Action research and design science, Newton and Darwin, and why IS researchers should try HARDS with Big Tech

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Abstract

Those of us who do research in the field of IS, and who are in schools of business, are commonly faced with rather dim view of the field, figuratively speaking: finance is royalty, accounting is nobility, and the rest (including IS) proudly occupy the house of commons. A major point that is made in this paper is that this can change if IS researchers employ a holistic action research and design science (HARDS) approach, in a way that draws inspiration from the academic trajectories of Isaac Newton and Charles Darwin. It is also argued that IS researchers can particularly benefit from employing HARDS by building closer ties with big technology companies.

Keywords: Information Systems, Action Research, Design Science, Isaac Newton, Charles Darwin

Introduction

Research in the field of information systems (IS) has the potential to disrupt research in other fields, because IS research is often interdisciplinary in nature, even when it is published in IS journals (where non-IS academics are regularly invited to review). A nice way of saying the same thing is to state that IS frequently is a reference discipline that provides the basis for research and new ideas in other disciplines (Baskerville & Myers, 2002). This is not meant to imply that IS provides the basis for new ideas only in other disciplines. As pointed out by Straub (2012), the IS field also creates its own theories; i.e., the IS field provides the basis for new ideas in IS itself.

This applies to IS vis-à-vis other disciplines housed in schools of business, which has the promise to raise the profile of the IS discipline in those schools. In spite of this, it is hard to argue with the fact that those of us in the field of IS who are in schools of business are commonly faced with a somewhat surprisingly and quite different reality, figuratively speaking: finance is royalty, accounting is nobility, and the rest (including IS) proudly occupy the house of commons.

Such reality is somewhat surprising given the increasingly disruptive role that information and communication technologies play in businesses in general (Duan et al., 2019; Raguseo, 2018), often upending entire industries, and a related business phenomenon: the enormous market capitalizations of big technology companies such as Microsoft, Nvidia, Apple, Amazon, Meta, and Alphabet. At the time of this writing, these six big technology companies alone make up over 30 percent of the Standard and Poor's 500 (a.k.a. S&P 500), which is a stock market index that tracks 500 of the largest publicly traded companies in the United States.

A major point that is made in this paper is that this rather dim view of the IS field can change if IS researchers employ a holistic action research and design science (HARDS) approach, and in a way that draws inspiration from the academic trajectories of Isaac Newton and Charles Darwin.

Arguably these two scholars pursued different research trajectories, better and worse aligned with HARDS, respectively, leading to outcomes that could be seen as Newton's triumph and Darwin's tragedy.

Another major point that is made in this paper is that this rather dim view of the IS field can change if IS researchers start building closer ties with big technology companies, while following the HARDS approach, as part of independent IS research teams that are outside of these companies. Even though big technology companies can hire very talented researchers into their ranks, those will not have the same credibility as independent IS researchers, when it comes to studying themselves. It is the independence that comes from being affiliated with an academic or research organization, and not with a big technology company, that makes IS researchers an extremely valuable resource in this context.

Holistic action research and design science (HARDS)

It is instructive to build on the academic experiences of Isaac Newton and Charles Darwin in the context of the HARDS research approach. This will be done later in this paper. In this context, HARDS can be viewed as a new epistemological orientation that integrates, in a holistic way, two key principles from action research (Avison et al., 1999; Baskerville, 1999; Baskerville & Wood-Harper, 1996; 1998; Kock, 2007; Lau, 1999) and design science (Baskerville et al., 2018; Gregor & Hevner, 2013; Iivari, 2007; Järvinen, 2007) applied to the field of IS. These two principles are also consistent with action design research (Sein et al., 2011).

While HARDS can be envisioned as a new epistemological orientation founded on the two principles, discussed below, it is best seen not as a new epistemology nor as a research approach tied to a specific epistemology. For example, in line with previous views underscoring the epistemological diversity in the practice of action research and design science, one can see HARDS as being conducted in both interpretive and positivist ways (Baskerville & Wood-Harper, 1998; Iivari, 2007; Klein & Myers, 1999; Kock et al., 2017). The two principles discussed below draw inspiration from the two pillars of the HARDS research approach, namely action research and design science. The principles build on action research and design science in the context of IS investigations.

Immediate benefit. The first principle is inspired by IS action research (Avison et al., 1999; Baskerville, 1999; Baskerville & Wood-Harper, 1996; 1998; Kock, 2007; Kock et al., 2017; Lau, 1999), and it is that HARDS studies must seek to benefit practitioners while the research is being conducted; as opposed to after the research is completed. This could be called HARDS' immediate benefit principle. For the purposes of our discussion, research completion is defined as the completion of what Susman & Evered (1978) call specifying learning, where the researcher builds on the outcomes of data analyses to create knowledge about the situation under study that is expected to have a certain degree of external validity, being thus generalizable to similar contexts (Kock et al., 2017). Research completion is frequently characterized by the publication of a research report with lessons learned, with both theoretical and practical implications, which could be subsequently submitted to a journal for publication.

