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Article

Digital Entrepreneurs in Artificial Intelligence and Data Analytics: Who Are They?

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Abstract: Digital technologies are key resources for entrepreneurial activities and there is great interest in digital entrepreneurship. While much research has focused on the role of digital technologies in entrepreneurship and how they are shaping the field, there has been relatively little research on those key players of digital entrepreneurship. Using data from Crunchbase and Twitter API and a learning machine, this study attempts to answer the question of “who are digital entrepreneurs?” This study reports that digital entrepreneurs in the artificial intelligence and data analytics (AIDA) industry are more likely to be male and to be active and connected online than non-digital entrepreneurs. In addition, they tend to be more extroverted and less conscientious and agreeable than other, non-digital, entrepreneurs. Our findings help to develop a clearer picture of digital entrepreneurs, which would be of great interest to investors, policy makers, current and future digital entrepreneurs and educators.

Keywords: digital entrepreneurs; personality traits; digital data; machine learning; open innovation

1. Introduction

Digital technologies are driving the creation of new ventures in the twenty-first century [1]. Digital entrepreneurship has emerged as a field as digital technologies have begun playing important roles in innovation and entrepreneurial activities. Recent studies in the entrepreneurship literature have highlighted differences between digital ventures and other types of ventures [2]. Yet, the study of digital entrepreneurship is still in its infancy (e.g., [3]). In particular, there is a lack of understanding of those key players, called “digital entrepreneurs” [4], who are behind this emerging entrepreneurial activity.

In response, the goal of this study is to answer the question of “who are digital entrepreneurs?” This question is important since “at the center of the entrepreneurial process stands the individual entrepreneur as key agent” [5]. Several studies have highlighted the important roles of entrepreneurs in value creation and open innovation [6–8]. The extant literature has suggested that digital ventures and digital entrepreneurs are different from other types of ventures and entrepreneurs, in terms of demographic characteristics and personality traits [9–11]. This study is interested especially in digital entrepreneurs in the artificial intelligence and data analytics (AIDA) field. AIDA represents the most important source of digital innovation in our era [12], with significant implications for business, society [13], entrepreneurship and open innovation [14]. There is no published work on digital entrepreneurs in this emerging field, other than the presumption that those individuals are technology-savvy.

This study focuses on three types of traits of entrepreneurs in this emerging venture area: personality, demographics and social media presence. While these three dimensions are not necessarily comprehensive in understanding an individual, they can offer a glance at those digital entrepreneurs in this evolving field. Using Crunchbase API, this study identified a long list of entrepreneurs in AIDA.

Twitter API was then used to collect their tweets and metadata [10]. A machine learning approach was utilized to extract demographic and personality traits from the Twitter data. Data on entrepreneurs' social media presence were extracted from their Twitter activity and networking.

To better understand the group of digital entrepreneurs in AIDA, another group of entrepreneurs was sampled from such sectors as construction and machinery manufacturing. The aforementioned data collection and processing activities were then repeated for this non-digital group of entrepreneurs. Logistic regression was performed to explore whether digital entrepreneurs in AIDA are associated with specific personality, demographics and social media traits. The results show that digital entrepreneurs are more likely to be male and to be active and connected online than entrepreneurs in more traditional sectors. In addition, they tend to be more extroverted and less conscientious and agreeable than non-digital entrepreneurs. The study findings provide a clearer picture of those digital entrepreneurs in the emerging field, which would be of great interest to investors, policy makers, current and future entrepreneurs and educators. The study findings also provide a discussion about digital entrepreneurs and open innovation.

2. Background

Four areas of the literature are reviewed below. First, this section reviews the studies of digital entrepreneurship and digital entrepreneurs, places AIDA in the entrepreneurial contexts and highlights the significant role of digital entrepreneurs in implementing the disruptive technology. Then, from the literature it summarizes some extant understanding about entrepreneurs in terms of personality, demographics and social media traits. The goal is to provide a background for studying digital entrepreneurs, particularly in the AIDA field.

2.1. Digital Entrepreneurship and AIDA

Today, digital technologies are ubiquitous and enable the rapid development of products and services [15]. This phenomenon is broadly known as digitization and digital innovation [16]. Digital innovation refers to the process by which products and services are innovated with the help of digital technologies. This also explains the emergence of a new breed of entrepreneurs known as “digital entrepreneurs” [4] and a category of entrepreneurial activity called “digital entrepreneurship” [1,3]. Digital entrepreneurship is entrepreneurial activity arising from the extensive use of digital technologies as the primary means for creating and delivering service offerings. The literature suggests that digital venturing is different from traditional venturing [17].

