New world, or out of this world? Columbus – an exploratory study of HASS and STEM success factors in the first "space" race

Richard M. Kerslake
Independent Researcher, Burnie, Australia, and
Chandrasekhar Krishnamurti
UniSA Business, University of South Australia, Adelaide, Australia

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Abstract

Purpose – The purpose of this paper is to investigate the extent to which interdisciplinary (HASS, i.e. non-STEM) factors—in particular, accounting, stakeholder management and accountability—enable, influence and motivate large human exploration ventures, principally in maritime and space fields, utilizing Columbus's and Chinese explorations of the 1400s as the primary setting.

Design/methodology/approach – The study analyzes archival data from narrative and interpretational history, including both academic and non-academic sources, that relate to two global historical events, the Columbus and Ming Chinese exploration eras (c. 1400–1500), as a parallel to the modern "Space Race". Existing studies on pertinent HASS (Humanities and Social Sciences) and STEM (Science, Technology, Engineering and Mathematics) enablers, influencers and motivators are utilized in the analysis. The authors draw upon the concepts of stakeholder theory and the construct of accountability in their analysis.

Findings – Findings suggest that non-STEM considerations—politics, finance, accountability, culture, theology and others—played crucial roles in enabling Western Europe (Columbus) to reach the Americas before China or other global powers, demonstrating the pivotal importance of HASS factors in human advancements and exploration.

Research limitations/implications – In seeking to answer those questions, this study identifies only those factors (HASS or STEM) that may support the success or failure in execution of the exploration and development of a region such as the New World or Space. Moreover, the study has the following limitation. Relative successes, failures, drivers and enablers of exploratory ventures are drawn almost exclusively from the documented historical records of the nations, entities and individuals (China and Europe) who conducted those ventures. A paucity of objective sources in some fields, and the need to set appropriate boundaries for the study, also necessitate such limitation.

Practical implications – It is observable that many of those HASS factors also appear to have been influencers in modern era Space projects. For Apollo and Soyuz, success factors such as the relative economics of USA and USSR, their political ideologies, accountabilities and organizational priorities have clear echoes. What the successful voyages of Columbus and Apollo also have in common is an appetite to take risks for an uncertain return, whether as sponsor or voyager; an understanding of financial management and benefits measurement, and a leadership (Isabella I, John F. Kennedy) possessing a vision, ideology and governmental apparatus to further the venture's goals.

Originality/value – Whilst various historical studies have examined influences behind the oceangoing explorations of the 1400s and the colonization of the "New World", this article takes an original approach of analyzing those motivations and other factors collectively, in interdisciplinary terms (HASS and STEM). This approach also has the potential to provide a novel method of examining accountability and performance in modern exploratory ventures, such as crewed space missions.

Keywords STEM, New world, HASS factors, Space race

Paper type Research paper

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1. Introduction

The concept of accountability has been embraced not only in accounting but also in various human endeavors. Lerner and Tetlock (1999) define accountability as "the implicit or explicit expectation that that one may be called on to justify one's beliefs, feelings and actions to others". Implicit in this definition is that there might be significant consequences for not supplying adequate justification. The lens of accountability has been used in the study of several outcomes, such as Corporate Social Responsibility (Baudot *et al.*, 2022), block-chain systems (Tyma *et al.*, 2022), religious organization (Moggi *et al.*, 2016), customer–supplier negotiations (Chang *et al.*, 2013) and innovation strategy (Verwaeren and Nijstad, 2022). We note that the accountability lens has not been used to study human expeditions, such as the "Space Race".

We extend this literature by conducting an exploratory study on the role of accountability in driving the first global "space race" of the fifteenth to sixteenth centuries. Whilst many historical studies of accounting, and to some extent accountability, exist, a wide examination of the extant literature did not reveal any previous studies of exploration though the accountability and HASS/STEM measurement lens that we adopt. Therefore, this paper is an exploratory study that will enable other scholars to support, extend, build upon or even refute the findings and insights developed in this paper.

Hypothetically, with superior maritime technology, manufacturing, engineering and medicine—STEM capabilities [1]—the Chinese were far better placed in the fifteenth century than other nations to "discover", colonize, settle and develop the Americas and, Australia, but that did not occur. Therefore, it appears that enhanced STEM capabilities are not the be all and end all concerning achievements of this nature. There must be other reasons. This paper views this issue from a multidisciplinary perspective, and conjectures that non-STEM, i.e. HASS [2], factors—politics, accounting, finance, accountability, culture, theology, and others—played crucial roles in allowing Columbus to reach "undiscovered" territories, viz. the Americas before China, and, thereby, demonstrates the pivotal importance of HASS in human advancements and exploration. In particular, we examine this issue using the accounting/accountability and stakeholder engagement lenses.

For 500 years, the Americas (North and South), historically termed the "New World", have been the subjects of a story of massive expansion, economic growth and the displacement of indigenous populations by European powers and cultures. From a Western viewpoint, New World colonization expanded Earth's land space by almost 50%. The navigators, armies, enterprises and colonists of Britain, Spain, France and Portugal principally led what we could term the first global "space" race. In the Americas and Australasia today, a billion people speak those European nations' languages, whereas, apropos to this article, only a small percentage speak Chinese as their first language.

We are motivated by the relative scarcity of work in the space accounting area (Alewine, 2020; Tucker and Alewine, 2022), and take their call for further research in this area.

We address the following questions in this study:

(1) "Why Columbus?": what factors (HASS and STEM) enabled, influenced and motivated Columbus and his European successors, rather than China, to dominate and colonize the Americas?

(2) Why, given their evident technological (STEM) superiority over Europe, did the Chinese not undertake comparable exploratory and colonial programs (e.g. to the Americas or Australasia) in the same era?

(3) What lessons does this hold in understanding the HASS vs STEM interdisciplinary factors behind similar modern ventures, such as crewed space explorations?

In seeking to answer those questions, this study identifies only those factors (HASS or STEM) that may support success or failure *in execution* of the exploration and development of a region, such as the New World or space.

Based on a review of both historical writings and current journal articles, we find that HASS factors, not least accounting and accountability, are likely factors contributing to the success of Columbus's expedition to North America relative to potential Chinese expeditions. While the balance of STEM factors was tilted in favor of China, the fact that China did not attempt a similar venture highlights the importance of HASS factors—particularly, accounting and accountability.

We motivate our study based on two compelling rationales. First, most experts writing about the future of space tend to concentrate on technological issues, rather than HASS issues. For instance, the KPMG (2020) report covering the views of 30 experts regarding the future of space as of 2030 pay little attention to HASS issues. In this paper, we draw parallels from the "first" human space exploration, which we believe will hold implications for future space explorations, such as the mission to Mars.

The second motivation is a theoretical one. While technical factors may be a necessary condition for most path-breaking endeavors, the role of non-STEM factors, including HASS, has been underexplored. Our work, by focusing on HASS factors—particularly, accounting and accountability—highlights the complementary role played by these two types of drivers.

We compare China and Western Europe for the following reasons. First, both had the capability to undertake long voyages. Their exploration objectives were comparable. In the case of Columbus, it was trade and potential riches. For China, it was national pride and extending the maritime silk road. Since other societies did not have comparable capabilities for similar expeditions during the fifteenth century, we did not consider them. We have kept our focus narrow in examining the factors that explain the "first space race", and do not include other contexts, such as the Norse and Arab explorations, mainly due to the relative paucity of historical materials, and our lack of expertise in handling materials in languages other than English.

Our work contributes to the emerging literature on space accounting. Alewine (2020) reviews the space accounting literature and addresses the issues of identifying accounting challenges in the space economy and suggests research strategies to address accounting challenges. Our contribution lies in assessing the relative roles of STEM and non-STEM factors in space exploration, such as accounting and accountability. In particular, our work examines how accountability affects human exploration activity. Our work suggests that while STEM capabilities are a necessary condition, they are not sufficient as drivers of space exploration. We find that accountability plays a significant role, suggesting that HASS factors matter significantly in our examination of the first global "space race".

The rest of the paper is structured as follows. The following section describes the theoretical framework underlying our work. This is followed by the methodology section, wherein we describe how the research questions were examined. We then provide a historical overview of the first "space exploration", comparing Europe with China. In the following section, we describe the enablers, influencers and motivators that highlight the differences in STEM and HASS factors, emphasizing accounting and accountability. We draw parallels to the modern space race in the subsequent section. In the final section, we conclude the paper with a discussion of our results, outlining our contribution to the literature, suggesting implications for practice, as well as acknowledge the limitations and pitfalls of our study, and offer suggestions for future work.

2. Theoretical framework

The theoretical motivation for our paper is to explore the role of HASS factors, particularly accounting and accountability, which have so far not been explored in the context of the space race. We are inspired by Tucker and Alewine (2022), who suggest that the social sciences

have enormous potential to contribute to interdisciplinary research in the space sector. In particular, we focus on accounting and accountability, which are part of the HASS umbrella.

The concept of accountability is complex and takes on different meanings, depending on the context and time (Deegan, 2009). In the words of Gray *et al.* (1996, p. 38), accountability is "the duty to provide an account (by no means necessarily a financial account) or reckoning of those actions for which one is held responsible". Accountability may be characterized as either external or internal accountability, conditional on who holds an organization to be accountable (Ebrahim, 2003a). Demands for external accountability could arise from legal requirements for disclosure, or moral obligations to donors and beneficiaries (Cordery and Baskerville, 2011), whereas internal accountability pressures are mostly driven by cognizance of valuation actions and the taking of internal responsibility for actions (Ebrahim, 2003b).

Accountability as a concept is used extensively in multiple disciplines, such as accounting, management, psychology, human resource management and marketing. There are several conceptual models of accountability, such as the pyramid model (Schlenker *et al.*, 1991, 1994), social contingency model (Tetlock, 1985, 1992) and phenomenological view (Frink and Klimoski, 1998), to name a few [3].