For example, let us say that an IS researcher employs questionnaires to gauge the impact of an IS tool in an organization; where the researcher developed, or helped deploy, the IS tool. In this case, the immediate benefit principle is met, because of the use of the IS tool is aimed a benefitting the organization, while data collection (through questionnaires) is taking place. However, if the researcher conducts an online survey of multiple organizations, and then publishes a report analyzing the data to benefit organizations after the research is completed, then the immediate benefit principle is not met.

Useful artifact. The second principle is inspired by IS design science (Baskerville et al., 2018; Gregor & Hevner, 2013; Iivari, 2007), and it is that the benefits provided by HARDS studies to practitioners are centered on one or more IS artifacts that are perceived as useful by the practitioners. This could be called HARDS' useful artifact principle. Typically, the IS artifact (or artifacts) will be a technological implementation, such as a software tool or a hardware device. In some cases, it may be a conceptual tool, such as an IS modeling technique or a data analysis method. For example, if an IS researcher develops a software tool that practitioners pay to use (particularly if they engage in repeated purchases), or a modeling technique that practitioners pay to be taught how to use, then the useful artifact principle is generally met, because presumably practitioners will not pay for an IS artifact that they perceive as being of no use to them.

IS researchers employing HARDS' immediate benefit and useful artifact principles will notice two major advantages to their HARDS research orientation. The first advantage is that they will be close to practitioners who will typically know more about the subject that the researchers are investigating than the researchers do – much more, in some cases. The second advantage is that they will win the support of the practitioners, which will positively influence the perceptions from other researchers about them. After all, research in IS is expected to have a constructive impact on practitioners, and in HARDS this impact occurs even before the research is completed. The positive perceptions from other researchers will help IS researchers employing HARDS succeed in their academic careers. One extra advantage, in addition to the two advantages just discussed, is highlighted by Baskerville et al. (2018). Those authors correctly point out that, if an artifact is novel and useful, then it necessarily contributes to design knowledge.

My experience with HARDS: An overview

Most of my past research has employed the principles that form the foundation of the HARDS approach to IS research, without my having a very clear idea about the use of those principles. One recent area of HARDS research for me has been on the development of data analysis methods and software for conducting structural equation modeling (SEM). SEM has been, and continues being, widely used in IS research and many other fields (Chin & Todd, 1995; Kock, 2023). My colleagues are often surprised to know that my SEM research has drawn inspiration from the work of Newton and Darwin, as will be explained in the next sections, which are also good examples of how to do HARDS well and not so well, respectively.

The SEM software that I developed (an artifact) has over 10,000 users worldwide at the time of this writing. It is a commercial software for which users pay, through purchases of yearly licenses. Many of the users are repeat customers, who voluntarily renew their licenses annually. In this instance of HARDS research, the practitioners are other researchers who employ the analysis methods and software that I have developed; often in partnership with colleagues, notably with respect to methods. This has led to a number of publications and full release of several pieces of intellectual property. My particular focus is on an approach to SEM where latent variables are estimated by aggregating indicators and what are called "measurement residuals", where the indicators are quantifications of answers provided to questions on Likert-type scales in questionnaires.

I try to work very closely with my software's users, some of whom are very sophisticated SEM experts. A few of these experts have posed methodological problems to me that were both difficult to solve, and very promising if solved. Because these experienced SEM experts collectively knew much more than I did about SEM in general, they steered me toward longstanding and important topics that were not necessarily the ones I would have chosen otherwise.

Working on these types of topics, to the point of having publishable outcomes, normally is a slow process. The sophisticated SEM experts who use my software tend to also offer much more to me than reviewers for selective journals where I submit my work, because, as stakeholders, those SEM software users want me to succeed, so that they can also succeed by using a recognized SEM software tool.

My HARDS research on SEM has been published mostly in IS journals, because it is more related to numeric computing than to statistics. That placed me in an advantageous position, but also created an obstacle – resistance from incumbents who see me as unworthy of sitting at the same table as them.

IS researchers, as well as researchers in other fields, are likely to encounter resistance from academic incumbents if those perceive their research as a threat. And, if the research is novel, it will most likely be perceived as such (i.e., as a threat), because it is liable to disrupt the field or subfield that it is targeting. This is, in my experience, particularly the case when the contribution is from outside of a field – e.g., an IS contribution to SEM, which is (i.e. SEM) traditionally seen as belonging in the broader field of statistics. Statistics researchers often review for IS journals, and in many cases pretend to know significantly more about numeric computing than they actually do.