Among different digital ventures, those in the artificial intelligence and data analytics (AIDA) industry have received much attention as venture funding to these areas is increasing. Many believe that the current wave of artificial intelligence likely leads to disruptive innovation in business and society, with various implications [18]. Many successful businesses have adopted AI in their business operations and innovative AI-based business model [19]. CB Insights reported that there have been four straight years of venture investment growth in AI startups and in 2018 the venture funding reached a record \$9.3 billion. This is eight times more than five years ago. There are a growing number of startups focusing on AI in the US. Certainly, this rising investment in AI is not isolated in the US, but also has become a major trend in Europe and Asia [20].

Some recent studies have paid attention to individuals who are engaged in digital venturing. The term, digital entrepreneurs, refers to those primary actors driving the growth of digital entrepreneurship through new practices in communication, customer interaction, employment, and new product/service development. The literature suggests that digital entrepreneurs differ from traditional entrepreneurs in several aspects, including age, gender, risk-taking and cultural diversity [9,10]. Along this line, in the literature there have been two streams of research on individual entrepreneurs. The first stream of research focuses on demographic factors such as gender, age and education [11]. The other group of studies has investigated personality traits of such entrepreneurs [21,22]. In the

context of digital entrepreneurship, there has been little research on individual characteristics and psychological traits. Thus, our understanding of digital entrepreneurs and who they are, is limited.

2.2. Personality Traits

The literature on the psychology of entrepreneurship [23] has provided valuable insights into the effects of different psychological constructs on entrepreneurship. In this line of research, there has been an active stream of academic inquiry as to how individual personality affects entrepreneurial activities and outcomes [21,24]. Previous research has asked whether certain personality traits predict entrepreneurship and compared entrepreneurs with other populations, including the general population and managers, in terms of personality traits [25].

One of the popular frameworks used is the Big Five model or OCEAN (openness to experience, conscientiousness, extraversion, agreeableness and neuroticism) [26]. Entrepreneurs are initiators: they take risks, need to attract investors, develop and execute their plans and navigate uncertainty. Thus, it is expected that entrepreneurs exhibit certain personality traits and that they are also within certain demographic groups. For example, extroverted people tend to be more entrepreneurial than those who are introverted. Likewise, those who are open to newness and high in conscientiousness tend to be more entrepreneurial than those who are not. In contrast, low values in agreeableness, as well as low neuroticism, are associated with high entrepreneurial activities [22,27].

2.3. Demographic Traits

In addition to personality traits, other personal characteristics such as ethnicity and gender have been the focus of previous research in understanding entrepreneurs [21,23]. Entrepreneurial activity requires discovering and integrating resources through venture creation and growth [28]. For example, research indicates that, traditionally, women are less likely to become entrepreneurs than men [29] and African-Americans and Latinos are less likely to enter into entrepreneurship than their white counterparts [21].

However, there is also an expectation of some changes in entrepreneurs' demographics. Digital technologies make entrepreneurial boundaries more fluid and attract actors with "varied goals, motives and capabilities" (p. 2) to pursue entrepreneurship [3]. Thus, there are some popular beliefs, i.e., that there is less of an entry barrier in digital start-ups in terms of resources [4,30], so it is likely that there is more ethnic diversity in high-tech sectors, compared to other industry sectors [31] and digital entrepreneurs are expected to be more ethnically diverse. Additionally, there may be more representation of female-led digital venture creation in practice [32]. However, this assumption may be challenged in practice. A recent study in the European context [33] notes that females account for over half of the entrepreneurs in non-digital sectors, but they represent only 19 percent of the entrepreneurs in digital sectors.

2.4. Social Media Traits

Entrepreneurs are embedded in social ties, which become part of their identities in entrepreneurial pursuits and within which social interactions are formed and developed throughout their career. Specifically, networks are the source of a variety of resources in venture development and social interaction within their networks provides opportunities to discover ideas, identify potential partners and/or raise funding [34]. Traditionally, off-line ties such as family and friends tended to be key aspects of the networks, as entrepreneurs searched for information and funding opportunities.

In recent years, social media has offered entrepreneurs more means to build and maintain networks with others [35–37] and has become an integral part of entrepreneurial pursuits. This may be particularly true for entrepreneurs in high tech fields for information searches, marketing, networking and crowdfunding [38], as a great number of social interactions, such as sales, promotions, searches and communication, occur in digital platforms and infrastructure. In social media like Twitter, entrepreneurs build relationships through followers or friends and interaction is initiated and maintained through

tweets. They make conscious decisions, such as whom to follow [39] and how and what to tweet about [36]. Thus, network size and Twitter activity can be considered digital traits of individual entrepreneurs. These digital traits are considered increasingly important to digital entrepreneurs for building social, financial and human capital.

