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Agricultural UAVs in the U.S.: potential, policy, and hype

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ABSTRACT

New technologies often pass through a period of their promoters' exaggerations. Unrealistic expectations, or hype, produce consumer excitement and then disenchantment with the technology before its acceptance. Using the Garter Hype Cycle as a framework, this study examines expectations regarding domestic applications of the unmanned aerial vehicle (UAV) in agriculture. A content analysis of 5418 U.S. media reports from 2010 through 2014 shows hype was used in describing potential UAV applications in farming. Media reports were highly speculative and overly optimistic, and in the near term largely unrealistic. The agricultural UAV hype appears to be a response to hostility toward government domestic surveillance use of UAVs. As public hostility toward police use of UAVs increased, media reports shifted away from government deployment to the economic development created by relatively noncontroversial commercial applications.

Hype has both potential benefits and costs for those seeking expansion of a technology. The hype was arguably necessary to allay negative public opinion and a hostile political environment toward domestic expansion of the UAV. The negative ramification of hype is that a period of disillusionment follows the inevitable realization that expectations for the technology were unrealistic. Market expansion is stalled or even derailed. According to the Garter Hype Cycle, there will be a period of disillusionment regarding the contributions of UAVs to agriculture once there is the legalization of commercial applications in the U.S. However, UAV deployment on farms should increase after realistic expectations regarding near-term contributions are developed and disseminated.

1. Introduction

Aerial drones both fascinate and frighten. They can be amazing toys; but when misused, they can also endanger the nation's airspace and invade personal privacy. Some media and blog commentators foresee drones triggering an agricultural reformation. However, the colloquialism "drone" is not encouraged. Its industry promoters and the Federal Aviation Administration (FAA) prefer the descriptors of Unmanned Aerial Systems (UAS) and Unmanned Aerial Vehicles (UAV). The term "drone" may evoke an association with hovering robotic predators, and government surveillance (Kaminski, 2013; Villasenor, 2013).

The inexpensive UAVs currently entering agricultural applications are at, or just above, hobbyist grade (Fig. 1). Their operating range, flight times, and payload are much less than the advanced militarized drones. Nevertheless, the consumer-grade UAV offers promise, especially with its low-equipment expense, open-source software, flight control intelligence, and satellite-based navigational control. By using imaginative and creative speculation, the

Abbreviations: FAA, U.S. Federal Aviation Administration; GAO, U.S. Government Accountability Office; UAV, Unmanned Aerial Vehicle; UAS, Unmanned Aerial System; U.S., United States of America; UK, United Kingdom.

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Fig. 1. DJI Phantom, a small hobbyist quadcopter used for crop scouting (Dilmen, 2014).

agricultural UAV can conceivably perform many astonishing tasks; most appealing for agriculture are the inexpensive airborne scouting of field crops and of ranging livestock. Because the UAV-hobby enthusiasts are supplying research and development at no cost, consumer UAV-technology costs are spiraling downward.

U.S. law currently bans all but for the most-limited commercial use of the UAV. Exceptions are made for commercial applications under the FAA Section 333 Exemption[1], for which certain pre-approved airframes and flights are allowed under strict operation limitations. Although there are rumors of many illegal farm applications, there will not be a dramatic increase in agricultural operations unless there is a loosening of the stringent FAA regulations (Rutkin, 2014). Under 2014 FAA rules, only hobbyists, individuals, and agencies that have acquired special Certificates of Authorization (COA) are allowed to fly commercially a UAV. A COA-holding operator must operate under the FAA specifications that are stated within the COA, which typically have the UAV staying below 122 m above ground level (AGL). Its flight paths cannot occur within 8 km of an airport or navigational facility (i.e., uncontrolled Class G Airspace).