Hall *et al.* (2017) proposed the notion of features of the accountability environment. One of the features they highlighted is accountability focus: the extent to which there is emphasis on process vs outcomes. Process accountability demands that individuals need to justify their decision-making process, while outcome accountability requires individuals to explain the outcomes of their decisions. We focus on outcome accountability in the context of space exploration.

As outlined by Ebrahim (2010), accountability is a relational concept that depends upon the relationships between actors and organizations in different contexts. The concept of accountability is inextricably tied to stakeholders. Freeman and Reed (1983, p. 91) characterize a stakeholder as "any identifiable group or individual on which the organization is dependent for its continued survival". Stakeholder theory is generally applied to the corporate context. However, Freeman (2010) suggests that it is increasingly used in the public sector and by nonprofit organizations, due to its management implications.

Prior research has used the concept of accountability and stakeholder engagement in a variety of non-corporate contexts. For instance, Moggi *et al.* (2016) describe the accountability features of Confraternities in Verona during the seventeenth century. Bigoni *et al.* (2013) assess the presence of a sacred–secular dichotomy during the fifteenth century in the Roman Catholic Church, by analyzing the role of accounting and accountabilities. Dobie (2015) studied the role of general and provincial chapters in Benedictine monasteries during thirteenth-to fifteenth-century England in the diffusion of accounting and financial management practices.

Scott *et al.* (2003) study the influence of government as the main stakeholder on the use of cash and accrual accounting in New South Wales's hospitals. Funnell (2006) attributes ineffective and deceptive accounting systems to costly administrative failures during the South African war of 1899–1902. Ferry *et al.* (2023) examined the accountability and disciplinary practices embedded in the codes of conduct and corporate governance in English local government, using Foucauldian archaeological and genealogical perspectives.

Robertson and Funnell (2012) examine the accounting practices of the Dutch East India Company, the epitome of modern capitalism in early seventeenth century and conclude that double-entry bookkeeping was not an essential condition for the rise of Dutch capitalism. Funnell and Robertson (2011) debate vigorously on the contention that the development of modern capitalism was dependent on double-entry bookkeeping during sixteenth-century Holland.

However, we did not find any literature relating the concepts of accountability and accounting to space exploration. The closest work we found that links accountability focus to exploration is that of Verwaeren and Nijstad (2022). They focus on individual managers'

decisions regarding engaging in exploration vs exploitation. Our context is different, in that we examine the drivers of human expeditions of the kind that Columbus engaged in.

We use the accountability lens to address the question of why Columbus embarked on his voyage, which resulted in the discovery of the New World, while a much superior technological power, viz. China, did not attempt a comparable venture. Specifically, we compare the prevailing contexts faced by Columbus in Europe and China's Ming Dynasty, with respect to specific elements of accountability, such as quantification of outcomes, documented investment contracts, sharing of profits/losses, incentives for risk/profit sharing, and the existence of a system for measurement of inputs and outputs. In our context, "outcome accountability" appears to be the best lens for comparing Columbus in Europe and China's Ming dynasty. We posit the view that, absent an environment of accountability, Columbus (or other aspiring explorers) would not have gained access to resources that made his expedition possible.

A quick review of the literature covering the technological capabilities of Western Europe and China (Edson, 2007; Hadringham, 2003; Ward, 2006) shows that China had superior STEM abilities. Therefore, the only possibility is that Western Europe had superior non-STEM capabilities, which we refer to as HASS factors in this paper. The HASS factors surveyed by us include accounting and measurement, legal and contractual, and finance, investment, and trade factors. For the sake of completeness, we also examined factors of ideology and theology, as well as arts, literature and literacy, government, politics and leadership and economic size.

3. Methodology

The study examined archived data to understand why, in spite of their technological superiority, the Chinese did not complete large human exploration ventures, such as the one accomplished by Columbus.

Our analytical approach consisted of two stages. In the first phase, we considered factors other than technology (STEM): HASS factors. Our aim was to explore to what extent the two societies focused on differed in terms of various HASS factors. In the second phase, we examined whether the factors which were different across the two cultures could potentially influence decision-making and execution, in the context of such large human exploration ventures.

We followed the insightful recommendations of Parker (1997) and Previts *et al.* (1990a, b) and utilized both narrative and interpretational methods to examine prior historical and contemporary accounts of the voyages undertaken by Columbus and Zheng He in the fifteenth century. Given the paucity of academic sources, we included both academic and non-academic sources as our principal sources of data. Our methodology could be considered narrative-based, based on the descriptions provided of the accountability features in the documents studied. Additionally, this is also an interpretational methodology, due to the analysis of the relationships between the voyagers and stakeholders, which we conducted using the collected documents. We also theorized on the role of HASS factors, especially accounting and accountability, in order to advance our arguments regarding their impact on human "space" exploration activities.

The collection of "data" for this research occurred in two stages. First, we collected academic papers, monographs, research reports and online sources regarding the voyages of Columbus and Zheng He that were written in English. In the second stage, we gathered materials pertaining to the accounting, trade, and economics of the two cultures—Western Europe and China. We ensured reliability of our "data" by using multiple sources to corroborate the evidence provided by a given source. To ensure credibility, we placed more emphasis on refereed academic publications, rather than grey sources. When academic

sources were unavailable, we considered factors that pointed to higher credibility. For instance, we considered books published by reputable publishers, and websites associated with high-quality academic institutions. We discarded sources that seemed dubious and were not able to be corroborated by other sources.

Our analytical approach involved the following steps. First, we created a list of potential HASS factors for which we could obtain data for the two cultures studied—China and Western Europe. Second, we compared how China and Western Europe performed on each of these factors. Based on this, we then scored whether Europe or China did better on each aspect of the selected HASS factors. Finally, we discuss whether each potential factor could influence/motivate the decision to undertake human explorations. At the end of each subsection, we summarize our findings. Thus, an overall view, in addition to granular details, is provided on the impact of potential HASS factors that could influence/motivate explorers to undertake human expeditions.

4. Historical overview of the first space race: Europe vs China

Christopher Columbus was not the sole contender for New World "discoverer". By 1420, Chinese STEM technologies already far outstripped those of 1492 Europe. The Chinese fleets of the early 1400s were gigantic; their "treasure ships" of up to 120 meters in length, unmatched by wooden vessels in Europe until Victorian times, crewed by up to 1,000. Columbus's ships, in contrast, barely attained 20 meters, with crews of around 40 (Ward, 2006). Whilst plague and scurvy ravaged Columbus's fleet, and later his colonies, China's superior medical knowledge rendered them far less afflicted (Morison, 1963; Menzies, 2003).

Spain, Columbus's sponsor nation, was, by 1492, Western Europe's fourth-largest economic power, although its imperial dominance still lay in the future. China, meanwhile, boasted the world's largest economy (Maddison, 2001, 2003, 2007). The Ming Dynasty era (1368–1644) is regarded as one of China's three golden ages, marked by cultural achievements, such as the renowned Ming pottery and the construction of the Forbidden Palace.

During the decades c. 1400–1430, China dominated the known seas and made numerous voyages, principally under the command of Admiral Zheng He. Then, China stopped. In 1433, the emperor banned overseas trade; to sail from China in a multi-masted ship became a capital offence. The Middle Kingdom set upon a centuries-long course of xenophobic isolation. It would maintain its nautical lead for another century, until destroying or abandoning its last "treasure ship" in 1525. Thereafter, Europe would gain ground and surpass China in most STEM fields for the next four hundred years (Kristof, 1999; Wolla, 2013).

As every Western schoolchild knows, Columbus set sail across the Atlantic in 1492. Ironically, his goal was not to discover a New World, but to find a westward trade road to China and India, based on a gross underestimate of Earth's true size; yet the Europeans came to stay. Much of the New World story is in how others followed Columbus's footsteps in the land's exploration, trade, colonization and conquest. Zheng He, if he or other non-European explorers ever reached the Americas, left no such legacy (Menzies, 2003; Finlay, 2004). Columbus—merely the first—has given his name to a country (Colombia), over 30 cities and regions (from Colón, Panama to Columbus, Ohio), and countless streets and locations around the globe.

Other civilizations may have been fifteenth century New World contenders. For example, the Arabs had a history of successful exploration during the previous two centuries. Yet only the Chinese and Europeans appeared to possess *all* (HASS and STEM) requisites for success: accountability, stakeholder attributes, cultural motivation, maritime technology, economic capacity and, perhaps critically, the resulting exploratory and entrepreneurial will.

This study, accordingly, focuses on the STEM and HASS relativities of China and Europe in the 1400s.

4.1 The first "space" RACE—two great mariners

During the fifteenth century, two individuals from the East and West were major players in oceangoing voyages: Zheng He and Christopher Columbus. Whilst this article focuses on broad societal HASS and STEM factors, those mariners' abilities and characters doubtless influenced their explorations and successes.

4.1.1 Christopher Columbus. Christopher Columbus (c. 1451–1506 AD) (*Italian: Cristoforo Colombo*) was probably born in Genoa, Italy, the son of a wool merchant. From his teens, Columbus served on a merchant ship and travelled widely, becoming self-educated in geography, astronomy and history. He formulated a plan to seek a western sea passage to the East Indies, hoping to profit from the spice trade (Beck, 2021).

Columbus, as an entrepreneur, was willing to accept many risks, including that of his expedition never returning. He required capital to fund ships, equipment and a crew. In 1484, King Joao II of Portugal declined to fund his venture, after which Columbus spent six years persuading the Spanish Catholic monarchs King Ferdinand II and Queen Isabella I. In 1492, they agreed to provide Columbus with three small ships, in return for Columbus's promise to bring his benefactors gold, spices and silks from the Far East, spread Christianity and establish a trade route to China (Miller, 1992).

