors can contribute to the demise of an IUCRC in the USA and, by extension, other types of CRCs and Triple Helix initiatives operating around the world. Further, our single case of success may begin to provide some insight into how to avoid the plight of those that failed. Not surprisingly, our analyses suggest that centres need certain capabilities to succeed and the absence of some key ingredients can contribute to failure. For instance, the lack of doctoral-level programmes at Center A was certainly a key reason for its failure. Such deficiencies are difficult to compensate for and have a relatively immediate effect on survival. Obviously, this is something we could have inferred from studying the characteristics of successful centres. However, our results also suggest that even robust and successful centres can unravel if they confront a hostile environment and/or mishandle key transitions that established centres must navigate. In addition, centres appear to be particularly vulnerable when they have to grapple with multiple and/or cascading challenges.

Our analyses suggest that a variety of environmental factors can contribute to the demise of a centre. Attempting to fit a consortial partnership into an industry where firms are averse to sharing research results with other firms (Center B), or simply have a history of working in a more one-on-one fashion with the PIs (Centers A and C), can prove challenging. In addition, attempting to maintain the interest of talented faculty stakeholders when large sums of extramural research support are readily available from other sources (Center B) can be a difficult task. Finally, maintaining the commitment of firms that are sympathetic but lack absorptive capacity to utilize these findings is probably a losing battle (Center A).

At the same time, even robust and initially successful centres encounter transitions that, if not handled properly, can cause them to lose momentum and eventually unravel. While previous research and analysis has pointed out the importance of leadership in successful centres (Ailes *et al.*, 2000), our cases illustrate

the frequency with which founding Directors depart and highlight the importance of succession planning in sustaining successful centres, an issue we noted in particular in earlier work (Tornatzky *et al.*, 1999). Both Centers P and C were quite successful for an extended period of time but eventually suffered when less capable and less dedicated leaders assumed the director's role. In the case of Center C, turnover in the director role led to inconsistent and inattentive leadership, which the Center could ill afford. In contrast, the successful Center Z made a smooth transition to its second Director, a co-founder able to provide continuity of leadership for the Center as it coped with environmental turbulence.

The impact of external, economic conditions for the centres in these cases apparently depended largely on how the centres dealt with changing conditions in their environments. For example, Centers P, C and Z were all affected by the economic downturn of 2001 and responded in very different ways, with differing results for the centres' failure or success. Center P, with a new and inexperienced Director, made essentially no change in its mode of operation after the economic decline of 2001 because the new Director exercised no meaningful leadership role. The Center retained its one-company, one-project mode of research management. The Center's scientists made limited efforts to recruit new members in the same industries as before, mainly from the troubled chemical industry at the lead university site, before Center P dissolved after practically no centre-wide attempt was made to deal with the economic recession. Center C, also operating with a new and inexperienced Director, apparently mismanaged its research portfolio by replacing projects of interest to its primary membership in the chemical and pharmaceutical industries with new projects designed to appeal to other industries, and failed shortly thereafter.

In contrast, Center Z's more experienced Director responded to the economic setbacks of 2001 by maintaining and enhancing the Center's cooperative approach to research management and mounting an extensive, proactive and globally diversified campaign of recruiting new member organizations. As a result, Center Z weathered the challenging economic conditions by essentially re-constituting the Center's membership with firms from around the globe that survived the economic downturn and subsequently prospered.

Another important factor in tipping the scales toward failure or success involves institutional support. In both of the cases of long-term failure the host university failed to demonstrate the willingness to invest the resources necessary to attract a qualified and motivated leader. In the success case, on the other hand, the host

university has provided sustained support for Center Z: this support even extended to hiring new faculty scientists in key research areas and providing renovation of Center facilities. Of course, host universities need to select which initiatives they will invest scarce resources in and which they will not. Nonetheless, in the cases recounted here the failure of the universities to provide even modest sustaining support appeared to be the 'kiss of death' for these still-viable but struggling partnerships.

During a period of interim or reluctant leadership, additional problems surfaced at the failed centres. At Center P, after the founding Director departed and the replacement Director did not make the necessary effort to support and develop the Center, the lack of cohesiveness and commitment by the IAB became an important problem. In truly consortial centres, cohesive groups of member firms have effectively lobbied the host university to commit the resources needed to sustain a centre. However, because Center P used a more one-on-one mode of research sponsorship its members failed to see and/or use the influence they could wield as a unified group.