The main point of the paragraphs above is to set the stage for the discussion of the academic trajectories of Isaac Newton and Charles Darwin, in the following sections. As it will be seen, these two scholars pursued different research trajectories. For Newton, better aligned with HARDS than for Darwin. The different outcomes could be seen as Newton's triumph and Darwin's tragedy. Like Newton, I have faced resistance from incumbents, and was able to overcome that, at least to a certain extent, by developing a technological artifact and working very closely with its users. I hope that many IS researchers can draw inspiration from this discussion, especially those who may approach despair when faced with reactions from incumbent academics that may appear to support the dictum: "no good deed goes unpunished".

Isaac Newton's triumph

As previously noted, Isaac Newton is arguably an academic role model in terms of his use of the two HARDS principles. One of the first fields in which Isaac Newton conducted research was optics. At that time, among the most prominent researchers in this field was Robert Hooke, who, as a major incumbent, predictably criticized Newton's disruptive work (Westfall, 1963). At that point Newton had already done a considerable amount of research on topics related to the field of optics, and arguably had staked his career on his ability to make an important academic contribution in that area. So, the criticism could potentially had hampered or even ended Newton's career.

Newton's response was the development of an artifact based on his research in the field of optics, the first functional reflecting telescope, which was an immediate sensation among both academics and the general public. The reflecting telescope was seen as a major improvement over the then prevalent refracting telescope design. Newton provides one of the best examples of how HARDS' immediate benefit and useful artifact principles can lead to desirable outcomes. In fact, HARDS could be called Newton's approach to research, or Newton's epistemological orientation.

Following his applied work on the reflecting telescope, which launched his successful career as an academic, he made several important theoretical contributions in the field of optics.

For much of Newton's subsequent career, he has also developed conceptual artifacts that were used by other researchers in a variety of fields of study. One of these is a generic method to find a root of a function $f(x)$. (Note to readers: the discussion below may seem like a digression, but, as you will see later, it is much more closely connected with this paper's argument than it may look now.) Newton developed this method, but not immediately published it, approximately 20 years before another mathematician, Joseph Raphson, independently developed the same procedure. The technique is often referred to as Newton's method, and sometimes as the Newton-Raphson method. It entails starting with an approximation $\hat{x}$ of the root of the function, and then iteratively changing it by making:

$$\hat{x} = \hat{x} - f'(\hat{x})^{-1} f(\hat{x}).$$

In the equation above, $f(\hat{x})$ is the value of the function for $\hat{x}$, and $f'(\hat{x})^{-1}$ is 1 divided by the first derivative of the function for $\hat{x}$. The iterations take place until the value of $\hat{x}$ changes by less than a small fraction, which is also the point at which $f(\hat{x})$ differs from zero by less than a small fraction. If instead one wants to find the maximum or minimum value of $f(x)$, a different assignment equation, based on the one presented above, is used:

$$\hat{x} = \hat{x} - f''(\hat{x})^{-1} f'(\hat{x}).$$

In the modified equation above, $f''(\hat{x})^{-1}$ is 1 divided by the second derivative of the function for $\hat{x}$. Analogously, iterations take place until the value of $\hat{x}$ changes by less than a small fraction, which is also the point at which $f'(\hat{x})$ differs from zero by less than a small fraction. With the above equation, if one has a good approximation of the point at which a maximum or minimum value of $f(x)$ is to be found, often one can then find the target value $\hat{x}$. As will be explained later, this method had a strong influence on my HARDS work on SEM.

Charles Darwin's tragedy

Newton embraced practitioners and developed artifacts that were useful to them, was embraced back by them, and gained the support of academics during his lifetime. He died in 1726 aged 84, fairly wealthy in part because at the end of his career he went into finance (he literally printed money, legally). Charles Darwin, who published his theories of evolution by natural and sexual selection in 1859 and 1871 respectively (Andersson, 1982), had a different experience. His publications captured the public's imagination, but he never gained true academic recognition during his lifetime.

Darwin's detailed descriptions of evolution by natural and sexual selection (Oldroyd, 1986; Ruse, 1975) can be seen as descriptions of a fundamental algorithm that leads to modifications of traits across generations of living organisms. This fundamental algorithm can be viewed as an invaluable conceptual artifact. Arguably the most obvious practitioners who could have benefited from this conceptual artifact developed by Darwin were animal breeders. Even though Darwin was interested in animal breeding (Secord, 1981), he was not close enough to breeders to fully take advantage of their knowledge.