Whilst Columbus could potentially have secured private financing, he needed a royal sponsor (e.g. Spain) to defend any claims to new territories he discovered. Similar to a modern financer, Columbus invested his own resources into his voyages. He agreed to finance one-eighth of future voyages in return for a one-eighth profit share, and the titles of Admiral of the Ocean and Governor-General. A contract, the *Capitulations of Santa Fe* ("*Capitulaciones de Santa Fe"*), documented Columbus's "investment proposal" and the royal acceptance of that proposal.

Columbus' three ships made landfall in the Americas, specifically, the Bahamas, on 12 October 1492. In early 1493, he returned to Spain, and news of his voyage spread throughout Europe. Columbus completed three further New World voyages. He did not discover a trade route to China, but his voyages opened the way for widespread European exploration, invasion and colonization of the Americas.

With "New Spain" eventually spanning the central and southern Americas, the investors Isabella and Ferdinand, as well as Columbus, presumably achieved an excellent financial return. Indeed, some have used the records of Columbus's voyages to construct profit statements (Satava, 2007).

4.1.2 Admiral Zheng He. Zheng He (1371–1433 or 1431 AD) was a Chinese eunuch military leader who led "treasure fleet" oceangoing voyages during the early fifteenth century, born Ma He to a Muslim family, in China's far southwest. At age ten, he was sent to the capital for military and literary training and renamed "Zheng" by the emperor. Growing up an imposing and talented man, he ascended the military hierarchy with ease. When the Emperor required a trustworthy ambassador, familiar with Islam and the south, to lead his armada to the "Western Oceans". Zheng He was the clear choice.

China had built its first oceangoing trade ships in the Song dynasty (c. 960-1270 AD). The subsequent Mongol emperors of the Yuan dynasty (c. 1271-1368 AD) commissioned the first imperial treasure fleets, and founded trading posts in Sumatra, Sri Lanka and South India. When Marco Polo made his famous journey to the Mongol court, he described four-masted junks with 60 individual cabins for merchants, watertight bulkheads and crews of up to 300.

As the "Admiral of the Western Sea", Zheng He led China's most ambitious and successful oceangoing voyages. The Yongle Emperor ordered him to sail to "countries beyond the

horizon . . . all the way to the end of the earth . . . to display the might of Chinese power and collect tribute" from the "barbarians beyond the seas." An objective of Zheng He's visits was to open a maritime Silk Road; the Turks having blocked the overland Silk Road (echoing Columbus's purpose 70 years later). Between 1405 and 1433, Zheng He made seven voyages as far as Africa, and perhaps beyond. For his first voyage, Zheng He amassed 300 vessels, the largest being 130 meters long. His 28,000 crew members included interpreters, astrologers, astronomers, pharmacologists, ship repairers and doctors. During his seven voyages, Zheng He visited more than 30 countries, expanding China's political influence and trade routes.

Zheng He did not sail with intent to discover unknown lands, any more than initially did Columbus, and his voyages apparently remained within the boundaries of the Chinese known world. A sound leadership, communication and management model assisted Zheng He's undoubted success (Hum, 2012). Nevertheless, there is no evidence of any entrepreneurial agreement or quantified targets for Zheng He to fulfil, in contrast to Columbus's *Capitulations of Santa Fe*. Nor were the seven forays of He's treasure fleets trading missions with defined profit outcomes but were rather designed to showcase Chinese might to the world's kingdoms, primarily around the Indian Ocean (Szczepanski, 2020).

Additionally, from a Confucian worldview, merchants were lowly members of society, who were seen as parasitic upon farmers and artisans who produced trade goods. An imperial armada would not usually besmirch itself with trade. During and after his lifetime, Zheng He received little reward for his efforts, in sharp contrast to Columbus, a renowned explorer and celebrated figure to this day. The near absence of Chinese monuments or art dedicated to Zheng He reflects the suspicion and low regard with which China's conservative elite viewed him. That imperial elite, fearful of outside influence, made sure to destroy all records of Zheng's voyages (Kristof, 1999).

After Zheng He's voyages, the Chinese appetite for new trade routes diminished, notwithstanding a continued disruption of Eurasian land routes. China had a low dependency on European goods, given the Indian Ocean trade alternatives that their geography afforded them. By 1525, China had stopped sending its treasure fleets (Szczepanski, 2020).

5. Enablers, influencers and motivators

In this section, we study the underlying factors that motivated the Europeans to go west and reach the new world. We also discuss the potential impact of incentives (or lack of them) and motivators on Chinese explorations in the fifteenth century.

From the point of a view of a hypothetical person of the early 1400s able to observe their contemporary world, China's role as "discoverer" of the New World within a few decades may have seemed a foregone conclusion. China was an undisputed leader in almost every field necessary for a maritime conquest of the world: shipbuilding, medicine, maritime technologies and economic might; their unprecedentedly large fleets had sailed the known oceans, and they had a record of executing world wonders, such as the Forbidden Palace and Great Wall (Kristof, 1999; Finlay, 2004).

Whilst the shortest hypothetical Chinese voyage across the Pacific to Alaska (~5,000 km) is somewhat longer than the shortest distance from Europe to the Newfoundland in the Americas (~3,500 km), both journeys would have been well within the capabilities of both Zheng He's and Columbus's fleets. In fact, Columbus's first voyage from Portugal to Hispaniola traversed more than 6,000 km without sight of land, which is more than sufficient for a hypothetical North Pacific crossing, especially since the latter is achievable via a mostly coastal route. Furthermore, if we point out that the fifteenth century Chinese exploratory focus was mainly centered upon the Indian Ocean, rather than the Atlantic (Hadringham, 2003), we must still question why the Chinese did not then "discover", explore or colonize Australasia, as Columbus and his successors did the Americas. The Australian land mass not

only abuts the Indian Ocean, but lies barely 1500 km southeast of Java, which, in Zheng He's era, hosted prosperous trading ports of the Majapahit empire.

As a modern space parallel, when Neil Armstrong planted the first footprints on the Moon in July 1969, a US Mars Mission seemed equally close to many. Within two months of Armstrong's fateful lunar steps, Wernher von Braun, director of NASA's Marshall Space Flight Center and chief architect of the Saturn V launch vehicle, presented his plans for a human spaceflight to Mars to NASA. Bookmakers offered odds as high as 1:1 in favor of a manned Mars landing within 10 years, by 1979. Of course, that did not happen. Yet, the odds in 1400 for a Chinese New World first landing (e.g. by 1450) may have seemed even better.

We posit that both technical factors (STEM) and human factors are relevant in motivating human expeditions. We, therefore, examine the STEM and HASS factors in more detail in the following sections. The aim is to understand how extant STEM disparities, then, influenced exploration. We summarize in Table 1, STEM factors in China and Europe.

5.1 STEM factors

From 1400, the Chinese possessed substantial advantages over Europe in the STEM field of shipbuilding. These included not only her far larger vessels and crews, but such innovations as the lugsail, leeboard and watertight compartments. Maritime archaeological, ethnographic and surviving textual evidence afford many examples of the size-related, technical and constructional superiority of the Chinese treasure ships when compared to the fleet of Columbus (Ward, 2006). Chinese shipboard medicine and nutritional science was also superior (Morison, 1963). An oceangoing voyage in a treasure ship posed far less risk for the crew of contracting scurvy or other illnesses than did a journey in one of Columbus's ships.

Furthermore, evidence shows that in the fields of navigation and astronomy, the Chinese were at least the equal of the West (Guangqi, 1992). Having invented the compass c. 1100, China had been using it in navigation for far longer. China possessed a sound understanding of the Earth's size, in contrast to the geodesy of the West, which was inadequate even to calculate the globe's circumference with certainty. Columbus had his calculation wrong by 24%, underestimating the Earth's circumference by as much as 19,000 miles, rather than its true 24,901 miles. Geographical accuracy had not improved since Eratosthenes of ancient Greece, 1700 years earlier, had measured the globe to better than 10%.

Astronomers played important roles in Ming China, making calendars, reporting abnormalities to the emperor and presiding over ceremonies. They also (as Western astrologers would) decided what days were auspicious and good for different events, such as military parades, marriage, construction, etc. The astronomers also predicted invasions or dangerous moments within the empire. Although Chinese astronomy was, then, inextricably linked to astrology and numerology (whilst in the West, those STEM and HASS disciplines were becoming more distinct), China's expertise in observing, measuring and cataloguing the heavens reflected an unbroken tradition of thousands of years.

The Europeans may, however, have had an edge in one field: navigational instruments used to measure latitude via astronomical sightings (Guangqi, 1992). The astrolabe, the ingenious invention of Hipparchus of Ancient Greece, is only documented as being used in China from the fourteenth century. The quadrant, in essence a more advanced astrolabe, which the Europeans steadily improved through the fifteenth–seventeenth centuries, was unknown in China until later periods.