3. Data and Methods

The goal of this paper is to develop an initial understanding of digital entrepreneurs, particularly in the AIDA field. Among many types of individual traits, personality, demographics and social media traits are considered in this study. The study of digital entrepreneurs is rare in the literature and there are no public data available for the research question. This study aimed to identify as many digital entrepreneurs as possible in AIDA and to collect relevant data from which their personality, demographics and social media traits could be extracted.

This research employs a computational social science approach [40] that uses digital data (or “big data”) and often combines statistical and machine-learning techniques for data analysis. This big data analytics approach has gained momentum in entrepreneurship research [41]. The relevant data came from two digital sources: Crunchbase API and Twitter API. Crunchbase is considered the largest database for entrepreneurship-related research, offering information about more than 600,000 companies [42]. Crunchbase API was used to extract an extensive list of over 48,000 entrepreneurs in the U.S. with personal Twitter account information and whose affiliation title is CEO, founder, cofounder or president. These criteria exclude (1) entrepreneurs whose Twitter account information is not available in the database and (2) anyone whose affiliation title is such as CFO, CIO, CTO, CPO, senior software engineer, or VP.

These entrepreneurs’ personal data (e.g., name, gender, country, personal twitter account) were then linked with their primary organization data (e.g., company type, date founded, funding status, industry category). Data sampling focused on currently active entrepreneurs with recent funding histories. The process involved selecting only those entrepreneurs whose businesses were operating as of 2019 and with a history of receiving funding since 2017. This criterion (since 2017) resulted in a relatively small sample size for non-digital entrepreneurs, compared to digital entrepreneurs, so 2014 was used for non-digital entrepreneurs.

Two groups of entrepreneurs were identified, hereinafter called “digital (or AIDA)” and “non-digital (or others)”. Crunchbase’s category list was used for this sampling. Crunchbase organizes companies using over 40 category groups and over 900 categories where each category group (e.g., agriculture and farming) includes many categories (e.g., agriculture, agTech, animal feed). A company can belong to multiple categories. Digital entrepreneurs in AIDA were identified from those whose businesses are in one of two category groups: “artificial intelligence” or “data and analytics”. This procedure resulted in 1133 digital entrepreneurs.

Next, selecting “other” entrepreneurs involved a series of data filtering. First, the process involved selecting 116 “non-AIDA” category lists such as office administration, farming, fuels, food and beverage, machinery manufacturing and construction. However, it is also necessary to avoid misclassifying digital (or AIDA) as non-digital (or non-AIDA), since a business may belong to multiple categories such as “manufacturing” and “artificial intelligence”. This led to further identifying 331 category lists considered to be “digital technologies or IT”, including enterprise applications, mobile apps, online marketplaces, internet services, artificial intelligence and analytics. The following step was to select entrepreneurs whose companies belong to one or more of those non-digital categories, but not to any of those AIDA (and digital technologies) categories. The final sample contained 187 “other or non-digital” entrepreneurs.

Twitter API was used to collect tweets and metadata for those 1320 entrepreneurs. Python was used as a tool for accessing Twitter API and processing the data. Twitter metadata includes user-specific profile and activity information such as followers count, friends count and statuses count. Twitter is popularly used by entrepreneurs for a variety of purposes, including social interaction, opportunity

discovery and mitigating uncertainty [36,38]. Twitter has also been a popular source of digital data to study individuals’ psychometric properties and their relationships with business-related outcomes. For example, Lee et al. [43] reported that founder CEOs of S&P 500 companies use more optimistic expressions on Twitter than professional CEOs do.

Variables

This study focuses on three dimensions and relevant traits. The variables are summarized in Table 1.

- Personality traits: openness, conscientiousness, extraversion, agreeableness, neuroticism
- Demographic traits: gender (male, female), ethnicity (African, Asian, Hispanic, White)
- Social media traits using Twitter: followers count, friends count, statuses count.

Table 1. Summary of variables.

Dimensions	Variables	Data Source	Method of Extraction	Mean or Counts *	SD **
Personality	Openness	Twitter API	IBM Personality Insight	0.79	0.16
	Conscientiousness	Twitter API	IBM Personality Insight	0.63	0.23
	Extraversion	Twitter API	IBM Personality Insight	0.62	0.25
	Agreeableness	Twitter API	IBM Personality Insight	0.31	0.23
	Neuroticism	Twitter API	IBM Personality Insight	0.31	0.21
Demographics	Gender	Crunchbase	Crunchbase	1146 males 174 females	
	Ethnicity	Crunchbase	Python	71 African, 239 Asian, 49 Hispanics, 961 White	
Social media	Followers	Twitter API	Twitter API	2341	6758
	Friends	Twitter API	Twitter API	804	2447
	Statuses	Twitter API	Twitter API	2212	6061

* Reporting mean for numerical variables and counts for categorical variables; ** Reporting standard deviation for numerical variables.