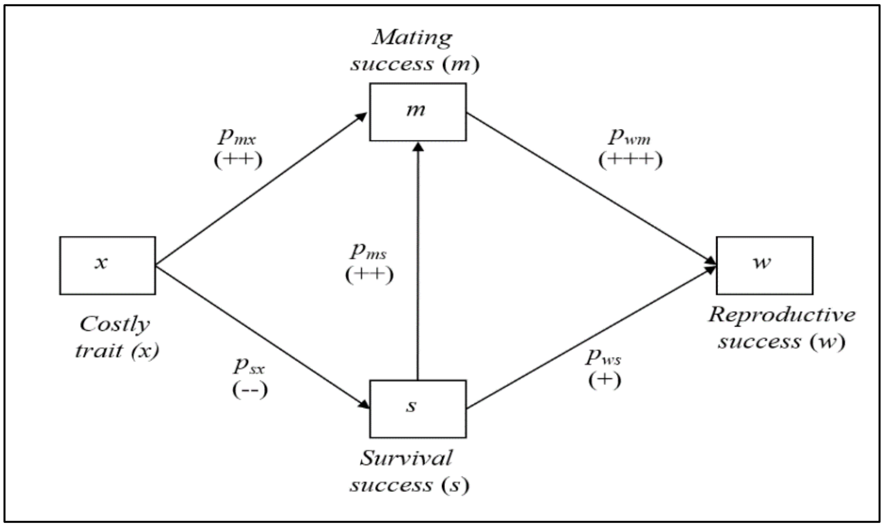
The above has led to some flaws making their way into Darwin's formulation, which severely undermined its support by the academic community. One major flaw was that of blending inheritance (Vorzimmer, 1963), or the belief that offspring would inherit traits from the parents in a "blending" way. For example, if one parent had blue eyes, and the other had dark brown eyes, the offspring would be expected to have an eye color somewhere in between, like a dark muted blue eye color. Blending inheritance was in fact the opposite of what was frequently obtained by animal breeders: an exaggeration of traits that made breeds unique.

If Darwin had followed HARDS' immediate benefit and useful artifact principles, it is my view that he would have been too close to animal breeders to even remotely subscribe to the idea of blending inheritance. Moreover, many animal breeders happened to be farmers who were also devout Christians, whose faiths' leaders turned out to be among Darwin's most vociferous detractors. Perhaps those leaders would have been less vociferous if Darwin had the support of their constituents. Another unfortunate aspect of Darwin's work was that he was unaware of the theory of particulate inheritance, which ironically had been developed by a Catholic priest named Gregor Mendel.

Sewall Wright to the rescue

Darwin died in 1882. His theoretical formulations would only gain proper footing and academic recognition through their integration with Mendelian genetics, which required the development of new mathematical tools in the early 1900s. This integration and related mathematical tools emerged as a new field, population genetics. One important mathematical tool developed in this context was path analysis, proposed by Sewall Wright, one of the founders of the field of population genetics. This form of analysis relies on the use of path models, where variables are causally connected through arrows (Wright, 1934). Figure 1 shows an example of path model. This tool directly influenced my HARDS work on SEM, as will be discussed later (because of this, the discussion below is not a digression, even though it may look like one).

Figure 1. Example of path model



Under each path coefficient (e.g., p_{mx}) there are symbols that indicate the sign of the path's association and its strength; e.g., "+++" indicates a positive and strong association. The variables in the model (e.g., x) are measures that apply to a population of individuals. For example, in a table with population data, each column could refer to a variable, and each row could refer to an individual in the population, over a period of time. In path analysis all variables are assumed to be standardized; i.e., scaled to have a mean of zero and standard deviation of one.

The path model not only illustrates how a genotype-based costly trait (x) could spread through a population (i.e., evolve), but also sets the necessary condition for this to happen. The condition is that the total effect of x on reproductive success (w) has to be positive, where reproductive success is measured as the number of surviving offspring of an individual. In our simple illustrative model, x is assumed to take one of two values, 1 or 0, referring to the genotype-based costly trait in question being present or not. A costly trait is defined as one that has a negative impact on survival success.

In this example, survival success (s) is measured as the age of an individual at the time of death, and mating success (m) as the number of lifetime copulations in which the individual has engaged. Survival success (s) is shown as a precursor of mating success (m) because an individual normally must be alive to engage in sexual intercourse, even if the individual dies as a result of the intercourse (e.g., female spider sexual cannibalism). For our path model, the condition that the total effect of x on w has to be positive is expressed in the equation below.

$$p_{mx}p_{wm} - p_{sx}p_{ws} - p_{sx}p_{ms}p_{wm} > 0.$$

Path analysis provides a mathematical foundation on which one can easily understand something that was a major problem for Darwin, namely the evolution of costly traits (Hiraiwa-Hasegawa, 2000). This was a problem for Darwin even though he developed a theory of sexual selection, and costly traits often evolve in this context. The classic example of costly trait evolution is the male peacock's train, also a good example of sexual selection. (Both male and female peacocks have tails; only males have trains.) Males of the peacock species have evolved elaborate, large, and colorful trains via selection; at the expense of their own survival. Among other handicaps, the trains impair mobility, making it more difficult for the male peacocks to flee predators. The reason for their evolution is that the trains make the male peacocks more attractive to the females (Zahavi & Zahavi, 1997).