Mathematics was another apparent exception to the Ming STEM superiority. Although China had in some cases (such as in algebra and the study of irrational numbers) outstripped the West, during the Ming era it began to experience something of a decline, just as the West was readying itself for its mathematical renaissance (Martzloff, 2008). This lag in Chinese

	China Ming dynasty Zheng He's voyages (1405–1433)	Spain/Europe Columbus's first voyage (1492)
Shipbuilding – engineering (Ward, 2006; Hadringham, 2003; Wolla, 2013)	1. Lugsail—Yes (A sail for sailing into wind.) 2. Compass—Yes 3. Axial stern rudder—Yes 4. Leeboard—Yes (A board to avoid leeward drift.) 5. Watertight compartments (bulkheads)—Yes	1. Lugsail—No, not until sixteenth century 2. Compass—Yes 3. Axial stern rudder—Yes 4. Leeboard—No. Introduced in fifteenth–sixteenth centuries 5. Watertight compartments (bulkheads)—No. in 1784 Benjamin Franklin was first to advocate "Chinese" bulkheads
Shipbuilding – size and capacity (Ward, 2006; Hadringham, 2003)	50 or more meters long Crew of up to 1000 per ship, total fleet crew >25,000	20 meters long Crew of ~40 per ship, total fleet crew <150
Medicine (Morison, 1963)	Understanding of scurvy and its prevention Herbal medicine, acupuncture, traditional treatments. Generally, more advanced and effective than Western medicine	Little understanding of scurvy, which plagued Columbus's crew Herbal medicine, pseudoscience (leeches, humours)
Astronomy & navigation (Guangqi, 1992)	1. Highly sophisticated star catalogues (c. 1500 star charts) and astronomical calendars, used to determine latitude and longitude 2. Shipboard astrologers (astronomers) 3. Navigational equipment including the compass and "board for carrying [measuring] stars'	1. Basic star catalogues and almanacs. Pre-telescope era astronomical science 2. Shipboard navigators 3. Navigational equipment, including the compass, astrolabe and quadrant (first documented use in navigation was in 1461)
Mathematics (Martzloff, 2008)	Moderately advanced geometry, arithmetic, algebra; mathematical innovation in decline	Moderately advanced geometry, arithmetic, algebra; start of upswing in mathematical innovation
Cartography (Edson, 2007; Woodward, 2007)	Long tradition of map-making; maps more decorative and stylized than in Europe. China-centric worldview ("Middle Kingdom") evident. Advanced nautical chart used by Zheng He	Recent advances in mapmaking, supporting STEM nautical and navigational improvements

Source(s): Authors' own compilation

Table 1.
Table of comparative STEM factors—China and Europe

pure mathematics contrasts with their evident superiority in related STEM fields, such as engineering and applied mechanics.

Whilst less directly related to oceangoing success, China c. 1400 possessed many additional (STEM) leads over Europe, including in paper-making, porcelain, metallurgy and textile manufacturing, as well as movable type and printing. Before 1500, both China and the West still had much to improve in the fields of geodesy and cartography; their capabilities were similar. Columbus's mistake on the Earth's size, which China's greater geodesic accuracy might have avoided, nevertheless proved a fortuitous incentive for his first voyage (Guangqi, 1992). Cartography (arguably as much a HASS as a STEM discipline) was a growing Western strength. In the two centuries before Columbus, European mapmaking had developed to support STEM nautical improvements. Cartography from 1450 to 1650 was

considered the most important period of European mapping. Scientific advances, such as classical charting improvements, new trade routes and mass printing, all drove an explosion in the creation and use of maps (Woodward, 2007).

China had an even longer history of map-making, although maps tended to be more stylized and decorative. For example, the elaborate and colorful *Da Ming Hunyi Tu* ("Amalgamated Map of the Great Ming Empire"), created c. 1389, shows China at the center and Europe, halfway round the globe, is shown very small and compressed at the edge.

Overall, barring a few factors, such as the use of cartography and navigational instruments, China had absolute superiority over Western Europe as regards to STEM capabilities, which are essential for pioneering human expeditions [4]. This leads us to search for factors beyond STEM. In search of answers as to why Western Europe won the "first space race", we examine HASS factors.

5.2 HASS factors

Although, as described above, China led the fifteenth century world in virtually every STEM category, evidence suggests that many of Europe's (including Spain's) HASS attributes were equal or superior to those of China in enabling, influencing and motivating New World exploration. Those HASS factors include accountability, trade, government and other HASS categories critical to Columbus's eventual success. This suggests the dominant factors in why China did not go to the New World, whilst Columbus and his successors did, to be predominantly HASS, rather than STEM. Relevant HASS factors are tabulated and described in Table 2.

5.2.1 The role of accountabilities. Overall, levels of accountability appear to be a clear, perhaps dominant, differentiator between the explorations of Columbus and Zheng He. We argue that accountabilities, particularly outcome accountability, strongly influence, and correlate to, exploration success. The accountability factors summarized below are, in fact, composites of HASS factors from several disciplines (accounting, legal, trade, ideology and government), explored discretely in subsequent sections.

Columbus's voyages were predicated upon a high accountability to deliver quantified, specific outcomes, under a documented "investment contract" with his principal investor: stakeholders (Columbus *et al.*, 1492). Columbus, in turn, received profit share as a monetary incentive for his trading outcomes. His accountability was not solely input-focused ("sail west"), but output-focused ("generate trade profit"). Columbus had high autonomy as a private investor (and as a stakeholder in his own right) in how and where he explored. He had a high personal entrepreneurial incentive to explore (e.g. money, governorship). Other European entrepreneurs could, and had incentive to, undertake ventures similar to Columbus's without restriction, provided they could find willing sponsors.

Finally, one can develop a meaningful profit and loss statement of Columbus's voyage, based on the records of the era. Modern attempts to calculate a direct cost and investment return of his voyages include Satava (2007). Overall, Columbus operated in an environment of high outcome accountability, and this setting created both the incentives and motivation for undertaking his arduous and risky expedition to the New World.

Zheng He (admittedly based on fewer surviving records) had less accountability (Wolla, 2013). There is no evidence of a written "investment contract", and outcomes were unquantified and non-specific, determined principally by a single stakeholder (the emperor). Zheng He did not receive any share of profits, so had little monetary incentive from any trade he developed. He had an input-focused objective to visit ports, primarily in the Indian Ocean, and to showcase China's mighty wares. He had low autonomy to enter into trade agreements or explore unknown regions, due to Imperial concerns about merchants gaining too much power. Zheng He, an admiral and employee of the emperor, had a low personal

	China Ming Dynasty Zheng He's voyages (1405–1433)	Spain/Europe Columbus's first voyage (1492)
Overall accountabilities (Columbus *et al.*, 1492; Morison, 1963; Satava, 2007; Wolla, 2013; Kristof, 1999)	*Low–medium accountability* 1. No evidence of documented investment contract 2. Non-quantified, non-specific outcomes, e.g. "promote trade" 3. No known profit share/ monetary reward for mariner 4. Input-focused, e.g. "visit 30 ports" 5. Limited autonomy of mariner 6. No known (or unclear) entrepreneurial or personal incentives for mariner 7. Profit and loss statements of voyage(s) not readily producible	*High accountability* 1. Documented investment contract (signed by parties) 2. Quantified, specific outcomes, e.g. profit 3. Profit share/monetary reward for mariner 4. Output-focused, "e.g. bring back goods and make a profitable trade route" 5. High autonomy of mariner 6. Entrepreneurial or personal incentives for mariner (profit, governorship, etc.) 7. Profit and loss statement of voyage(s) producible
Stakeholders (Wolla, 2013; Li, 2015; Edwards, 2017; Chen, 2017) *L* Leading stakeholder* *R* Possibly resistant stakeholder*	Key stakeholders (*by descending influence*) 1. Emperor of China (L*) 2. Government (imperial civil service) (R*) 3. Religious institutions (R*) 4. Trading partners and nations 5. Lead mariner—Zheng He (L*) 6. Merchant class 7. Fleet crews 8. Fleet constructors *Stakeholder engagement*: primarily directive, hierarchical	Key stakeholders *(by descending influence)* 1. Entrepreneurs—Columbus and Spanish monarchs (L*) 2. King and Queen of Spain (L*) 3. Lead mariner—Columbus (L*) 4. Financiers, investors, and bankers 5. Government (institutions) 6. Roman Catholic Church 7. Merchant class 8. Fleet crews 9. Fleet constructors 10. Trading partners 11. Legal representatives 12. Accounting representatives 13. Peer and prospective explorers and mariners *Stakeholder engagement*: primarily collaborative, contractual
Legal and contractual (Chen, 2017)	Absence of developed contract law including investing or partnership agreements. Legal system based on penal code authority	Well-developed contract law, including investing and partnership agreements. Relatively modern European legal systems for criminal and civil law, embodying common law, equity, contracts, and statutes

Table 2.
Table of comparative HASS factors—China and Europe

(*continued*)

	China Ming Dynasty Zheng He's voyages (1405–1433)	Spain/Europe Columbus's first voyage (1492)
Accounting and measurement (Jun Lin, 1992; Sangster, 2015, 2018; Wang, 2017)	1. Basic accounting systems 2. Absence of double-entry bookkeeping 3. Numbers retaining strong numerological and astrological connection 4. Lack of clear profit or benefits model (oceangoing trade not seen as a benefit)	1. Moderately sophisticated and recognizable accounting systems: debits, credits, balance sheets, capital 2. Double entry bookkeeping widespread for over a century 3. Numbers retaining numerological connections, but increasingly used as practical tools for business and science 4. Concepts of profit and investment return (oceangoing trade seen as a benefit)
Finance, investment and trade (Li, 2015; Edwards, 2017; Wolla, 2013)	1. Established banking systems but no evidence of exploration finance 2. Lack of individual entrepreneurship or supporting legal framework. Heavy government intervention in trade 3. Zheng He (project leader) not an entrepreneur, but a military leader and government employee 4. Merchant class and international trade held in low regard. Merchant guilds not yet common. *Haijin,* or sea trade restrictions, from 1368; full ban of ocean voyages from 1433 5. No "stockholder" concept 6. Low appetite for trade and finance risk 7. Low international focus 8. Other nations of low interest; believed backward, impoverished and "barbarian"	1. Established, growing banking sector with appetite to finance exploration 2. Established individual entrepreneurship (independent of government) and supporting legal framework 3. Columbus (project leader) as an entrepreneur 4. Merchant class and international trade generally well-regarded. Merchant guilds long-established in Europe, e.g. "Merchant Adventurers" (England). High incentives available for oceangoing trade 5. Early "stockholder" concept. Guilds as predecessors of joint stock companies (e.g. Dutch East India Company), reflected in private trading partnerships 6. Moderate–high appetite for trade and financial risk 7. High international focus 8. Interest in other nations and their trading, and sometimes cultural, opportunities

Source(s): Authors' own work

Table 2.

entrepreneurial incentive to go beyond his immediate instructions, even (as subsequent history has shown) in the case of personal advancement or renown. The absolute rulership of the emperor, as well as Confucian culture, placed severe restrictions (ultimately, a ban on overseas trade) on merchant-minded individuals who might follow in Zheng He's footsteps or undertake voyages akin to Columbus's.