Personality traits: The Big Five model [26] is considered in this study. The entrepreneurs’ tweets were analyzed to discover those five personality traits. There are two methods to extract personality traits from digital texts [44,45]: closed-vocabulary models [46] and open-ended vocabulary models [47]. A popular text analysis tool used for closed-vocabulary models is Linguistic Inquiry and Word Count (LIWC), which provides a dictionary of words to capture psychometric properties from texts [48]. Open-ended vocabulary models rely on machine learning algorithms to discover hidden relationships between psychometric properties (e.g., personality traits, sentiment) and language. Recently, an increasing number of studies have adopted open-vocabulary models using machine learning. Schwartz et al. [44] noted that open-vocabulary models outperform closed-vocabulary models in extracting personality traits from language.

This study uses an open-vocabulary model called IBM Personality Insights (IBM PI) to identify personality traits. Earlier versions of IBM PI used LIWC dictionary with machine learning models [49], but its latest version, used in this study, is an open-ended vocabulary model using word embedding, an advanced natural language processing (NLP) technique, to identify personality characteristics from tweets [50]. IBM PI was validated with over 1500 survey responses reporting 0.09 as the average Mean Square Error and 0.31 as the correlation between inferred and actual scores and the latest version of the service reportedly outperformed the LIWC-based earlier versions [47]. An increasing number of studies in accounting, finance and management have adopted IBM PI to extract personality traits of CEOs, CFOs and the public [51].

Demographic traits: This study considered two demographic traits: gender and ethnicity. Entrepreneurs’ gender information is obtained from the Crunchbase database. Ethnicity information relied on *ethnicolr* [52], a Python package predicting ethnicity from name using machine learning. The out-of-sample accuracy of this method is reported as 83 percent and 84 percent for precision and

recall, respectively. This technique was used to assign each entrepreneur to one of the four ethnic categories: African, Asian, Hispanic or White.

Social media traits: There could be several individual-level variables to digital or social media presence [53]. This study includes network size and Twitter activity as two of the digital traits of individual entrepreneurs. To measure an entrepreneur’s network size, previous studies focused on entrepreneurs’ ego networks [54]. In this study, Twitter’s follower counts and friend counts are considered for the network size of an entrepreneur. Twitter activity is measured by Twitter statuses counts.

4. Analysis and Results

4.1. Descriptive Analysis and Correlation

Contrary to our expectation, there was a lower percentage of females among digital entrepreneurs in AIDA (11% female and 89% male) than among non-digital entrepreneurs (26% female and 74% male). While women represent more than 45% of the labor force, they are far less likely to be entrepreneurs [29]. In regard to ethnicity, there seems to be a slightly higher representation of Asian and African in digital entrepreneurs (6% African, 19% Asian, 3% Hispanic and 72% White) than in non-digital entrepreneurs (4% African, 13% Asian, 5% Hispanic and 77% White). Entrepreneurs “tend to be disproportionately white” ([55] p. 969) There is evidence that this statement still holds true in the emerging AIDA field. However, it may also be worth noting the proportionally large Asian representation (19%) among digital entrepreneurs, in comparison to 13% among non-digital entrepreneurs. When gender and ethnicity are considered simultaneously, the largest groups are White males, 65% and 57%, for digital and others, respectively. Asian males represent the second largest group (16.3%) for the digital group, while White females account for (20.3%) of entrepreneurs in non-digital sectors. While females are the third largest group, but represent only 6.97% among digital entrepreneurs, African males (4.68%) and Hispanic males (3.74%) are the fourth largest groups among digital entrepreneurs and others, respectively.

In terms of network size and Twitter activity, digital entrepreneurs in AIDA are more active in Twitter than non-digital entrepreneurs: the average statuses counts of digital entrepreneurs and non-digital entrepreneurs are 2329 and 1507, respectively. Additionally, digital entrepreneurs appear to be more influential in social media than others: on average, digital entrepreneurs have more followers (2393 vs. 2029) and fewer friends (781 vs. 943) than others. Table 2 shows the average percentage scores for Big Five personality traits.

Table 2. Average percentile scores for Big Five personality traits.