1.1. *Impact of expectations for an emerging technology*

Positive consequences: Considerable research has examined the role that expectations play in the acceptance of scientific or technological change (Brown and Michael, 2003; Geels et al., 2007; van Lente et al., 2013). Expectations are the “real-time representation of future technological situations and capabilities” (Borup et al., 2006). A wide variety of applications has been envisioned for unmanned aircraft. Agriculture has been a focus since 2013 by the UAV industry's largest trade group. The Association of Unmanned Vehicles Systems International (AUVSI), predicted that the legalization of commercial pilotless aircraft would create more than $80 billion in economic impact between 2015-2025 and that agriculture could account for 80% of the commercial market (AUVSI, 2013). UAV advocates contend that unmanned aircraft will revolutionize agriculture (Doering, 2014). Fertilizer, water, or chemicals will be applied only when needed. The inexpensive on-demand aerial photography will quickly spot disease, unwanted vegetation, and detect erosion. Increased crop yields and profit may result. Furthermore, there will be environmental advantages as less water and chemicals are used (Anderson, 2014).

Expectations can help turn an idea into reality as they provide the momentum and resources to go forward with innovation (Brown and Michael, 2003). Since optimistic visions can attract resources, stimulate research, and create public support, the dissemination of highly positive expectations may be an effective strategy by a technology's advocates to gain support (Bakker and Budde, 2012; Borup et al., 2006; Konrad, 2006; Pollock and Williams, 2010).

The expansion of unmanned flight faced a major obstacle in gaining momentum within the U.S.: the creation of legitimacy. Immediately after the U.S. Congress authorized movement toward domestic UAV implementation, lawmakers at the local, state and federal level rapidly proposed restrictions or outright bans on private UAV ownership because of safety and privacy concerns (Kaminski, 2013; National Conference of State Legislatures, 2015; Sullivan, 2013; Villasenor, 2013). Public opinion polls showed a noteworthy percentage of the public hostile to unmanned flight; in one survey 63% of Americans thought it would be a change for the worse “if personal and commercial drones are given permission to fly through most U.S. airspace” (Smith, 2014). Given this environment, expectations regarding the contributions of UAVs if allowed to fly commercially needed to be very high. The expectations had to be sufficiently high to convince skeptics that the benefits of unmanned flight outweighed the privacy and safety concerns.

1.1.1. *Negative consequences of technological expectations: hype*

Although expectations produce advantages in the launch of a new technology, overly high expectations may have a detrimental impact on technology adoption. When it appears the high expectations for a technology are not going to be met, at least not within the period expected, there are accusations of hype. The impact of hype on the subsequent pattern of innovation for a technology is depicted in the Gartner Hype Cycle, a highly influential graphical depiction of the process by which emerging technologies or applications move from conception to maturity and then commercial viability (Bakker, 2010; Ruef and Markard, 2010; van Lente et al., 2013). Gartner Inc., a global research and consulting firm, provides information to practitioners who use the Hype Cycle to guide technology investment decisions.

The Gartner Hype Cycle consists of five stages (Fig. 2). A *Technological Trigger* produces the first phase. The technology may not be new; it may have been under development for a while, or there is perhaps interest in new

[1] FAA Section 333(b) of P.L. 112 95 states, in part: “In making the determination under subsection (a), the Secretary shall determine, at a minimum – (1) which types of unmanned aircraft systems, if any, as a result of their size, weight, speed, operational capability, proximity to airports and populated areas, and operation within visual line of sight do not create a hazard to users of the national airspace system or the public or pose a threat to national security; …”.

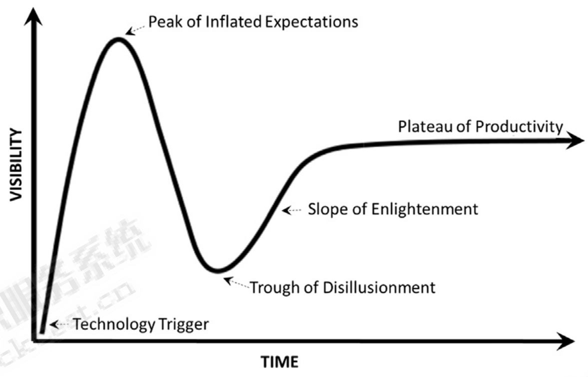

Fig. 2. The Gartner Hype Cycle (van Lente et al., 2013).