A compilation of a viable profit and loss statement of Zheng He's voyages is much more difficult than Columbus's (compounded by a paucity of bookkeeping, trade or other records). Given the lack of a comparable outcome accountability environment, potential Chinese explorers were not motivated or incentivized to pursue comparable exploratory journeys.

Overall, we find that outcome accountability is higher in Western Europe compared to China. We argue that outcome accountability incentivizes and motivates potential explorers, and possibly explains why a Columbus emerged in Europe to conduct human expeditions, while a similar environment did not exist in China to offer up a comparable explorer.

5.2.1.1 Legal and contractual. In Europe, the concept of the written contract was well-established by the 1400s, developing from ancient Greco–Roman legal frameworks.

Columbus's and the Spanish monarchs' *Capitulations of Santa Fe* is such a contract. *Capitulations* contains an offer, acceptance, intent to create legal relations, consideration, informed consent and legal capacity: all elements that are necessary to a modern contract. It defines the outputs, inputs and obligations of all parties. This document was critical for Columbus to secure financing and to undertake and achieve his voyages' objectives. In fact, Columbus's descendants later sued the Spanish Crown for failure to fulfil its obligations under the *Capitulations*. Without such an agreement between Columbus and other stakeholders, it is unlikely Columbus's voyages would have proceeded.

In contrast with Columbus, we have no record of Zheng He having executed a legal agreement with the Emperor or other stakeholders. He doubtless carried detailed written orders on his voyages, but such records have been lost or destroyed. Whilst European legal practitioners were widespread by the fifteenth century, the Chinese traditionally despised the role of advocates, perceiving them as parasites profiting from the difficulties of others. In contrast to Western legal systems, Chinese criminal law preceded civil law. The Western concept of a contract, therefore, came late to China (eighteenth–nineteenth centuries) (*Chen, 2017*). Yet, for European New World expansions, contracts were a foundation of their mercantile and colonial activity from the very first.

Absent a legal and contractual framework, the Chinese did not pursue expeditions to discover and claim new lands as Columbus did. We argue that if Columbus did not exist, there would have been other potential explorers who may have embarked on similar expeditions since, the incentives and motives were there.

5.2.1.2 Accounting and measurement. Luca Pacioli of Venice, a monk and numerologist, is traditionally named the progenitor of bookkeeping and, in 1494, wrote an encyclopedia with an instructional section on double-entry accounting (Sangster, 2015). Sangster (2018) viewed the life and works of Pacioli through a biographic lens and concludes that his teaching method was influenced by other HASS, factors such his Christian faith, his humanist beliefs and his desire to give all merchants access to the practical mathematics and bookkeeping they required. Marino de Raphaeli's *Rules of Bookkeeping* dates from 1475, and Benedikt (aka Benedetto) Cotrugli's 1458 work, *Book on the Art of Trade,* also incorporates double-entry bookkeeping (Kotruljević, 1458). The records of Amatino Manucci, a Florentine merchant, include the firm's 1299–1300 ledger, which evidences the earliest recognizable use of double-entry bookkeeping.

So, by the time of Columbus's proposal for exploration, the roots of modern accounting were firmly emplaced in his mercantile community. We have no indications that Columbus ever submitted an accounting statement to his royal sponsors. Nonetheless, he was surrounded by merchants and treasurers with an appetite for financial return, and an accounting system by which future New World successes could be quantified and promoted to prospective investors. The *Capitulations* also includes clear accounting-based obligations and incentives, which would have been substantial drivers for Columbus's voyages.

In contrast, China's accounting capabilities in the 1400s were less established. There is little evidence that before 1500 China independently developed accounting techniques, such as double-entry bookkeeping, debits and credits, the "accounting equation", and capital, or other familiar tools of post-medieval Western enterprise. Nevertheless, Chinese and other Eastern accounting techniques could have influenced double-entry's European development (Wang, 2017).

In general, it has been generally recognized and documented that the Chinese accounting system was weaker in the fifteenth century when compared to Western Europe. Several factors, such as a high degree of state control, a lack of a vigorous class of entrepreneurs independent of government and the low status of commercial enterprises when compared to agriculture, have been attributed to explain the relative weaknesses in Chinese accounting (Aiken and Lu, 1993). Jun Lin (1992) further elaborates on the weaknesses in Chinese accounting methods. Among the cited weaknesses are inadequacies in the classification of ledger and journal accounts, absence of separation between capital and liabilities, lack of separation between earnings and capital, and imprecision in journal entries and posting.

A reason for double-entry accounting's late adoption in China is offered by Gao and Handley-Schachler (2003), in that Chinese accounting was influenced by Confucianism and Taoism. Confucianism, especially, eschewed material and financial interests. Whilst for European accounting, religious concerns appear to have had little impact, in China, the Confucian religious philosophy may have slowed accounting's development.

Similarly, mathematical differences between the cultures meant differences in accounting and their concept of (and appetite for) investment. While mathematics is part of STEM, it retained, in the 1400s, strong non-STEM (HASS) influences, such as theology and astrology. As late as the 1500s, numbers in China were largely associated with numerology and mysticism, with mathematics being in something of a decline, just as the European Renaissance was elevating numbers to the status of practical measures for science, engineering and business.

When we compare the levels of accounting and accountability capabilities of China and Western Europe, we clearly show the dominance of the West European system in the fifteenth century. Barth (2015) posits that accountability is enhanced when high-quality accounting information is available. We argue that accounting capabilities matter in the context of expeditions of the kind pursued by Columbus. First, a well-developed system of accounting and accountabilities facilitates the quantification of profits (losses), investments, rates of return, etc. In the case of China, a lack of a well-developed private accounting system probably led to the cancellation of expeditions after Zheng He. The lack of an environment with a high degree of accountability perhaps lead to an absence of other potential explorers with similar motivations as Zheng He. Second, the presence of a reasonably well-developed system of accounting and accountability was potentially a factor leading to explorers such as Columbus. Even if Columbus did not exist or succeed, the existence of a robust accounting/accountability environment would have encouraged others to venture on similar/comparable explorations.

Besides enabling/influencing aspects of accounting, we also find that accounting systems significantly influence motivate potential explorers. While the concept of double-entry bookkeeping and its impact on bank loans and investor returns is so evident for Columbus, we find that accounting in China tended to focus more on governmental accounting, and less on accounting for private entities (Aiken and Lu, 1993). Improved accounting systems in Western Europe facilitated better stakeholder management, i.e. European 15th century accounting tended to facilitate the management of stakeholders, such as shareholders, lenders and investors (e.g. Isabella), whereas Chinese accounting of the period appears to have had a less significant stakeholder role in exploration.

Further, in examining a somewhat later period of history, accounting methods tailored to organizational needs became important by the early 1600s for the advent of Dutch social capital, e.g. via the Dutch East India Company, which played a significant role in colonial exploration and trade (Robertson and Funnell, 2012). Such methods differed from "traditional" double-entry bookkeeping of the era, being driven not by religious principles or social conflict, but instead by the Netherlands' long experience with institutions, such as medieval water-boards and land reclamation projects. This, in turn, gave rise to the notions of

joint ownership and a free market for intangible rights, fundamental to the idea and practice of capitalism. This suggests that, similarly to Columbus's New World ventures, locally relevant HASS factors (such as accounting and social institutions) may have been the key enablers of Dutch successes in fields both related and unrelated to exploration, e.g. land reclamation, foreign trade and early market capitalism.

Sombart (1953) and Funnell and Robertson (2011) also find that accounting practices formed a prerequisite for the European development of modern capitalism and the emergence of the public corporation during the late sixteenth and early seventeenth centuries (although the authors differ opinion in terms of the importance, specifically, of double-entry bookkeeping, in such developments).

Overall, accounting systems, at least in the modern era (Hopwood, 1983), are influenced by and develop from the organizational contexts in which they operate, and by external factors and stakeholders from non-accounting disciplines. Accounting is correlated to and entangled with the requirements of the organization. The projects and enterprises of fourteenth–fifteenth century Europe and China, including expeditions such as Columbus's and Zheng He's, may, then, have driven and influenced the development of the HASS factors of accounting and accountability in the respective societies, as well as being facilitated and enabled by those very factors.

5.2.1.3 Finance, investment and trade. The apparent strength of Western Europe over China with regard to accounting capabilities would also have led to a better environment for facilitating finance, trade and investment. Trade, whether in Europe or China, needs a good accounting system. It requires a capacity for investments in major ventures, such as exploratory voyages, and an appropriate risk appetite for trade. Frequently, it also requires a source of finance, such as a bank.

Columbus's voyage and subsequent exploratory expeditions, up to modern lunar and planetary missions, have borne huge risks: loss of life, failure of investment and political embarrassment. Over-conservatism has little place in nautical or space exploration, so a risk-taking model is essential. Such a risk-taking model must encompass finance, trade interactions, political entrepreneurship and sometimes the need to adopt radical new practices. Europe had such a rudimentary trade risk model by 1492, China less so (Wolla, 2013).

Utilizing an erroneous size of the Earth, Columbus's voyage could have been one of history's most foolish, ill-advised ventures. Despite the accidental nature of Columbus's discovery, as well as his unrealistic model in seeking an impracticable trade route, it was founded on a high appetite for international maritime trade, an understanding of the economic benefits this could bring, and a government and culture that permitted individual entrepreneurship and enterprise. Columbus was, first and foremost, a merchant and businessmen, whose vision and quest for gold found its expression in his voyages.