Sewall Wright was an evolutionary biologist and geneticist who was very close to animal breeders. One of his chief interests was the study of the impact that inbreeding, caused by the heavy form of artificial selection typically employed at the time by animal breeders, had on livestock used in American beef production. Wright clearly employed HARDS' immediate benefit and useful artifact principles, by working closely with animal breeders and developing useful artifacts (e.g., path analysis). In doing so, he significantly contributed to rescuing Darwin's natural and sexual selection theories from extinction.

My experience with HARDS: A new form of SEM

Wright's path analysis is essentially a sequence of least squares regression analyses with standardized variables. It happens to be one of the key foundations on which SEM rests. In fact, from a conceptual point of view, SEM is path analysis with latent variables. In practice, it is not, in part due to Newton's method. In SEM, conceptually the latent variables are quantifications of factors, which are mental constructs that are measured indirectly and with error through indicators. The indicators, in turn, are quantifications of answers provided to questions on Likert-type scales in questionnaires (Kline, 2023; Maruyama, 1997).

One of the most fundamental problems with SEM is that it has been so far impossible to estimate the latent variables in a way that leads to estimates of parameters obtained via path analysis (e.g., path coefficients) that converge to the true population values as sample sizes increase. But it is possible to create functions of the parameters that minimize the differences between: (a) the indicator covariances in any empirical samples being analyzed; and (b) the indicator covariances estimated based on the model, known as model-implied covariances. This minimization is done iteratively, starting with well-informed initial guesses of the parameters. Let us go back to Isaac Newton's technique to find the minimum value of a function $f(x)$:

$$\hat{x} = \hat{x} - f''(\hat{x})^{-1} f'(\hat{x}).$$

If we extrapolate Newton's technique from a single variable x to a set of parameters stored in a vector θ, the function above takes the form below, where: each element of the vector $u(\hat{\theta})$ is calculated as the first derivative of a function F of the difference between the model-implied and actual indicator covariance matrices, with respect to each parameter. Typically, the function F is the maximum likelihood function; although other functions can also be used – e.g., the generalized least squares function. Each element of the Hessian matrix $H(\hat{\theta})$ is calculated as the second derivative of the function F with respect to each parameter.

$$\hat{\theta} = \hat{\theta} - H(\hat{\theta})^{-1} u(\hat{\theta}).$$

The approach to SEM based on the equation above entails starting with initial parameter estimates, stored in $\hat{\theta}$, and then generating new estimates iteratively until final convergence is achieved. This general approach employing Newton's method is known as covariance-based SEM (Kline, 2023). A competing approach, known as partial least squares (PLS) path modeling, entails generating linear combinations of the indicators that are used as approximations of latent variables that are then used in a path analysis. This competing approach, however, yields parameter estimates that do not converge to the true population values as sample sizes increase (Kock, 2019).

As noted earlier, one recent area of HARDS research for me has been on the development of data analysis methods and software for conducting a new form of SEM, where latent variables are estimated by aggregating indicators and a new entity that is called "measurement residual", and in a way that leads to estimates of parameters (e.g., path coefficients) that converge to the true population values as sample sizes increase. I do this by employing Wright's artifact and conducting a path analysis that yields coefficients with the precision of covariance-based SEM employing Newton's method. The latter is the gold standard, which I use in comparisons based on simulated data, and also the basis for some of the ideas that underlie my SEM approach.

Using HARDS in IS research partnering with Big Tech

While I have been employing HARDS in IS by developing data analysis methods and software for conducting the new form of SEM discussed above, and I think this has been quite useful for my research, I do not consider this to be the most efficient or effective way of practicing HARDS in IS. The reason is that, in mine and similar cases, we have one or a few individuals doing nearly all the work: research design, software development, interaction with software users, research execution (using Monte Carlo simulations), reporting of results, submission to publication outlets, and many other related tasks.

This situation is akin to that of a small business, where the owner or a few co-owners do all the work. The most efficient and effective approach to conducing HARDS, is arguably to grow this small business into a larger one, where distinct stakeholders specialize in different areas. A particularly promising structure applied to the study of IS artifacts in organizations is arguably one in which: (a) IS research is conducted by one team, and IS development and deployment is conducted by another; and (b) the IS research team is affiliated with an academic or research organization, and the IS development and deployment team is affiliated with a large technology organization. Typically, in this arrangement, the end users of the IS artifacts are the large technology organization's customers.

The structure above has two main advantages, for researchers concerned with the study of IS artifacts in organizations, and for large technology organizations. Those IS researchers, who will typically be affiliated with schools of business, will normally not be as competent at IS artifact development and deployment (e.g., software development and deployment) as colleagues in schools housing computer science and engineering researchers. And even the latter will not be able to match the IS artifact development and deployment prowess of large technology organizations (this applies even to professors and researchers in elite universities). So, by collaborating with an IS development team that is affiliated with a large technology organization, the IS research team will bring into the overall project unique skills that will arguably make the research outputs more valuable.