applications. Knowledge of the technology expands, and marketing and the mass media may greatly accelerate the dissemination of expectations (Fenn and Raskino, 2008). Inflated expectations, or hype, often exceed the reality of what the technology can deliver, at least in the short term. At the *Peak of Inflated Expectations,* either the innovation delivers as expected, or more commonly, disappointment sets in because of the gap between hype and reality. The technology enters the third stage, the *Trough of Disappointment*. Investment in the technology continues if improvement is enough to satisfy early adopters. A *Slope of Enlightenment* will occur if the technology sufficiently matures. When the benefits of the technology are disseminated, interest picks up again. The technology then enters the *Plateau of Productivity.* At this stage, there is comprehension of the technology's contributions. The mainstream adoption accelerates as the technology's value is recognized.

A review of annual "Hype Cycle for Emerging Technologies" by the Gartner group shows a graphical placement of dozens of technologies along the five stages of the hype cycle. Examples of academic analyses of technologies that have followed the Gartner Hype Cycle include the hybrid car (Jun, 2012), nanotechnology (Roco et al., 2011); stationary fuel cells (Ruef and Markard, 2010); hydrogen fueled cars (Bakker, 2010); information systems (O'Leary, 2009), voice over internet protocol (VoIP), gene therapy, and high-temperature superconductivity (van Lente et al., 2013). Gartner, Inc. in their 2014 report on smart machines placed "Commercial UAVs (Drones)" on their curve rising toward the *Peak of Inflated Expectations* (Brant and Austin, 2014).

Emerging technologies do not always follow the Gartner Hype Cycle (Ruef and Markard, 2010). Economic, political, and socio-cultural factors, as well as perceived limits to the technology's potential, can significantly alter the course of adoption. A technology superior to the UAV may emerge. An economic downturn, a shift in political attitudes, or a U.S. Court decision regarding the 4th Amendment's guarantee of privacy could slow UAV implementation. An airliner crash attributed to a UAV could derail implementation for years. The Hype Cycle forecasts the path for most, but not all, emerging technologies.

The hype cycle for agricultural UAVs began with government action in 2012, which was in reaction to several pre-existing mature technologies acting in concert. Radio-controlled remote-controlled aircraft have been a reality since the 1940s. However, it was the development of the miniaturized GPS sensor, miniature high-resolution digital camera, microcontroller-based automatic flight control, and open-source software that when combined, triggered the domestic low-cost UAV revolution. The FAA became aware of many low-cost hobbyist UAVs entering the nation's airspace at high altitudes. There was also deployment for commercial and law-enforcement endeavors, which raised additional legal concerns. In 2012, the U.S. Congress enacted the Modernization and Reform Act (PL 112-95). This law instructed that the FAA safely integrate small unmanned aerial vehicles under 25 kg into the domestic airspace by September 2015. An industry lobbying group that is supported by aviation defense contractors during this period promoted the economic potential of domestic UAVs (Freeman and Freeland, 2014). The AUVSI estimates that the U.S. economy loses $10 billion for every year that domestic UAVs production sales are delayed (AUVSI, 2013). Although the military has acquired thousands of sophisticated UAVs, high-dollar R&D government contracts were declining due to defense cuts (U.S. Department of Defense, 2012).

There was an immediate surge in media attention directed toward UAVs after the Congressional mandate to allow expanded domestic unmanned flight. Some of the reports were directed toward efforts to restrict flight while others described the various contributions domestic UAVs could make in both the commercial and public realm. The follow section describes the methods used to ascertain expectations regarding the UAV when the domestic expansion was authorized in the U.S.

1.2. *Objectives*

The objectives of this paper are: 1) to examine the expectations of UAV applications in agriculture, 2) to discuss the reasons for the types of expectations generated, and 3) using the Gartner Hype Cycle as a framework, offer projections regarding the likely consequences of these expectations on UAV adoption when commercial deployment becomes more widespread.