Conversely, in the China of seven decades earlier, the great Admiral Zheng He and his fellows were servants of the emperor, in a society where individual enterprise was discouraged and often seen as a threat to Imperial leadership. By 1424, the new emperor, Hongxi, had ample financial motivation to cease exploration. The treasure fleet voyages had cost Ming China enormous sums of money; they were not primarily trade excursions, so the government recouped little of their cost. There was no financial return model, no trade benefit incentive and no private investors to step in and fill this void. The Chinese, ultimately, dismantled their treasure fleets without replacement, because they disliked, and could see no benefit from, foreign trade, relegating multi-masted ship expeditions to the status of a capital offence (Wolla, 2013).

Whereas, for Europeans, the trade incentive was stronger than ever. The rapid pace at which Europe grew in wealth and power was unforeseeable in the early fifteenth century, because it had been preoccupied with internal wars and was slowly recovering from

depopulation caused by the Black Death. The Ottoman Empire's hold on Eurasian trade routes, and Columbus's mission to find trade alternatives, then allowed the accidental "discovery" of the New World.

Columbus and other European explorers and traders had the capacity to act as entrepreneurs. Marco Polo's Asian voyages (1271–1295) were an earlier example. In Western Europe, the first private trading corporations were forming, e.g. The Merchant Adventurers, chartered in 1407, was a company of English merchants who engaged in woolen industry trade. Had Isabella and Ferdinand not financed Columbus's expedition, early European banks and alternative financiers might have been available. China's merchant class had much less freedom to trade (especially once the Emperor had imposed his maritime trade ban), fewer sources of non-Imperial finance, and a culture of imperial obedience, rather than individualism. Western state leadership typically viewed a wealthy and powerful merchant as an asset. In China, such an individual could pose a threat, as illustrated by Hongxi's motive to restrict trade and influence beyond China's borders.

Even until Columbus's era, Medieval Christianity frowned upon usury and the acquisition of wealth and viewed merchants as falling outside the productive core of society: those who worked, fought or prayed. However, in Europe, a growing merchant and banking class was overtaking those views and gaining a more favorable reputation, abetted, to some extent, by religious reformism. Similarly, in Confucian China, merchants and traders represented the lowest social class, because they did not, apparently, produce anything, instead gaining profit from others. Unlike in the West after c. 1420, however, the strengthening of traditional Confucian values tended to reinforce this view of trade and support a more isolationist Chinese position.

Independent craft and merchant guilds flourished in Europe between the eleventh and sixteenth centuries and formed an important part of the economic and social fabric. In China, in contrast, it was not until after 1500 that many merchant halls and guilds appeared. Although they played a role in protecting merchants' interests, merchant halls were tied to provincialism and feudal forces, hindering commodity exchanges and socio-economic development. There were huge differences between merchant halls during the Ming era and modern Western chambers of commerce or trade associations. Chinese guilds and trade associations were not "third parties", independent of government, but rather social organizations comprising fellow provincials and peer traders, attached to the government (Li, 2015).

A banking system was also important; the Bank of St. George managed Queen Isabella and King Ferdinand's finances for Columbus's first voyage. Such European banks were well established and expanding by that time. Banca Monte Dei Paschi di Siena remains the oldest surviving bank in the world, founded in 1472. Later, bank loans would play a growing role in the colonization of the Americas.

It is unclear whether Chinese banking institutions were (or could have been) similarly instrumental in financing the earlier voyages of Zheng He. Chinese financial institutions of the era performed all major banking functions and had been established by the Song Dynasty (960–1279). However, by the 1440s, the confidence in fiat money was so undermined that China abandoned its paper money around 1445.

Overall, we argue that one key enabler of human expeditions (of the kind that Columbus embarked on) viz., accounting, was far less established in Chinese society. Thus, it appears that weaknesses in their accounting capabilities prevented the Chinese from benefitting from trade, finance and investment.

5.2.2 The role of stakeholders. In line with prior research, we argue that stakeholder salience is a key driver of accountabilities, leading to greater incentives for "space explorations" (Moggi *et al.*, 2016; Mitchell *et al.*, 1997). Mitchell *et al.* (1997) posit that power,

legitimacy and urgency are the key attributes of stakeholders that influence economic activities.

Columbus and Zheng He, as leading mariner-stakeholders, had differing stakes and roles in their respective voyages. Columbus's stakeholders also necessitated different engagement approaches, morals and values from those of Zheng He. Such differences, in turn, influenced or gave rise to many of the ventures' distinct accountabilities, as described in the following section.

The engagement and flow of accountabilities from Columbus's stakeholders appear principally to have been based upon a collaborative and contractual approach, embodied in, e.g. the *Capitulations of Santa Fe*. Columbus's stakeholder influence was distributed among several parties. Conversely, Zheng He had a more hierarchical and directive stakeholder approach, in that he followed the orders of a single stakeholder of primary influence: the Emperor. This concentration of stakeholder power ultimately led to a future Emperor cancelling Chinese oceangoing trade without any effective opposition, or alternate (non-imperial) opportunities for exploration being available. Without the Emperor's approval, Zheng He would not have sailed. Whereas, in the absence of Queen Isabella, Columbus as entrepreneur may well have continued to seek, and have gained, support for his voyages from among the many other potential European stakeholders. Overall, while the stakeholders exercised more power in China when compared to Columbus, they exhibited less urgency and legitimacy.

European fifteenth century accounting tended to facilitate the management of exploration stakeholders, such as shareholders, lenders and investors, whilst Chinese accounting of the period appeared to have a lesser stakeholder role (Jun Lin, 1992; Sangster, 2015). Even making allowances for the destruction of Zheng He's voyage records, there is no indication of Chinese accounting stakeholders of the kind who would, for example, have needed to determine or audit Columbus's one-eighth investment or the calculation of Columbus's one-eighth profit share (under the *Capitulations*).

Another stakeholder was the Church. On May 4, 1493, after urging by Spain, Pope Alexander VI issued the bull "*Inter Caetera*". That document played a substantial role in the Spanish conquest of the Americas, by giving Spain an exclusive right to the lands Columbus discovered.

Aligned with the differences in accountabilities between the voyages of Zheng He and Columbus, the Chinese and Europeans also show substantial differences in stakeholders. Of the two, the stakeholders of Columbus were considerably more diverse. They included several stakeholders that were seemingly absent from China (e.g. financiers and peer maritime explorers). Further, we also find that the stakeholders exercised their influence through legitimacy and urgency attributes, which were missing in China.

5.2.3 Other HASS factors. In this section, we consider five other broad categories of HASS factors, including ideology and theology, arts, literature and literacy, government, politics and leadership, and economics.

It is important to note that this section discusses only a subset of the many HASS differences between China and Europe during the 1400s. The majority of such HASS factors arose from cultural, geographical and historical differences between nations, and had little or no bearing on explorations or maritime affairs. Approximately 10 such additional HASS categories were subjected to initial comparison, but have been excluded from the detailed analysis (e.g. education, law enforcement, architecture, music, food and agriculture) as having had minimal or no direct bearing on 15th century exploration.

Accordingly, this section excludes such purely cultural differences. It concentrates solely on those Chinese and European HASS factors that appear to have influenced human exploration, whether positively or negatively.

5.2.3.1 Ideology and theology. Whilst the ideology, theology and worldview of Columbus's Europe generally encouraged ventures, such as his voyages, Ming China's values regarding those HASS fields tended to discourage and impede such projects (Smith, 2012).

The end of China's "Age of Exploration" coincided approximately with the Yongle Emperor's death in 1424 AD. Bad omens accompanied or followed the Emperor's death, including a lightning strike and fire in the Forbidden Palace. Astrological horoscopes held grim news, sages counselled caution and bold explorations took second place to traditional, Confucianist and Taoist management of the Middle Kingdom. Outside nations were seen as offering little value to the Middle Kingdom's prosperity.

Astrological and theological portents (and their attendant political benefits to China's elite) seem to have been more significant than in Europe in influencing international explorations; worrisome omens or adverse planetary conjunctions seem not to have discouraged Columbus.

Just as China reverted to a more conservative, Confucianist and isolationist worldview, Europe began to question traditional, Judeo-Christian cosmologies. New, controversial opinions gained traction, aided by newly invented printing presses. Advocates of church reform grew. By the time of Columbus, Martin Luther's Protestant Reformation was little more than two decades away.

In contrast to China, Europe's theology may have been a positive driver for European colonization (Delaney, 2012). The papal bull "*Inter Caetera*" is an instance of support from the Catholic Church. The prospect of evangelizing natives to Christianity (an objective of the *Capitulations*); a new "promised land"; the acquisition of Church gold; all were justifications for the settlement and conquest of the New World. Researchers (Baehr *et al.*, 2002) also postulate a link between Protestantism and the capitalist philosophies that spurred future trade and development in the Americas, notwithstanding that Columbus's Spanish sponsor, and New Spain, remained Catholic.

China's religious ideologies also strongly dictated its appetite for explorations conducted in pursuit of trade, such as Zheng He's. Neo-Confucian scholars held many important government posts, and their philosophy discouraged a desire for worldly things, holding trade and profits in contempt. In the West, despite Christian admonitions against covetousness, profit gained increasing institutional support, abetted by new trading structures, such as the corporation, banking, and accounting advances, and the expansionist aims of the Church itself.

Overall, on the balance, theology played a greater role in motivating explorers in Europe to seek distant lands with the intention to convert populations to Christianity. A comparable motivation did not exist in China.

5.2.3.2 Arts. By 1492, non-STEM cultural innovations were also dawning in the West. The young Leonardo Da Vinci, his paintings already renowned, had begun to fill his journal with novel ideas. Hitherto "backward" Europe countries, unlike their wealthier but more insular Oriental rival, had started to spread their exploratory wings, curious to learn what lay beneath the surface of the natural world and the *terra incognita* of their charts.