Among other benefits, the IS research team will have access to data that will be difficult to replicate by other IS research teams, increasing the chances of publication in highly visible (and also highly selective) outlets. Moreover, the IS research team will not have to deal with the internal organizational politics related to IS artifact development and deployment, which can sometimes bring projects to a halt, because the large technology organization will be in charge of that development and deployment. Nevertheless, IS research teams will have to be careful with how they approach the politics of research reporting, as exemplified by the case of Joan Donovan, a researcher who was allegedly pushed out of a unit of Harvard University that indirectly received research support and funding from Meta, for publishing study results that portrayed Meta in a negative light (O'Sullivan & Duffy, 2023). Apparently, this was done without Meta’s consent; a special case of a broader theme that is revisited shortly in this paper.

The second advantage, for large technology organizations, comes from the fact that they do not have the same credibility as an independent IS research team, when it comes to studying themselves. Many large technology organizations employ very competent internal IS researchers (frequently recruited from elite universities), who can be collaborators working with an independent IS research team employing HARDS. But it is the independence that comes from being affiliated with an academic or research organization, and not with the large technology organization, that makes IS researchers an extremely valuable resource to a large technology organization in this context.

One issue that may arise in the context above is whether it is ethical for the independent IS research team to publish research that portrays the collaborating large technology organization in a negative light. The answer to this question is “no”, if the technology organization does not agree with the publication, in which case potentially important findings of the research could eventually go unpublished. In our formulation of HARDS, discussed here, it would be generally unethical to gain support from a technology organization and then stab them in the back by publishing without consent. This stance is consistent with the idea of informed consent by human subjects, often enforced by institutional review boards (IRBs) of academic and research organizations.

If an IS research team affiliated with an academic or research organization wants to expose via research the possible evils perpetrated by a technology organization, which is a valuable and highly meritorious research goal, they should employ other approaches. One such approach could be to collaborate with government agencies that regulate technology organizations, agencies that can extract incriminating data from those technology organizations by force.

It would be difficult, in my view, to employ HARDS in the above context, which could be seen as one of the weaknesses of the HARDS approach. This brings us to an important point that should be stressed: HARDS is not applicable in all IS research contexts, nor is HARDS the only approach that we see as worthy of being used by IS researchers. Also, while one can see merit in a career-long dedication to HARDS in the field of IS, which is well-aligned with my personal orientation and those of many academic colleagues, clearly researchers in the IS field would be wise to employ HARDS for some topics and not for others.

Discussion and conclusion

This paper discusses HARDS as a new epistemological orientation that integrates, in a holistic way, two key principles derived from action research and design science, applied to the field of IS. These are the immediate benefit and useful artifact principles. While HARDS is presented as a new epistemological orientation, it should not be seen as a new epistemology or as an epistemology-specific research approach. For example, arguably HARDS can be conducted in both interpretive and positivist ways.

Two advantages associated with IS researchers employing HARDS' immediate benefit and useful artifact principles were emphasized. The first advantage was that IS researchers will be close to practitioners, who will typically know more about the subject that the researchers are investigating than the researchers themselves will. The second advantage emphasized was that IS researchers will win the support of industry practitioners, which will positively influence the perceptions from other researchers about them, and help IS researchers employing HARDS to succeed in their academic careers.

How can IS researchers with no Big Tech contacts approach large technology organizations? One of the best ways to do that is to contact the research divisions of Big Tech firms. Let us take Meta for example. Meta Research (https://research.facebook.com) is Meta's main research division. Meta Research provides a number of databases that can be analyzed by IS researchers, as well as financial sponsorship by way of a number of research awards, which are funded through calls for research project proposals. These are available to IS researchers from the US and other countries.

Analyzing public datasets and obtaining financial sponsorship for targeted research are arguably entry points, through which other more exclusive opportunities may become available to IS research teams once they become trusted insiders. This approach to funding independent IS research teams, even though Big Tech firms have their own research teams, is advantageous to large technology organizations. This is because, as noted earlier, Big Tech firms do not have the same credibility as independent IS research teams, when it comes to studying themselves.

Let us go back to the scenario discussed earlier, where an IS research team affiliated with an academic or research organization wants to expose, via research based on data from government agencies, the evils perpetrated by a technology organization. There is a problem with this scenario that may not be so obvious to IS researchers: the incriminating data from the government agencies will very likely be shared with multiple research teams, if not made publicly available. This will lower the value of the related IS research contributions, decreasing the chances of publication in highly visible (and also highly selective) outlets for research teams, outside a small group of first movers.