	Openness	Conscientiousness	Extraversion	Agreeableness	Neuroticism
Digital AIDA	0.80	0.62	0.63	0.30	0.32
Non-Digital	0.80	0.68	0.63	0.37	0.34

IBM Personality Insights provided a percentile score for each Big Five personality trait. For example, a percentile of 0.80 for the personality trait openness indicates that the entrepreneur’s score for that trait is in the 80th percentile [47]. The results show that each entrepreneur group exhibits a high tendency to openness, conscientiousness and extraversion, while being low in agreeableness and neuroticism. These characteristics are referred to as entrepreneurial or Schumpeterian personalities in the literature [56]. What is noticeable is that digital entrepreneurs in AIDA, on average, appear to be less agreeable and conscientious than entrepreneurs in non-digital sectors. This may be related to entrepreneurship in digital and emerging fields. “Conscientiousness involves orderliness . . . in favor of longer term plan” [57] and is “a person’s tendency to act in an organized or thoughtful way” [47]. There may be some unique characteristics associated with digital entrepreneurship, including the need for continuous feedback and business revision [2] and the dynamic nature of digital artifacts, platforms

and ecosystem [3,58]. In this dynamic context, digital entrepreneurs’ conscientiousness still needs to be high, but may not be as high as that of non-digital entrepreneurs.

For correlation analysis, first, the variables were checked for normality using both visual analysis and the R function `shapiro.test()`. The data were not normally distributed and a non-parametric method, Spearman’s ρ statistic was used to estimate associations among the variables. Table 3, based on an R package (`psycho`), shows the results of the correlation analysis.

Table 3. Correlation analysis.

	Openness	Conscientiousness	Extraversion	Agreeableness	Neuroticism	Followers	Friends
openness							
conscientiousness	−0.08						
extraversion	0.11 **	0.55 ***					
agreeableness	0.01	0.52 ***	0.54 ***				
neuroticism	−0.08	−0.45 ***	−0.37 ***	−0.21 ***			
Followers	0.18 ***	0.03	0	0.06	−0.07		
Friends	0.16 ***	−0.05	−0.04	0	−0.04	0.6 ***	
Statuses count	0.18 ***	−0.06	−0.03	−0.02	−0.06	0.73 ***	0.63 ***

*** $p < 0.001$, ** $p < 0.01$.

Openness is shown to be positively correlated with extraversion. Conscientiousness is also positively correlated with extraversion and agreeableness. Extraversion is shown to be positively correlated with agreeableness. Neuroticism exhibits a negative correlation with the other four personality attributes and the negative association is statistically significant with conscientiousness, extraversion and agreeableness.

The Twitter activity (statuses count) is positively correlated with openness and network size (followers count and friends count). Followers count and friends count are positively related to each other and also are positively correlated with one of the personality traits, openness.

4.2. Results of Logistic Regression

In this study, logistic regression analysis was performed to test whether digital entrepreneurs are associated with certain demographic characteristics and personality traits. The logistic regression model formulates the probability of digital entrepreneurship in AIDA, given personality, demographics and social media traits. Therefore, the analysis helps identify what traits are distinct for digital over non-digital entrepreneurs by estimating the regression coefficients. Since there are several traits from three dimensions, it is necessary to exclude irrelevant traits from model construction, so that the resulting model becomes more interpretable. First, a backward elimination procedure was run, based on Akaike information criterion (AIC), to remove the redundant traits not related to digital entrepreneurs in AIDA and then fit the logistic regression model with the remaining important traits. The statistical analysis is performed in the statistical environment R.

The logistic regression analysis results are summarized in Table 4. From the backward elimination procedure, all of the Big Five personality traits (OCEAN), two demographic characteristics (gender and ethnicity), and two social media traits (friends count and statuses count) are selected as important predictors of digital entrepreneurs. In Table 3, the p -values smaller than 0.05 support the statistical significance of the predictors at the 0.05 level. Similarly, the predictors with p -values less than 0.10 attain statistical significance at the 0.10 level.

Digital entrepreneurs in AIDA are shown to be correlated negatively with conscientiousness, agreeableness and neuroticism and positively with extraversion at the 0.05 level. The negative coefficient for conscientiousness indicates that digital entrepreneurs are less conscientious than non-digital entrepreneurs. The negative coefficient for agreeableness implies that digital entrepreneurs tend to have a lower level of agreeableness compared to that of non-digital entrepreneurs. The coefficient for neuroticism is negative, indicating that digital entrepreneurs are more likely to score low on neuroticism than non-digital entrepreneurs. On the other hand, as the coefficient for extraversion has a positive sign, digital entrepreneurs have a tendency to be more outgoing and social than non-digital entrepreneurs.

Table 4. Estimated coefficients of the logistic regression model.