The European Renaissance c. 1300–1500 had wrought enormous changes and innovations in the arts, philosophy and science. Western artwork was moving away from its traditional ecclesiastical themes to embrace secular and more adventurous concepts. Paintings, for the first time, began to incorporate perspective and light. Paradoxically, this impetus for the Renaissance, as with its inventions, such as the printing press, may have originated in China, as East–West relationships had burgeoned.

In contrast, China did not experience a comparable surge in art, innovation or "renaissance"; the early Ming dynasty (1368 onward) maintained similar steady progress to the previous Yuan (1279–1368). Its art manifested a revival of even earlier Chinese

traditions (Song and Tang Dynasties), rather than embracing innovation (Department of Asian Art, 2002).

Many of China's people, and its elite, resisted the influence of foreign art, goods and ideas upon their culture, whereas, in Western Europe, in its blooming Renaissance, foreign ideas and fresh approaches were often welcomed; this may have been a positive factor in inspiring explorations, such as Columbus's and his successors'.

Overall, we are not convinced that differences in arts and allied fields in Europe and China contributed in any significant manner to motivate or incentivize explorers to conduct human expeditions to distant foreign lands.

5.2.3.3 Literature and literacy. In the West, by Columbus's era, literature was reviving after a stagnant century. China's literary output remained traditional, with Ming prose and poetry cited as imitative and old-fashioned. Two Chinese schools of writing challenged that trend, claiming that literature should change with the age instead of imitating the past. However, the influence of those schools did not last long,

In this period, literacy remained low worldwide: less than 10% in 1490 for both Europe and China. However, in China, it would remain low (restricted to male elites) for a far longer period, whilst in post-Reformation, colonialist Europe, literacy increased steadily. By 1800, the literacy rate of the developed countries of Western Europe would have risen to ~50% (including both men and women), whereas in China, only 30% of men, and barely any women, could read or write.

Despite these trends in literature, library collections in China before 1500 were impressive: three to four times bigger than Europe's greatest book collections of the time. However, the imperial libraries were exceptional in China, and their use was restricted to the privileged few.

There is no evidence that the fields of literature and literacy were substantial HASS factors contributing to the comparative explorations of Europe and China, at least during the fifteenth century.

5.2.3.4 Government, politics and leadership. The political leadership personae and governments of the 1400s appear to be major factors contributing to Columbus, not China, becoming New World "discoverer". In terms of accomplishments, Isabella I is known for unifying Spain through her marriage to Ferdinand II of Aragon, her financing of Columbus's voyage, the 1492 *Reconquis*ta defeating the Arabs at Granada, and, more infamously, for empowering the Spanish Inquisition.

Queen Isabella I was Europe's first great queen regnant, one a small group of leaders whose influence far transcended their nations' borders. The theme of European female influence followed with Elizabeth I and her dramatic expansion of English New World possessions. It may be a stretch to attribute the West's successes to greater female "diversity" when compared to China's, but an increased European female political involvement from the late fifteenth century can hardly be questioned (Antolini, 1992). Isabella, similar to John F. Kennedy, entered the history books as something of a visionary in financing one of humanity's greatest explorations. Few Western monarchs did as much as Isabella I and Elizabeth I in inaugurating New World colonialism.

China, from 1400 to 1500, meanwhile, underwent leadership changes, but initiated no radical governmental innovations. A European female monarch (Isabella) was something new on the world's stage; Hongxi and 500 other Chinese emperors maintained, for thousands of years, a strict, male imperial tradition, whose rigidity may possibly have stilted a Chinese Renaissance or discovery, and allowed the West to surge ahead.

On the balance, it appears that government, politics and leadership in Western Europe were more conducive to explorers seeking to expand their reach as compared to China.

5.2.3.5 Economics. Economic capacity and structures are important HASS enablers for projects such as New World colonization and the Space program. However, economic size was

clearly not a decisive factor in determining which of Europe and China would reach the New World first.

As Table 3 illustrates, the economy of China was the world's largest during this period. China was also by far the largest politically contiguous region; India, Africa and Italy (for example) comprising multiple smaller states. Economically, China was 30% bigger than Western Europe and ~14 times larger than Spain, the primary financier of Columbus's expedition and fourth-largest economy in Europe. Italy, source of the Renaissance, was the leading European economic power. By the early 1700s the economy of Western Europe, excluding its new American colonies, would catch up with and overtake China.

An *economic threshold* may have influenced which region would become New World "discoverer". Two of the three largest economies (China and Europe) were apparently the only ones during the 1400s to establish oceangoing fleets or exploration programs of a scale likely to discover "New Worlds". This suggests that a *STEM* threshold, as well as an *economic* threshold, applied to the potential to discover a New World.

This parallels the Space Race of the 1960s: of all the "developed" nations possessing high STEM capabilities (then excluding China), only the Americans and Russians possessed sufficient threshold economic power for a moonshot, as well as the requisite technology. Europe was not a unified economic entity during the 1960s, and Japan's economy was still too small. Neither power embarked upon manned lunar programs.

As Table 2 shows, differences between Spain and China in finance, trade and government during the 1400s also played roles in incentivizing colonialism by the West, whilst disincentivizing Chinese voyages, such as Zheng He's. Spain's laws, customs and institutions rewarded international trade and exploration; China's did not. Changes in China's leadership from c. 1430 ultimately eliminated the economic incentive for oceangoing trade, via its overt prohibition (Wolla 2013).

On the balance, perhaps the larger Chinese economy did not create sufficient incentives for favoring human expeditions to distant foreign lands. Europe had a sufficient economic threshold to be able to afford such expeditions, and also had the hunger for more resources, which would potentially arise from such endeavors.

6. Parallels to modern space race

In this section, we draw parallels between the Columbus venture to the modern space race. We limit our discussion to crewed or "manned" space explorations.

We could characterize Columbus's quest to find a westward route to China as history's greatest exploration triumph, or its luckiest mistake. Columbus's explorations were primarily about trade. His bold proposal to the Spanish monarchs said little of expanding the

Civilization (1500 A.D.)	Economic size PPP GDP* USD millions – 1990	World ranking (largest = 1)
China (Ming)	61,800	1
Spain	4,495	[Europe** ranking: 4]
Italy	11,550	[Europe** ranking: 1]
Western Europe	44,183	3
Western Asia/Middle East	10,495	5
India	60,500	2
Africa	19,383	4

Note(s): * Gross Domestic Product (Purchasing Power Parity) in millions of 1990 International Dollars
** Excluding former USSR
Source(s): Authors' own compilation; Maddison (2001)

Table 3. Economic size estimates, selected economies, c. 1500 A.D

boundaries of known maps or exploiting possessions for the Spanish crown. Those goals mostly appeared later, after Columbus's New World "discovery". Not until 1498 did a European explorer set foot on the mainland Americas (Venezuela); John Cabot made first landing in North America, and explorer Amerigo Vespucci, lent the continents his name. Such post-Columbian explorations built European colonial momentum into the ensuing centuries.

The Apollo program's immediate goals were political and scientific, rather than trade. Armstrong's first moon landing has yet to produce generations of planetary explorers, missionaries or settlers, as Columbus's voyages did.

However, there are many parallels. Both Columbus's and Ming China's voyages were government-sponsored, financed and accountable, similar to the Apollo missions and every major space program to date. That role of government, as a key driver and stakeholder of exploration, has not changed much in 500 years. Although private enterprises (*Columbus, the East India Company, Grumman, SpaceX*) have had expanding and crucial roles, most human exploration remains subject to national states and their treasuries, ideologies and appetite for New Worlds: all HASS considerations.

Several commentators (including Pyne, 2003; Dick, 2005; Lester and Robinson, 2009) have noted the many similarities, as well as some differences, between ventures of the "Age of Discovery/Exploration" (c. 1400–1600), particularly in the West, and those of the modern "Space Age". Those include discussions of exploratory elements and drivers that may be ascribed both to, e.g. Columbus and to modern space venturers. "Exploration" has, in this context, a broad meaning that goes well beyond merely the purposeful discovery of new lands, and such meaning is unrestricted by what the exploration's original or subsequent purposes might be. Furthermore, human exploration may be considered either as a collection of separate (and diverse) ventures with relative success or failure or as more of a continuum of discovery and expansion that began in prehistory, that includes Columbus and his contemporaries, and continues into the modern Space Era.

Parallels between fifteenth century and modern exploratory ventures include the following.

(1) Columbus, Zheng He, and modern space missions to date have had a principal focus on discovery, exploration and the establishment of routes and communications, whether orbital or maritime, rather than direct exploitation. Whilst Columbus's successful New World explorations were not initially geared to the exploitation of new regions, they nevertheless paved the way for such future exploitations (e.g. colonization). Similarly, we can expect modern exploratory space race missions to enable future space exploitation (e.g. space tourism, space mining).

(2) From the standpoint of developed nations, the "Age of Discovery" of Columbus presaged a permanent expansion of the world's known and exploited land mass (through the addition of the Americas) to an extent unique in history—by some 40%. Space exploration is one of the few imaginable modern human ventures that could potentially achieve or enable such a dramatic increase in "living space". Under such a hypothesized future, the Moon and Mars alone possess more space for potential exploration and exploitation than Earth's entire land mass.

(3) Arguably, the exploration of the Earth, sea and space has been a continuous process since prehistoric times. However, the era of Columbus and Zheng He and their successors (c. 1400–1700) was marked by a huge increase in such global explorations. This paralleled the end of the Western Renaissance and accompanied rapid advances in both STEM and HASS fields. Subsequently, during the period c. 1800–1950, the "known world" (to the West) has then remained relatively stable. Since 1950, in analogy to the Age of Discovery, the Space Age has created enormous new

opportunities to explore and exploit "new worlds": Earth's orbit, the Moon, Mars and the broader Solar system. Those explorations, similar to the age of Columbus, have been assisted by numerous and rapid technological advances. As such, the modern space race may represent an enduring period of exploration, and an expansion of humanity's physical influence, which is unparalleled in history except by the era c. 1400–1700.