An alternative approach that would employ HARDS would be to convince the collaborating large technology organization to allow the publication of research that portrays them in a negative light. This is, in my view, quite possible if HARDS practitioners highlight the advantages of that approach in preparation for possible prosecution or lawsuits by government agencies. By allowing the publication of HARDS research that portrays them in a negative light, and adopting internal measures to address the problems unveiled by the research, large technology organizations can significantly improve their standings as defendants in future prosecutions or lawsuits (it works for cigarette makers). They can also do good for society, by doing good for their customers, should a deep sense of ethics and dedication to their customers be part of their organizational culture.

Table 1 provides IS researchers with a set of guidelines on how to successfully use HARDS, along with illustrative examples. The guidelines and illustrative examples summarize the main points made in the discussion presented in this paper. The sequence in which the guidelines are listed, from top to bottom, mirrors the order in which the related topics have been discussed in the paper so far. The progression leads to a scenario where IS research teams and Big Tech firms become close collaborators. These are envisioned as relationships that are based on IS research teams' deep commitment to the general rule of informed consent by human subjects, often enforced by institutional review boards (IRBs) of academic and research organizations.

Table 1. Guidelines on how to use HARDS and illustrative examples

Guideline	Illustrative example
Seek to benefit practitioners while the research is being conducted, as opposed to only after the research is completed.	An IS research team employs questionnaires to gauge the impact of an IS tool in an organization; where the IS research team developed and helped deploy the IS tool. Here the research team benefits practitioners, while the research is being conducted, by doing the latter - helping deploy the IS tool that the team developed. This is so even though the main scholarly learning outcomes will come after the data collected via questionnaires are carefully analyzed.
Focus on one or more IS artifacts that are perceived as useful by the practitioners.	An IS research team develops a software tool to model and analyze business processes, which practitioners pay to use repeatedly, via multiple yearly licenses voluntarily renewed annually, as well as a modeling technique that practitioners pay to be taught how to use together with the software tool. Here the practitioners are willing to pay because they see value in the use of the software tool and the related modeling technique.
Employ a structure in which the IS research is conducted by one team, and IS development and deployment is conducted by another.	An IS research team at a university, which is interested in studying the impact of enterprise systems on the interactions among C-suite executives and management accountants, partners with an IS development and deployment team working for a large firm that develops and commercializes enterprise systems.
Employ a structure in which the IS research team is affiliated with an academic or research organization, and the IS development and deployment team is affiliated with a Big Tech firm.	An IS research team at a university, which is interested in studying the impact of media naturalness on the interactions among C-suite executives and management accountants in a metaverse-like environment, partners with an IS development and deployment team working for Meta in the development of one of its experimental version of the metaverse. Here the technology development and deployment experts are at Meta, not at the university; even though university employees and

Guideline	Illustrative example
	students, interested in technology development and deployment, can also participate in and learn much from the collaboration.
Do not publish research results without the consent of the collaborating firm, particularly if those results portray the firm in a negative light.	An IS research team at a university studies data provided to it by a Big Tech firm, and uncovers results that seem to portray the firm in a negative light. The research team candidly informs the firm about the results, which does not consent to publication. The team respects the decision and does not publish. Doing otherwise would be inconsistent with the idea of informed consent by human subjects, often enforced by institutional review boards (IRBs) of academic and research organizations.
Establish research partnerships with Big Tech firms by contacting the research divisions of those firms.	An IS research team at a university approaches Meta Research, Meta's main research division, and obtains a few databases that are analyzed by the team. The IS research team then writes a study report and shares with Meta Research, which signals its approval of publication. This subsequently leads to a few publications by the IS research team in selective academic journals of high visibility.
Use initial research partnerships with Big Tech firms, via research divisions of those firms, as entry points for long-term funded relationships.	An IS research team at a university uses a few publications by the team, in selective academic journals of high visibility, as a basis to apply for funding from Meta Research, by competing with other universities and research centers in a public call for research project proposals. The prior collaborative research experience, and the high visibility publications by the research team, give the university an upper hand over its competitors. As a result, it gets the funding, which subsequently leads to a long-term research relationship and continued access to more exclusive data and research funding.

If the IS research community sees benefit in the HARDS approach to IS research, there are a number of topics that need to be further explored and that are outside the scope of this paper. For example, there are important methodological problems and benefits that emerge from using HARDS in IS studies, some of which are likely to be similar to those discussed in an article on the use of positivist action research in IS (Kock et al., 2017). Other topics to be further explored are: which subjects are more or less amenable to the use of HARDS, how to gain access in HARDS investigations to organizations that use IS artifacts, what ethical issues should be considered regarding the impact on employees' well-being in organizations where HARDS studies are conducted, how to combine different research methods in the context of HARDS studies, and how to best employ HARDS with different epistemologies.

References

Andersson, M. (1982). Sexual selection, natural selection and quality advertisement. *Biological Journal of the Linnean Society*, 17(4), 375-393.