	Coefficient	Std. Error	Z-Statistic	p-Value
Intercept	3.3497	0.8110	4.13	0.0000
Openness	−1.0002	0.5608	−1.78	0.0745
Conscientiousness	−2.2137	0.5576	−3.97	0.0001
Extraversion	1.7359	0.4709	3.69	0.0002
Agreeableness	−0.9537	0.4263	−2.24	0.0253
Neuroticism	−1.0850	0.4605	−2.36	0.0185
Friends count	−0.0001	0.0000	−1.71	0.0874
Statuses count	0.0001	0.0000	2.13	0.0330
Gender [Male]	0.9350	0.2042	4.58	0.0000
Ethnicity [Asian]	−0.1671	0.4629	−0.36	0.7181
Ethnicity [Hispanic]	−0.9416	0.5511	−1.71	0.0876
Ethnicity [White]	−0.6584	0.4194	−1.57	0.1164

The positive coefficient for statuses count implies that digital entrepreneurs are likely to be more active users of social media than non-digital entrepreneurs. Since the coefficient for male is positive, this result indicates that there are more male entrepreneurs in the AIDA field. The negative coefficient (at the 0.10 level) for friends count (those whom digital entrepreneurs in AIDA follow) indicates that digital entrepreneurs tend to follow fewer people than non-digital entrepreneurs, while there is no significant difference in followers count. This may indicate a higher follower-to-friend ratio for digital entrepreneurs, compared to the non-digital group, whose implication will be discussed in the next section.

5. Discussion

There is growing interest in digital innovation and digital entrepreneurship in the literature, as digital technologies have become the backbone of innovation and venture creation [1,3]. In this context, this study attempts to understand who digital entrepreneurs are, which is under-explored in the literature. Among digital ventures in different sectors, this study attempts to understand who digital entrepreneurs in AIDA are and to develop initial evidence for digital entrepreneurs in terms of three categories of individual-level factors: personality traits, demographic characteristics, and social media presence. This section provides a discussion of the results and some implications for open innovation.

5.1. Personality Traits

Overall, both digital and non-digital entrepreneurs appear to be high in openness, conscientiousness and extraversion, but low in agreeableness and neuroticism. These characteristics are referred to in the literature as entrepreneurial or Schumpeterian personalities [56]. In this regard, entrepreneurs, whether they are digital or not, tend to be highly open-minded, extroverted in relationships, organized, less agreeable and more emotionally stable than the general public.

However, digital entrepreneurs in AIDA look different from those in non-digital sectors in some personality traits. The results indicate that digital entrepreneurs are less conscientious than non-digital entrepreneurs. There are two potential explanations for this finding. First, “Conscientiousness involves orderliness . . . in favor of longer term plan” [57] and is “a person’s tendency to act in an organized or thoughtful way” [47]. There may be some unique characteristics associated with digital entrepreneurship, including the need for continuous feedback and business revision [2] and the dynamic nature of digital artifacts, platforms, and ecosystems [3,58]. In this dynamic context, digital entrepreneurs’ conscientiousness still needs to be high, but may not be as high as that of non-digital entrepreneurs. Second, men are highly represented in digital entrepreneurship in AIDA, according to the findings and the literature says they score lower than women on conscientiousness [59].

This study reveals that while entrepreneurs are, on average, emotionally stable, low neuroticism appears to be a strong personality trait for digital entrepreneurs. Neuroticism is “the extent to which a

person's emotions are sensitive to the person's environment" [47]. Thus, this finding seems to align with the common belief that entrepreneurs are more emotionally stable than others, but also raises the question of "why digital entrepreneurs in AIDA are more emotionally stable than non-digital entrepreneurs." High competition may be a key characteristic of the organizational and institutional environments for digital entrepreneurship. To be successful in such environments, there may be a greater need for emotional stability.

Low agreeableness is well-known as a Schumpeterian personality trait and entrepreneurs are likely to be less agreeable than the general public [21,56,60]. This study shows that digital entrepreneurs are, on average, lower (30th percentile) in this trait than non-digital entrepreneurs (37th percentile). Being less agreeable is correlated with competition. Digital entrepreneurs often operate in emerging markets where continuous innovation is critical for survival and thus, competition is high. It may be that a more competitive personality is necessary to succeed in digital entrepreneurship. Women are more agreeable than men, thus the large representation of men in the digital group may explain why the group appears to be lower in agreeableness than the non-digital group.

Finally, there is also evidence that digital entrepreneurs are more extroverted, but slightly less open to new experiences, than non-digital entrepreneurs. Being energetic and outgoing has been considered an important trait for entrepreneurial success. It may be that a stronger personality of extraversion is demanded in emerging fields like AIDA, involving diverse actors and fluid boundaries (e.g., [3]).