Thus embedded in our failure cases are concerns about the extent to which centres that fail actually confront multiple and cascading challenges. Center B had to cope simultaneously with declining interest from member companies and faculty. Stakeholders associated with Center A tried to make it work but the challenges posed by a lack of doctoral level research, member firms with limited R&D capabilities and a Director who lacked the influence that comes with being a tenure-track faculty member were too much to overcome. Both Center P and Center C attempted to manage a leadership transition without much institutional support and while confronting other problems, including a declining economy. In both cases the inability to handle a fairly routine management challenge – replacing the founding Director – appears to have contributed to and exacerbated other Center deficiencies (for example, a lack of cohesiveness among the member's consortia) and resulted in the demise of what had been a successful Center.

Since all of our failure cases involved multi-university centres, the question might arise as to whether this structural feature contributed to the failures. However, we are aware of a large number of successful multi-university centres, and unsuccessful single-university centres and thus we suspect this factor, by itself, more likely represented a complicating rather than a contributing factor. In a multi-university centre, the host university may resist providing additional support during stressful times until partner universities 'ante up' their share; or actually cut support, as

happened at Center C before it unravelled. Equally, in a leadership vacuum, as at Center P, where no site Director exercised leadership in negotiating equitable institutional support from three universities historically willing to provide it, the Center unravelled. A multi-university centre arguably has greater complexity, and more ways to fail, than a single-university centre. These conclusions are consistent with the findings of Cummings and Keisler (2007) who concluded that multi-institutional collaborative arrangements involve a coordination burden that may detract from scientific and related performance.

If we probe more deeply into what contributed to success or failure in all five cases it appears to come down to leadership. All of the failure cases involved shortcomings of leadership: directors departed, did not devote enough time, were marginalized because they were not tenured, or failed to lead their centres through key transitions. In contrast, the successful Center Z had effective leadership, continuity through a transition in the role of Director and effective leadership in coping with environmental turbulence that threatened the Center. *Social capital theory* (Adler and Kwon, 2002; Woolcock, 2001) points to key ingredients present in the success case and absent during the decline and dissolution of the failure cases. At Center Z, the broad experience of Center leaders, the continuity of their tenure, the rich decision-making processes and the intensive outreach to member companies may have built social capital via technical and non-technical interactions. In turn this may have built trust and connectivity and contributed to Center success and survival.

Recent research has identified twelve key dimensions of leadership in CRCs (Craig *et al*, 2009). While they include research-related qualities such as technical expertise and broad thinking and personality characteristics such as ambition and a strong work ethic, many of the dimensions relate to the social and boundary-spanning aspects of leading a complex Triple Helix organization, including balancing competing stakeholders, leveraging social capital, granting autonomy, interpersonal skills and team building and maintenance. When a disruption in centre leadership occurs, as in Centers C and P, what is lost is not just the thread of the R&D agenda but, perhaps more importantly, the connections, informal relationships and friendships that constitute the social capital that binds the participants together.

Research in the general innovation literature supports this proposition. For example, Landry *et al* (2002), in a survey of 440 manufacturing firms, found that technological innovation was enhanced by network participation and relational assets. Similarly, a review

by Nahapiet and Ghoshal (1998) supports the premise that social capital in the form of networks is related to the development and sharing of intellectual capital. An intra-firm survey by Tsai and Ghoshal (1998) indicated that social capital, in the form of inter-unit resource exchange, was related to product innovation. While none of these studies, nor the larger social capital literature, have focused on Triple Helix organizations, our cases suggest obvious questions for future research at CRCs.

## Implications for Triple Helix organizations

CRCs are prototypical Triple Helix organizations. For a centre to be successful it requires a complex balance of institutional resources at the host universities and capabilities within the centre to meet the expectations and needs of the diverse stakeholders. Our analyses suggest that centres can be launched successfully but may falter quickly if they possess some fatal flaw such as limited institutional support on the part of university or limited absorptive capacity by industry. In addition, industries such as biotechnology that place very high importance on exclusive IP rights may decide their needs are not compatible with the very collectively-focused IUCRC centre model and hence withdraw their support.

Our analyses also suggest viable mature centres can unravel when they fail to address organizational problems or challenges – for example, external pressures created by economic recession or changing global markets, or internal transitions such as turnover in the role of Director. Apparently minor problems can multiply and have cascading effects. Obviously, it is in the best interests of centres and the stakeholder groups they serve to understand what key challenges/transitions they are likely to face and prepare to handle them quickly and effectively. To this end, we hope our paper has highlighted some of the more important ones. However, our analyses suggest that at a fundamental level many of these Triple Helix failures derive from a lack, or loss, of effective leadership. This is an issue we have begun to explore in more depth (Rivers and Gray, 2010) and one that we think deserves more attention from the scholarly, policy and managerial communities interested in the success of Triple Helix organizations.

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