Avison, D. E., Lau, F., Myers, M. D., & Nielsen, P. A. (1999). Action research. *Communications of the ACM*, 42(1), 94-97.

Baskerville, R. L. (1999). Investigating information systems with action research. *Communications of the Association for Information Systems*, 2(1), 19.

Baskerville, R. L., & Myers, M. D. (2002). Information systems as a reference discipline. *MIS Quarterly*, 26(1), 1-14.

Baskerville, R. L., & Wood-Harper, A. T. (1996). A critical perspective on action research as a method for information systems research. *Journal of Information Technology*, 11(1), 235-246.

Baskerville, R., & Wood-Harper, A. T. (1998). Diversity in information systems action research methods. *European Journal of Information Systems*, 7(1), 90-107.

Baskerville, R., Baiyere, A., Gregor, S., Hevner, A., & Rossi, M. (2018). Design science research contributions: Finding a balance between artifact and theory. *Journal of the Association for Information Systems*, 19(5), 1-20.

Chin, W. W., & Todd, P. A. (1995). On the use, usefulness, and ease of use of structural equation modeling in MIS research: A note of caution. *MIS Quarterly*, 19(2), 237-246.

Duan, Y., Edwards, J. S., & Dwivedi, Y. K. (2019). Artificial intelligence for decision making in the era of Big Data – evolution, challenges and research agenda. *International Journal of Information Management*, 48(1), 63-71.

Gregor, S., & Hevner, A. R. (2013). Positioning and presenting design science research for maximum impact. *MIS Quarterly*, 37(2), 337-355.

Hiraiwa-Hasegawa, M. (2000). The sight of the peacock's tail makes me sick: The early arguments on sexual selection. *Journal of Biosciences*, 25, 11-18.

Iivari, J. (2007). A paradigmatic analysis of information systems as a design science. *Scandinavian Journal of Information Systems*, 19(2), 1-23.

Järvinen, P. (2007). Action research is similar to design science. *Quality & Quantity*, 41(1), 37-54.

Klein, H. K., & Myers, M. D. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS Quarterly*, 23(1), 67-93.

Kline, R.B. (2023). *Principles and practice of structural equation modeling*. New York, NY: The Guilford Press.

Kock, N. (2019). From composites to factors: Bridging the gap between PLS and covariance-based structural equation modeling. *Information Systems Journal*, 29(3), 674-706.

Kock, N. (2023). Contributing to the success of PLS in SEM: An action research perspective. *Communications of the Association for Information Systems*, 52(1), 730-734.

Kock, N. (Ed.) (2007). *Information systems action research: An applied view of emerging concepts and methods*. New York, NY: Springer.

Kock, N., Avison, D., & Malaurent, J. (2017). Positivist information systems action research: Methodological issues. *Journal of Management Information Systems*, 34(3), 754-767.

Lau, F. (1999). Toward a framework for action research in information systems studies, *Information Technology & People*, 12(2), 148-175.

Maruyama, G. (1997). *Basics of structural equation modeling*. New York, NY: Sage.

Oldroyd, D. R. (1986). Charles Darwin's theory of evolution: A review of our present understanding. *Biology and Philosophy*, 1(1), 133-168.

O'Sullivan, D., & Duffy, C. (2023, December 4). Former Harvard disinformation scholar says she was pushed out of her job after college faced pressure from Facebook. *CNN*. https://www.cnn.com/2023/12/04/tech/facebook-disinformation-whistleblower/index.html

Raguseo, E. (2018). Big data technologies: An empirical investigation on their adoption, benefits and risks for companies. *International Journal of Information Management*, 38(1), 187-195.

Ruse, M. (1975). Charles Darwin's theory of evolution: An analysis. *Journal of the History of Biology*, 8(2), 219-241.

Secord, J. A. (1981). Nature's fancy: Charles Darwin and the breeding of pigeons. *Isis*, 72(2), 163-186.

Sein, M. K., Henfridsson, O., Purao, S., Rossi, M., & Lindgren, R. (2011). Action design research. *MIS Quarterly*, 28(1), 37-56.

Straub, D. (2012). Editor's comments: Does MIS have native theories? *MIS Quarterly*, 36(2), iii-xii.

Susman, G.I., & Evered, R.D. (1978). An assessment of the scientific merits of action research. *Administrative Science Quarterly*, 23(4), 582-603.

Vorzimmer, P. (1963). Charles Darwin and blending inheritance. *Isis*, 54(3), 371-390.

Westfall, R. S. (1963). Newton's reply to Hooke and the theory of colors. *Isis*, 54(1), 82-96.

Wright, S. (1934). The method of path coefficients. *The Annals of Mathematical Statistics*, 5(3), 161-215.

Zahavi, A., & Zahavi, A. (1997). *The Handicap Principle: A missing piece of Darwin’s puzzle*. Oxford, England: Oxford University Press.