5.2. Demographic Characteristics

Race/ethnicity has received much attention in the literature [29,61]. With respect to gender, unlike many might expect, there is some evidence that digital entrepreneurs are less diverse than others: there is a significantly higher percentage (89%) of males among digital entrepreneurs, compared to 77% among others. While women represent more than 45% of the labor force, they are far less likely to be entrepreneurs. This study shows that women are less likely to enter digital entrepreneurship. This may be related to the fact that female entrepreneurs are highly represented in non-IT sectors such as sales and services and their firms are more likely to be family business-related [21]. While digital ventures like AIDA benefit from urban agglomeration and networks (e.g., Silicon Valley) [62], women have traditionally been at a disadvantage as to relocating to cities for new ventures and resources (e.g., time) for networking [63].

In terms of ethnicity, White represents 72% and 77.5% of digital entrepreneurs in AIDA and others, respectively and digital entrepreneurs are slightly more diverse than others. This increase in diversity seems to be largely related to more Asian representation in the digital group (19%), compared to others (13%). This may be because digital entrepreneurship has been shown to be strongly associated with cities and geographical clusters such as Silicon Valley [62]. There are high activities of immigrant entrepreneurs in technology entrepreneurship [31,64] and in places like Silicon Valley, Asians account for the majority of foreign-born entrepreneurs [65].

5.3. Social Media Traits

Digital entrepreneurs appear to be more active in using social media and have more followers, but follow others less than entrepreneurs in other sectors. This may be related to the nature of entrepreneurship in the digital era and broader institutional changes in entrepreneurship. For digital ventures, digital technologies, such as the Internet and Application Programming Interface (API), are the primary means for business transactions and relationships [66,67]. There are also institutional changes such as crowd-funding, user-centered innovation and digital ecosystems [3,30]. These contexts drive entrepreneurs to be more active in social media platforms and digital entrepreneurs may be using social media for promoting and selling products/services (e.g., software, algorithms, data), and for interacting with customers and suppliers.

In online networks, the ratio of followers-to-friends tends to indicate the level of the users' network power, as average people follow popular people rather than being followed by [68].

This indicates popular people tend to be influential in online networks. Online networks are vital to entrepreneurial endeavors such as opportunity discovery [54], mitigating uncertainty [36], fundraising [35,69] and business development [39]. The result may suggest that digital entrepreneurs are taking advantage of online networks for many purposes. They tend to be not only more active, but also more effective in online platforms as they enjoy having more network influence. Table 5 summarizes key characteristics of digital entrepreneurs.

Table 5. A summary of discussion.

Traits	Key Characteristics of Digital Entrepreneurs
Personality traits	<ul style="list-style-type: none"> • Digital entrepreneurs are less conscientious than non-digital entrepreneurs.
	<ul style="list-style-type: none"> • Low neuroticism appears to be a strong personality trait for digital entrepreneurs.
	<ul style="list-style-type: none"> • Digital entrepreneurs appear to be less agreeable than non-digital entrepreneurs.
	<ul style="list-style-type: none"> • Digital entrepreneurs are more extroverted, but slightly less open to new experiences, than non-digital entrepreneurs.
Demographic characteristics	<ul style="list-style-type: none"> • Digital entrepreneurs are less diverse than non-digital entrepreneurs in terms of gender: less female representation in digital entrepreneurship.
	<ul style="list-style-type: none"> • In terms of ethnicity digital entrepreneurs appear to be slightly more diverse than non-digital entrepreneurs.
Social media traits	<ul style="list-style-type: none"> • Digital entrepreneurs appear to be more active in using social media and have more followers, but follow others less than entrepreneurs in other sectors.

5.4. Digital Entrepreneurs and Open Innovation

The study findings also provide a discussion about digital entrepreneurs, AIDA and open innovation. Many studies have pointed out a close relationship among them. Digital entrepreneurs are combining resources in creative ways to produce innovative products and services. Such resources are distributed and exist beyond organizational boundaries and thus the open innovation strategy and process are critical for them [7,14,70]. This is particularly true for entrepreneurship in AIDA where innovation often follows the logic of openness, convergence and generativity [15]. Digital entrepreneurs’ characteristics, such as being extroverted and openminded in personality and active and influential in social media platforms, are expected to play positive roles for them in leveraging open innovation in their entrepreneurial endeavor.

Not only that, digital entrepreneurs also are likely to play some key roles in the future of open innovation. Open innovation stresses flow of ideas and resources outside organizational boundaries and feedback-based learning from the external environment [71]. Recent studies have highlighted the role of digital technologies and technology solutions for supporting this distributed innovation process and open innovation strategies and process [72–74]. For example, digital platforms [75] like the Moving platform [76] are increasing entrepreneurs’ capability for information literacy and collaborative problem-solving, which is the key in open innovation. Digital entrepreneurs are those creating these types of technology-based tools and thus their activities are increasing the capability of open innovation among people and organizations [3,73].