2. Methods: assessing expectations

A quantitative and a qualitative analysis were conducted of stories appearing in the U.S. media for years encompassing 2010–2014 that involved domestic UAVs. To assess the existence of hype, the number of articles along with their tone and content concerning domestic UAVs were examined. In documenting hype, the use of superlatives in the reports to describe the technology are of particular interest. A large amount of media attention focusing on the future benefits of a new technology with superlatives signifies hype (Ruef and Markard, 2010; van Lente et al., 2013). When disillusionment sets in, a detailed analysis of negative media reports occurs.

Keyword searches of the "World News Bank," using solely U.S. sources provided the reports analyzed. NewsBank, Inc., Naples, Florida, provides web-based access to the largest newspapers database available and is a widely available academic research tool. It encompasses primary source content from local, national and international newspapers, blogs, newswires, business journals, popular periodicals, government documents and 136 broadcast transcripts and videos. In all 5418 sources were included. The analysis was conducted of reports that appeared during a five-year period, between 2010 and 2014 inclusive. In 2012, the U.S. Congress mandated the implementation of UAVs into domestic U.S. airspace by 2015.

Although this analysis examines domestic UAV implementation, media coverage of UAVs by the military and intelligence agencies internationally is part of the environment surrounding domestic use. To distinguish those media reports relating to domestic UAV implementation and to develop a classification scheme of the report's content and tone, an inductive approach was used. The researchers scanned a large sample of the reports before coding began to determine relevant keywords to use in a media search and to construct the themes or dimensions that appear meaningful for the content analysis of the reports (Abrahamson, 1983). To identify the reports describing domestic applications, a series of keywords identified with domestic implementation were entered with the words "unmanned." Keywords "police," "agriculture,", "border patrol", "search and rescue," "movie," "journalism" were individually combined with "unmanned." Reports that examined the use of UAVs to enforce U. S. border entry were not included in the count or analysis of police use of UAVs. Media reports not in the form of a story, such as stock reports, or stories not focusing on domestic UAV use were omitted.

A count was made of the number of reports mentioning each type of domestic application. Also, it was noted if the report had a focus on one type of domestic UAV application. A focus on one application was defined as a report that contains at least three sentences devoted to one particular use with less than three sentences discussing other types of domestic applications.

Two types of domestic UAV applications received the most attention: agriculture and police. The articles that focused on one of these two types of application were categorized regarding tone. Tone can be measured using a manifest approach, a latent approach, or a combination of both (Neuendorf, 2002). With a manifest approach, the number of units that were positive and the number negative were counted. A score was obtained from those two numbers (Riff et al., 2014). A latent approach is more of a holistic assessment; it is a judgment that is made regarding the content of the article (Riff et al., 2014). This approach used a combination of both. Three categories were constructed: positive, both positive and negative, and negative. Decisions regarding categorizations took place as follows. A positive article had more positive than negative coverage of domestic UAV implementation. There could be references to the fact that commercial UAVs are now illegal in the U.S. or general statements of privacy or safety concerns, but the statements contain no specific statistics, such as the number of crashes. There was no mention of specific national or state legislation that would further restrict UAVs or quotes by someone opposed to domestic unmanned aircraft. Media reports that provided specific information regarding restrictive legislation, cite negative statistics in regard to UAVs, or included a quote of someone critical of domestic UAV expansion were categorized as mixed or negative, depending on the mix with positive statements. Reports were classified as mixed if they contained approximately equal coverage of benefits and problems associated with domestic UAV expansion. Negative categorizations were given to reports that had more negative than positive statements about domestic unmanned aircraft. Negative statements included fears of privacy invasion, safety concerns, or assessment that called into question the benefits of domestic UAVs. A report classified as negative may contain some reference to possible positive contributions from UAV expansion, but more coverage was given to negative assessments. Table 1 provides examples of statements in each of the three categories.