7. Conclusion

By examining historical explorations through a *broad* HASS and accountability lens, this study has added to prior knowledge of the drivers and enablers of such explorations. On the balance of probabilities, the evidence in this article points to HASS factors (as enablers, influencers and motivators) as being likely explanations for Columbus's relative success in New World explorations when compared to China. This thereby demonstrates the key importance of HASS factors in human exploration and similar ventures. Whilst such explorations may require a *minimum* level of STEM capabilities, HASS factors principally determine their success.

Following our analytical approach, *accounting* and *accountability* emerge as significant factors that potentially influence the decisions and execution of exploring unchartered territories. Interestingly, we find that outcome accountability focus best explains the differences in motivations and incentives across the two cultures, driving large human explorations. Further, our evidence indicates that in addition to accountability to stakeholders, other HASS factors, such as finance (including trade and accounting), government and ideology (including theology) were influential in the West achieving "New World" prominence.

Our evidence also points to the role played by stakeholders in driving large human exploration ventures. Besides having more vested stakeholders, Columbus thrived in an environment where stakeholders influenced his expedition via legitimacy and urgency attributes.

7.1 Discussion

Having presented our findings, we next discuss the implication of our findings and the potential contribution to accounting and accountability research, as well as suggest implications for future research and practice.

First, based on our findings, we developed a conceptual model, shown in Figure 1, that succinctly captures our contribution to the emerging literature regarding the roles of accounting and accountability in driving human space explorations. Based on this study, STEM superiority by no means assures primacy or success in human exploration. HASS factors play at least as important a role and will, we surmise, be critical determinants of the winners and losers in humanity's future explorations to space. A broad-based HASS (i.e. not only STEM)-focused accountability, stakeholder, and strategic and performance model is thus highly recommended for such explorations.

Second, among the HASS success factors that we have examined, accountability emerged as the most critical HASS factor, in tandem with stakeholder management and accounting. Explorations (including space ventures) with poor accountability, accounting and stakeholder management, while not necessarily doomed to failure, will nevertheless be much less assured of achieving their aims.

Third, while prior work has examined the role of accountability in a variety of contexts, none of the prior work has examined "space exploration". The closest work we have found is research that suggests that process accountability is associated with managerial exploration

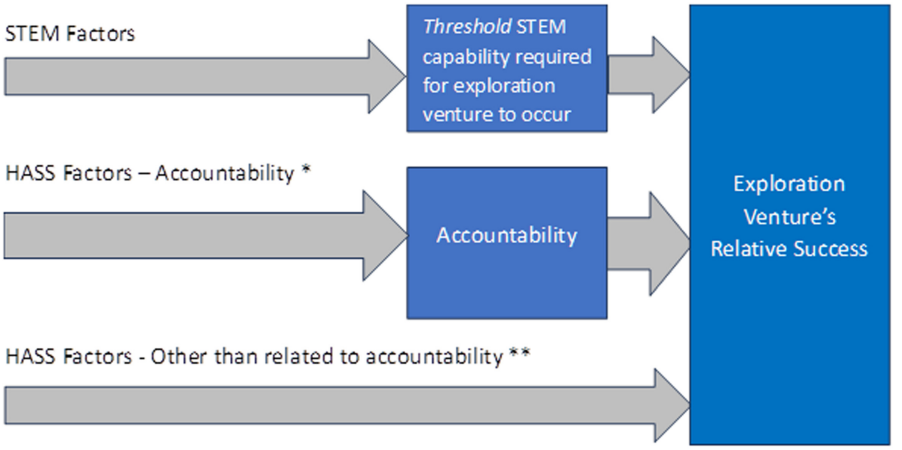

Figure 1.
Conceptual diagram of our contribution

Note(s): **Includes accountability drivers such as stakeholder management, accounting, and legal frameworks*
*** Includes all other HASS factors e.g., ideology, trade, finance (as itemised in Table 2)*
Source(s): Authors' own work

decisions. We exceed prior work by exploring the effect of HASS factors, focusing on accounting and accountability. Our findings indicate that HASS factors are at least as important as STEM factors in driving human explorations.

We were able to achieve these results because we were the first to undertake an exploratory study through a *broad* HASS/STEM lens, with a focus on accounting and accountability. While prior research has explored human explorations through the STEM lens, none of them have used a HASS lens.

Prior research posits that accounting and accountability have significant influence on human activities in a variety of contexts. For instance, Moggi *et al.* (2016) describe the importance of accountability features of Confraternities in Verona during the seventeenth century. Bigoni *et al.* (2013) analyzed the role of accounting and accountabilities, in order to ascertain the presence of a sacred–secular dichotomy in the Roman Catholic Church during the fifteenth century. Dobie (2015) studied the role of accounting and financial management practices in Benedictine monasteries in England. Funnell (2006) assesses the role of accounting systems in a military setting. Ferry *et al.* (2023) examined the accountability and disciplinary practices embedded in the codes of conduct and corporate governance used in English local government. Robertson and Funnell (2012) and Funnell and Robertson (2011) debate the role of the double-entry bookkeeping system in influencing modern capitalism. Verwaeren and Nijstad (2022) found that accountability focus is associated with the exploration strategy of firms. The overall message from these works is that accounting and accountability significantly influence human endeavors. What is missing in prior work is research on the relevance of accounting and accountability in human space exploration. Our study extends the present literature to include human explorations, which has not been attempted before.

7.2 Practical implications

To assure success, space explorers (e.g. NASA, SpaceX or their successors) should place due emphasis and resources on HASS factors—arguably as much or more as STEM factors, e.g.

technical innovations. Having good accountants, accountability structures, stakeholder managers, performance models, OH&S, strategists, finances, staff trainers, administrators, and even historians and ethicists may be as crucial, or more so, to space missions than having the most advanced science, the fastest spaceships or the best information technology experts or engineers.

It is apparent that many of the studied HASS factors also appear to have been influencers in modern era Space projects. For example, for Apollo and Soyuz, success factors, such as the relative economics of USA and USSR, their political ideologies, accountabilities and organizational priorities, have clear echoes.

What the successful voyages of Columbus and Apollo also have in common is an appetite to take risks for an uncertain return, whether as sponsor or voyager, an understanding of financial management and benefits measurement, and a leadership (e.g. Isabella I, John F. Kennedy) possessing a vision, ideology and a governmental apparatus to further the venture's goals.

7.3 Limitations

In seeking to answer the questions studied, this study identified only those factors (HASS or STEM) that may support the success or failure *in execution* of the exploration and development of a region, such as the New World or space. HASS or STEM factors that determine *decision-making* and *decision-influencing* in this regard are outside this study's scope. Moreover, the study has the following limitations.

(1) Relative successes, failures, drivers and enablers of exploratory ventures are drawn almost exclusively from the documented historical records of the nations, entities and individuals (China and Europe) who conducted those ventures. A paucity of objective sources in some fields, and the need to set appropriate boundaries for the study, also necessitate such a limitation.

(2) The study excludes value judgments against humanistic, theological, philosophical (HASS) or scientific (STEM) criteria regarding whether such explorations *should have occurred* or *how* they were conducted, not least, their moral or ethical rightness or wrongness. Accordingly, Columbus attaining the New World before China is counted as a relative success, rather than a failure, without regard to whether European decisions to seek a westward trade route or settle the Americas were "correct" or "ethical".

7.4 Potential future research

Because this study has been of a preliminary and exploratory nature, implications for practice and enterprise may only become evident following future research. Some recommendations for such are set out below.

First, human exploration endeavors appear to warrant an improved key performance indicator (KPI) and accountability framework, potentially a "balanced scorecard', that adequately incorporates both HASS and STEM factors. The development of such a HASS and STEM scorecard, particularly for human exploration, is one potential field for future study. Research and development of broad, HASS-based accountability and performance models (e.g. "scorecards') may potentially benefit modern space programs, space enterprises and similar exploratory ventures.

Second, a deeper investigation of the role and effectiveness, in explorations of decision-influencing (as opposed to enabling) and ethical and moral accountabilities, is called for.

Third, an examination of other sets of contemporaneous human exploratory ventures is likely to be a fruitful exercise. These include Norse and Arab explorations c. 800–1000 AD,

and colonialism by European powers (1600–1900). These extensions may potentially rebut or refine any of the findings of this study.

Fourth, an assessment (in the light of this study) of contemporary manned and unmanned space projects' HASS vs STEM factors leading to their success, as well as an assessment of the effectiveness of their accountability, stakeholder and performance models in measuring and enabling such success factors, would be a potential extension of the current research.

Finally, in addition to the HASS vs STEM drivers of exploration *success* explored in the current article, decision-enabling and -influencing drivers may merit further investigation, e.g. to what extent did ethical, philosophical or religious considerations (HASS factors) affect or modify the decisions of fifteenth century Spain and China even to consider such explorations?

Notes

1. Science, technology, engineering and mathematics (STEM) is an acronym often used to characterize these distinct but related technical disciplines. Typically, in the context of space exploration the STEM disciplines of interest include astronomy, astrophysics and several allied technology and engineering disciplines.
2. HASS refers to Humanities and the Social Sciences and encompasses various disciplines such as history, sociology, finance, economics, accounting, psychology, law and political science. The authors follow Tucker and Alewine (2022) in classifying accounting and accountability as part of HASS instead of the proposed reclassification as a STEM discipline (Cohn, 2021).
3. Hall *et al.* (2017) provide a comprehensive discussion on this.
4. In STEM, as in HASS, many differences between China and Europe were purely of a historical or cultural nature, or otherwise appear to have had little or no influence on exploration. Ship decoration, the type and quality of weaponry on Columbus's and Zheng He's vessels, choice of mapmaking materials, and non-maritime engineering achievements fall into such a category. Those have been excluded from further analysis.

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Corresponding author
Chandrasekhar Krishnamurti can be contacted at: Chandra.Krishnamurti@unisa.edu.au