Among many digital technologies [14,73], there is evidence that big data and machine-learning algorithms are making direct impacts on open innovation strategies and processes enabled by processing large-scale data collection and developing insights from open data [77,78]. External knowledge is considered the key enabler of open innovation and today, the volume and variety of such knowledge

has increased from social media, digital devices, and open databases. AIDA and those entrepreneurs in that field have changed the way external knowledge is acquired, processed, and further disseminated. The open innovation process has become increasingly faster and more automatic than in the past, largely driven by AIDA and digital entrepreneurs in that field.

6. Concluding Remarks

Digital technologies are key resources for entrepreneurial activities and there is much interest in digital entrepreneurship. Such interest is not limited to research, but is also growing among young practicing/potential entrepreneurs. While more research has focused on the role of digital technologies in entrepreneurship and how they are shaping the field [3], there is relatively little research on those key players of digital entrepreneurship. In response, this study has attempted to answer the question of “who are digital entrepreneurs?” Considering a growing interest in and venture funding of the artificial intelligence and data analytics field, this study attempts to develop initial evidence about digital entrepreneurs in that field. To our knowledge, this is one of the first studies attempting to understand who digital entrepreneurs are.

The study reported the findings from analysis of a large volume of digital data from Crunchbase and Twitter API using a series of statistical and machine-learning techniques. Our findings help us understand who digital entrepreneurs in AIDA are. This study provides initial evidence that digital entrepreneurs are highly open-minded, organized, outgoing, competitive, emotionally stable and less diverse in terms of gender and ethnicity than the general public. Furthermore, this study shows evidence that they are different from non-digital entrepreneurs in some personality, demographic and social media traits: they are likely to be male, more active and influential online and more extroverted and emotionally stable, but less agreeable, less conscientious and less open to new experiences. In addition, the emergence of AIDA and entrepreneurs in that field has implications for open innovation, as they are coevolving through interaction. AIDA is changing the process of open innovation and in turn, open innovation is likely to fuel advancements in AIDA and birth of digital entrepreneurs.

These findings and implications would be of great interest to investors, policy-makers, current and future AIDA entrepreneurs and educators. Extroverted and open-minded personalities appear to have an advantage in entrepreneurial endeavors. Education and training may focus on encouraging someone to be more open to new experiences and striving for achievement, both of which are considered important personality traits for entrepreneurs and open innovation. In addition, to be entrepreneurial means having the need to be highly-engaging, as well as competitive. This competitive personality is strongly present among those digital entrepreneurs. They, in particular, appear to respond to such competitive environments with strikingly high emotional stability.

There is strong gender disparity in digital entrepreneurship. The availability of digital infrastructure (e.g., the Internet), open-source algorithms, API and data does not necessarily lead to more female participation in this evolving field. There are still other barriers confronting women attempting to enter digital entrepreneurship in AIDA. This should be considered by investors, policy-makers, educators and individual entrepreneurs.

The literature has suggested immigrants may have certain advantages in high-tech sectors [31] and there is an expectation of more ethnic diversity among entrepreneurs in such sectors. The findings show more AIDA-related digital venture creation from Asian entrepreneurs, but there appears to be no statistical difference of ethnic diversity in the two entrepreneur groups. AIDA-related digital venture by black and Hispanic entrepreneurs is not as high as that of other sectors. Future research could study the relationship between education (e.g., degree type, college major) and digital entrepreneurship. For example, it may be that digital entrepreneurs tend to be technology majors (e.g., IS, engineering) at colleges and/or to hold graduate degrees (e.g., MBA, MS in CS). Future research could adopt a multifaceted approach considering gender, ethnicity, education, location, age and other personal factors

in attempting to understand digital venture activities. This requires more comprehensive data about individual entrepreneurs.

Entrepreneurship in evolving fields such as AIDA may not mean just being good at integrating algorithms, apps and data as new products and services. Those digital entrepreneurs are also active in communication and network-building in social media. In the digital age, digital communication appears to be in high demand for entrepreneurs for advertising, information search and sharing, and networking. Future entrepreneurs would focus on developing skills, not only in integrating resources for new product development, but also in using digital technologies for marketing and networking. This can be an important area for investors to pay attention to in their decision-making.

All the findings of this study should be considered in the context that this study selected a sample, from Crunchbase, of entrepreneurs meeting a number of criteria such as whether their business has a recent funding history. Thus, this study focused only on those who may be considered relatively “successful” entrepreneurs by others. In this line, future research could investigate whether there are differences in individual-level traits between those having a funding history and those not. Additionally, future study is called for to explore digital entrepreneurship with more comprehensive data of individual traits and organizational variables.

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