The reports that focused on UAV use by police and in agriculture were also coded for content. Coding for agricultural UAV operations included reference to the following: expected economic impact, the use of agricultural UAVs outside of the U.S., the expertise needed to collect and/or interpret agricultural information, and use by an individual farmer. Superlatives were noted. Superlative descriptions included some form of the following words or

Table 1
Classifying the expectation category.

Category	Explanation	Example excerpt
Positive	Highlights innovative break-through, profits	"unmanned aircraft could be as revolutionary to aviation as the jet engine" The Birmingham News, 12/4/2014 (Cason, 2014); "In Ohio, integrating drones into the skies could create 2700 new jobs and have a $2.1 billion economic impact by 2025" –Dayton Daily News, 12/15/2013 (Barber, 2013)
Positive and Negative	Potential with hurdles	"Not ready to make the statement that the use of drones will revolutionize farming, but the possibilities are exciting, but some farmers are not sold on drones." Forum News Service, 12/30/2013 (Horwath, 2013); "Anything can be used for a bad purpose, but that's not what most people do with them." The Gazette, 12/22/2014 (Kelley, 2014)
Negative	Low expectations, caution	"crash records released by military highlight dangers of aircraft that will soon be in civilian airspace" The Washington Post 6/20/2014 (Whitlock, 2014); "public outcry from civil rights attorneys and anti-drone advocates has now forced the sheriff's office to postpone the decision" Oakland Tribune, 12/4/2012 (Woodall, 2012)

Table 2
Yearly U.S. media reports referenced by keyword search.

Keyword	2010	2011	2012[a]	2013	2014
Unmanned + Aerial + Vehicle	4159	4662	5697	7218	7613
Drone	9058	11,932	17,049	32,729	29,606

[a] 2012 U.S. Congress enacted the Modernization and Reform Act (PL112-95).

Table 3
Yearly U.S. media reports search by UAV application.

Keyword[a]	2010	2011	2012[b]	2013	2014
Agriculture	189	271	398	1117	1296
Border Patrol	222	196	219	234	277
Movies	60	89	89	151	679
Photography	122	123	156	291	761
Police	592	584	969	2019	1503
Search/Rescue	151	210	328	662	612

[a] Keyword combined with "unmanned".
[b] 2012 U.S. Congress enacted the Modernization and Reform Act (PL112-95).

phrases: transformational, revolutionary, dramatic, or game changer. Also coded were whether the information presented came from the UAV industry. If the report focused on police use, it was noted if the story involved legislative efforts to curtail the use of UAVs in U.S. law enforcement and if the actual operation of a UAV by police or a government agency was mentioned. The authors manually coded the data. The percent agreement, the most widely used measure of reliability, exceeded 90%. This is at a level that is viewed as acceptable (Neuendorf, 2002).

3. Results and discussion

3.1. U.S. Domestic UAV expansion

There has been considerable media attention given to unmanned flight in the U.S. Table 2 shows the number of reports with two keyword searches of news media. One keyword search combined three keywords: "unmanned," "aerial," and "vehicle." The second keyword search contained the keyword "drone."

There has been a steady increase in reports between 2010 and 2013, with a small drop-off between 2013 and 2014. The increase was particularly pronounced with the keyword search using the term "drone." From 2010 to 2014, unmanned aircraft reports entered the public agenda with news reports of their use in armed combat internationally, and in the debate regarding their domestic expansion.

Table 3 shows the number of media articles from 2010 to 2014 that referenced domestic applications. Reference to UAV use in the areas of agriculture, photography, and movies increased each year between 2010 and 2014. Stories regarding UAV operations in police work jumped dramatically between 2012 and 2013, probably because of a large number of bills considered in state legislatures to restrict police use of UAVs in 2013. In 2014, the number of stories connecting police to UAVs fell from the 2013 high. Search and rescue as a UAV application increased between 2010 and 2013, doubling between 2012 and 2013. There was a slight drop-off between 2013 and 2014. The increase in UAV use in agriculture was dramatic over this five-year period, jumping from 189 in 2010 to 1296 in 2014.

While some of the reports reference a variety of UAV applications, others focus on one particular type of domestic use. Reports that referenced police or agriculture were subject to further analysis if they focused on one of these uses. The tone of the reports with a focus on domestic police use are displayed in Fig. 3.

The necessity of moving attention away from police use to other domestic applications is apparent. Few reports focusing on police use of UAVs have been positive in tone. The percentage of negative stories increased until 2013 when 62% of the stories were classified as negative. This was the year when a number of bills related to unmanned aircraft were considered in the states, and most of these bills involved placing limits on police UAV use (National Conference of State Legislatures, 2015; Williams, 2014). From 2013 to 2014, both the number and percentage of negative stories fell; this trend parallels legislative activity where there were fewer state legislative efforts in 2014 to curtail drone use (Williams, 2014).

Table 4 displays the content of the stories that focus on domestic UAV use by police. The vast majority of stories involve legislation to limit or prevent U.S. police from using UAVs. Relatively few reference actual UAV operations by law enforcement. There was little discussion of the contributions UAVs could make to law enforcement (Straub, 2014). Industry confronted a negative environment for expansion within police forces, strategically seeking a more receptive environment through a focus on other uses, agriculture in particular.

Fig. 4 classifies the stories that focus on agricultural UAV applications as either generally positive, positive and negative, or negative from 2010 to 2014. In contrast to the stories with a focus on police use, the stories with agriculture as a focus have been primarily positive with relatively few negative stories (never exceeding 10%) throughout the five-year period. The percentage of positive stories dropped somewhat between 2013 and 2014, but the shift was toward more mixed stories (positive and negative), and not toward negative media reports.

Table 5 displays the types of message tones conveyed in the media reports that focus on agriculture use of UAVs. The category "superlative" shows that the terms used to describe the UAV's potential impact on agriculture convey a dramatic impact in about 20% of the media reports from 2012 to 2014. During this period, about 30% of the media

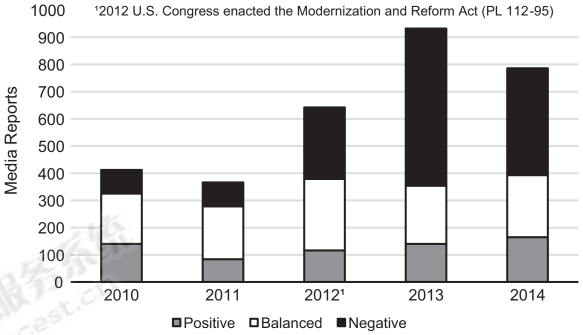

Fig. 3. Yearly tone of UAV media reports with police focus.

Table 4
Yearly content percentages of UAV media reports with police focus by topic.

Topic	2010	2011	2012[a]	2013	2014
Legislation	18%	34%	46%	76%	54%
Deployment	2%	5%	8%	6%	9%

[a] 2012 U.S. Congress enacted the Modernization and Reform Act (PL112-95).

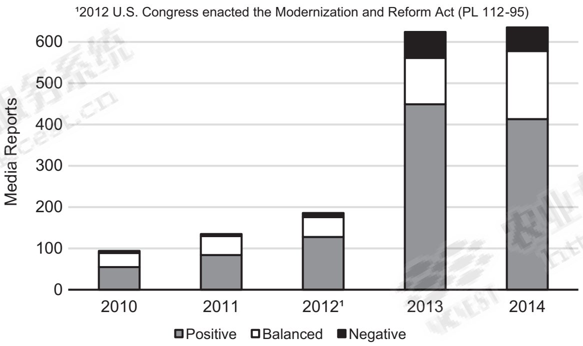

Fig. 4. Yearly tone of UAV media reports with an agricultural focus.

reports referred to the expected positive economic impact of the UAV. Almost one-quarter (24%) of the media reports between 2012 and 2014 included references to UAV agricultural applications in nations outside of the U.S. A pronounced number of media reports contained information that can be sourced back to the UAV industry estimations. Table 5 also shows that mention of international agriculture UAV use has increased steadily over the five-year period. Few of the articles noted any of the factors other than legal restrictions that could limit UAV implementation in agriculture. Some of the articles were framed in terms of contributions that will be made on individual farms. About one-quarter made reference to an individual farmer employing a UAV. Very few stories suggested that any type of expertise would be needed to successfully implement this technology on the farm.

The positive tone and optimistic content of the reports that focus on agricultural applications are in marked contrast to the media's reports of UAV use by police. While the media reports of police applications grew more negative in tone after 2012, the reports focusing on agricultural applications became more positive. The two may be related; the increased attention to agriculture may have been a response to the negative reports associated with police deployment. There are reports that the UAV industry initially planned to focus their expansion plans on law enforcement and regulatory agencies. However, since governments were limited by public opposition to domestic UAV use (Levin and Litvan, 2014), the industry sought to find another more palatable sector to showcase their products. Agriculture was a logical choice for a couple of reasons. First, there are a large number of agricultural producers, and UAVs appear to have the potential to perform crop scouting and other tasks. A second reason to target farmers is that public opposition to domestic UAV use is relatively low concerning agricultural applications (MacGillis, 2013). Consequently, policymakers are motivated to loosen UAV regulations if farmer constituents were clamoring to use them.

3.2. Agricultural UAV hype

Some of the media reports exaggerate the use of UAVs abroad or present unrealistic expectations regarding a hypothetical similar deployment in the U.S. For example, in most of the references to UAV international use, descriptions or statistics regarding the number of farmers, acres, or success of the operations are for the most vague, and are primarily provided by the UAV industry (Doering, 2014; Fresh Plaza, 2014; Grassi, 2014; Nicas and Pasztor, 2014; Otis, 2013; Sandoval, 2013). There is no compelling evidence that the U.S. agriculture is falling behind because it has not embraced UAVs. Nor is there information from media to suggest that nations with no UAV limitations plan to increase substantially their use of UAVs in agriculture.

Japan is the only nation that has implemented UAV applications in farming on a large scale. Yamaha Corporation estimates that about 2400 of its remotely piloted R-MAX helicopters are spraying one million hectares that make up 40% of the Japanese rice fields (Nicas and Pasztor, 2014) (Fig. 5). Although this statistic is impressive, what should not be overlooked is that agriculture in Japan is much different from the U.S., Canada, Australia, Brazil, and other nations with large fields. The average farm size in Japan is 1.9 ha (Dyck, 2015), whereas the average farm size in the U.S. is 178 ha (Agriculture Council of America, 2015). Consequently, small electric rotary wing systems may not prove cost effective for large fields, especially those with one crop. Since a piloted aircraft can carry several hundred liters of spray, it can cover large fields much faster and efficiently, although at higher pilot risk. Manned aircraft are often more efficient and economical (Watts et al., 2012). Thus, sprayer UAVs will likely make their most valuable contributions in smaller fields with higher-value crops, in particular, in built-up areas, where there is rugged terrain, and/or there is mixed crop use (Huang et al., 2013).

Cost and complexity of operation will also limit the domestic implementation of UAVs. Media reports frequently focus on the low cost of assembling a UAV, reporting on an individual farmer who is using a small

Table 5
Yearly content of UAV media reports with agricultural focus by topic.

	2010		2011		2012		2013		2014	
Superlative[a]	9	10%	15	11%	35	19%	131	21%	21	19%
Economic[b]	15	16%	26	19%	54	29%	187	30%	184	29%
Foreign[c]	14	15%	24	18%	41	22%	162	26%	171	27%
Farmer[d]	18	19%	31	23%	46	25%	168	27%	140	22%
Skill[e]	3	3%	4	3%	7	4%	31	5%	32	5%
Information[f]	16	17%	35	26%	87	47%	337	54%	324	51%
Total	94		135		186		624		635	

[a] Superlative.
[b] Positive economic impact.
[c] Agricultural use outside U.S.
[d] Single farmer use.
[e] Experience needed to use.
[f] UAV industry was source of information and data.

Fig. 5. Yamaha R-Max unmanned helicopter used for agricultural spraying (Gtuav, 2014).

UAV for aerial photography. This description is enticing; for little cost, a farmer possesses a tool that can gather images at a rapid pace on command. The reality is more complicated. The loss to crashes is well known, even among professionals. While a small UAV capable of handling some agricultural applications can be purchased for well under $10,000 (Green, 2013), these small vehicles have FAA-mandated range and payload limitations. Producers or commercial consultants will likely spend far more, between $30,000 to over $100,000 for their more-advanced professional variants of UAVs (Dobberstein, 2013).

Expertise is required to interpret and make decisions based on the data imagery collected (Ruzgiene and Aksamitauskas, 2013). Most operators will lack this level of knowledge or software tools, and to use these data most effectively, agronomists will require training in remote crop sensing (Harris et al., 2014).

3.3. *The consequences of hype for the agricultural UAV*

The Gartner Hype Cycle shows that enthusiasm for an innovation often falls after recognition that the foretold expectations were hype. Research suggests considerable promise for the contributions of unmanned flight to farmers, but it is likely that these benefits will not materialize as quickly or in the form that some envision. There is very likely going to be a "*Trough of Disillusionment*." During this stage, interest in UAV agricultural applications will wane, and one or more of the arguments against domestic expansion will be prominently featured in the media. The implementation by individual farmers will almost certainly not occur as envisioned, and this information will be disseminated. Although privacy concerns appear to have waned, social or political changes could resurrect public fears. Large numbers of people may be disappointed when government regulations are set that place stringent regulations on who may fly a UAV. The investment will diminish, as will efforts to market agricultural UAVs. The media reports that appear will be more negative in tone than positive (Ruef and Markard, 2010; van Lente et al., 2013). The technologies that never recover when it becomes apparent that expectations were unrealistic failed because the products never matured (Bakker, 2010). Because UAVs do have potential in agriculture, they will most likely enter a "*Slope of Enlightenment*." There is no guarantee of an upward trajectory, the hype cycle is a forecast, and can be negated by both anticipated and unanticipated events. However, most technologies recover. Further, since robotics is a key technology of the 21st Century, and UAV technology is a central part of the robotics industry, it is difficult to imagine the U.S. abandoning domestic unmanned flight. It is expected that during the "*Slope of Enlightenment*" phase, the technology will improve, and realistic expectations will be formed. This will move the agricultural UAVs into the final stage for an innovation characterized by hype, the "*Plateau of Productivity*."

4. Summary

A content analysis of U.S media reports from 2010 to 2014 shows that hype characterized the expectations for agricultural UAV applications in the two years after the U.S. Congress mandated a process of legalization. Although there are negative ramifications to hype, there are often positive impacts. Hype can help produce an expanded market, provide additional financing, and stimulate favorable regulations for a technology.

There were numerous safety and especially privacy concerns concerning domestic unmanned flight to overcome. Given the contentious environment for unmanned flight within the U.S when the domestic expansion was announced, the hype for unmanned flight in agriculture can also be understood as a strategy to gain support by its advocates that were confronting regulatory challenges and negative public perception. Using hype, advocates can reframe a controversial technology into a desirable innovation to be embraced by the public.

The Gartner Hype Cycle suggests that the hype characterizing UAV agricultural applications will also have negative consequences. Short term, it is unlikely that the high expectations depicted in the media will be met. The resulting disappointment will slow the adoption of UAVs in agriculture and perhaps call into question their profitable use for farming operations. However, given research and development, interest for unmanned flight in agriculture will increase again and realistic expectations established. Applications will accelerate as the benefits become widely acknowledged.

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