Valuation Model for Internet-of-Things (IoT) Startups

Georgios Chatsios

Department of Accounting and Finance, University of Macedonia | giorgos.g.chatsios@gmail.com

Georgios Foroglou

Department of Accounting and Finance, University of Macedonia | georgios.e.foroglou@gmail.com

Konstantinos Moutafidis

Department of Business Administration, University of Macedonia | konmouta@gmail.com

Abstract

This paper estimates a valuation model for Internet-of-Things startups considering previous models and primary research. In the first section, there is a brief introduction in the technology mentioned above, its areas of applications and the future possibilities to the global economy. In the second section, there would be mentioned further valuation models for startups in order to give the reader a broader view for the research of the subject. Third section develops our methodology for testing factors which will be used in the model. The last section analyses the developed model, its statistical features and its predictive ability. The paper concludes citing future uses for the model and suggestions for further research.

Keywords : valuation model, Internet-of-Things, startups

1. Internet-of-Things

1.1 Definition and history

The Internet of Things (IoT) is an enormous network which allows interaction among physical and virtual “things”. It is used for the collection and transportation of data by taking advantage of information and communication technologies. The expression IoT was invented by Kevin Aston and was first used as a presentation title at Procter and Gamble (P&G) in 1999.

1.2 Technologies

In fact, the growth of micro–electromechanical systems (MEMS) technology gave IoT the chance to increase extensive application. Some of these key technologies are described in this sector.

1.2.1 Wireless Sensor Network (WSN)

A Wireless Sensor Network (WSN) is made up of nodes that collect, process and save information such as related to the environment in which they are found temperature, sound, pressure, light intensity etc. At the same time the nodes communicate between themselves and with a central unit. A sensor is made up of a communication part used for the collection of data through radio frequencies, a processing part that coordinates all units and processes the data and the power supply part, which provides power to the sensors. When a network of sensors nodes is developed and communication between nodes is possible, then a WSN is established. The networks consists these of other nodes, sink nodes and gateway nodes that allow connection between the sink nodes and other networks such as the internet. Their purpose is to wirelessly transfer relevant information through other aforementioned sensors, towards a network node that in turn informs a database.

1.2.2 Radio Frequency Identification (RFID)

The main technology needed for the production of smart devices are the RFID sensors. The Radio Frequency Identification (RFID) technology is used for the automatic detection of objects and people. A RFID device, which is now called RFID tag is a small processor that is designed to transfer wireless data. A reading device, the RFID Reader, transfers “question” data to a RFID tag which then responds with “answer” data. The RFID tags are separated into two categories: RFID tags that make use of battery energy belong to the first category, while RFID tags that do not contain batteries belong to the second category. RFID passive-tags that are small in size and cheap to produce belong to the first category. They take the power that they need in order to send data from the radiofrequency of RFID reader. RFID tag with embedded sensors have batteries and belong to the second category, then separated into two subcategories, the semi-passive tags and the active tags. The active RFID tags have arrange that is greater than 100 meters and therefor also most expensive compared to other models. What’s makes the RFID useful in the same construction of IoT, is their ability to read hundreds of tags at the same time compared to a barcode that can only scan one tag at a time. In 2012 the market value of RFIDs was 7.4 $ billion, while it is expected to reach 21.9 $ billion by 2020.

1.2.3 Internet Protocol Version 6 (IPV6)

The IoT is the evolution of today’s internet. It is made up of many interconnected world wide networks. The nodes of the network are “things” that have unique IP addresses that are based on specific communication protocols. However it is obvious that the overall number of addresses is very small, due to the fact that in 2008 the number of the connected devices surpassed the entire human population of earth. In 2020 it is expected that connected devices will be 50 billion. This problem will be solved when the IPv4 (4.2 billion IPs) are substituted by IPv6 that can provide up to 2^{128} or $3.4x10^{38}$ unique IP addresses. The IPv6 is used in sensory networks with the protocol 6LoWPAN that gives all devices, the ability to take part in the IoT, without taking processing power into consideration.

1.2.4 Cloud Computing

Data management is a crucial aspect of the IoT since “things” are always interconnected and constantly transfer many types of information. The “data sets” that are produced by smart meter measures are comprised of “big data”, and need complex management and processing. A way to overcome these difficulties is to make use of cloud computing, a technology that allows on-demand access to services with high level of customization. The execution of needed processes is done through the internet and information regarding the user’s personal work, is exclusively returned directly to him/her. As a result, cloud computing is used for services that have low processing cost. At the same time it provides high levels of flexibility in computing power and technology, thus providing the best possible way to handled “big data”.

1.3 Application and use of IoT

In this paragraph the applications of the IoT will be described, so that its overall usefulness will be made clear. Examples of its use are divided in the following categories.

A) Transportation and Logistics: By making use of sensors in cars, trains, busses and also by taking advantage of sensor tags in the road infrastructure it is possible to avoid accidents and generally monitor traffic. In addition, vehicles can be automatically provided with information regarding traffic and alternative route options. Also the supply chain, can be improved though the continuous synchronization of the supply chain and the uninterrupted on demand observation and localization of objects. This allows for smart communication between people, products and services.

B) Smart environments: Future houses will be aware of what occurs inside a building regarding the following three aspects. First the use of resources in order to save water and energy, second security and third comfort. For example a lighting control panel, where lighting is automatically disabled when the presence of tenants is not found. Lighting could also be reduced throughout the day, based on the prevalence of natural light. Finally, when the automatized security systems detect unauthorized access to the home, they are then able to alert the police via email or telephone.

1.4 Security and Privacy

The IoT is a system that is to malicious attacks for a variety of reasons. A main concern regarding the security of the IoT has to do with the fact that every connection is made wirelessly. This facilitates the unauthorized monitoring and theft of transmitted data. Also, due to the low potential of wireless technologies used in the IoT, the execution of complex algorithms is not possible, particularly in passive RFID tags. Security can be divided into two main categories. The first category is related to privacy and is concerned with ensuring that data maintains its integrity throughout the transferring process. The second category has to do with the identification of information that concerns the user. A danger that threatens the identification process is the possibility for the tags to be read from a distance without user authorization. Privacy in addition can also be compromised due to the fact that information is saved within the tags or reader devices. This information can be accessed by an unknown third part after it is transferred to a "reading" device. In the modern world social media sites already have access to a great deal of information about our behavior in the digital world. What would happen if similar information could be accessed from any other device that connected to the internet?

2. Startup Valuation Models

Most valuation models are based on the idea that the value of the investment derives from the expected cash flows. That way, a business's real value discounts future earnings and forms that prize that holds in the markets. However, that does not stand for every company. Startup companies begin from scratch, with little to zero assets and cash, making it extremely difficult to forecast their money generating potential and intangibles, like brand value. Thus, certain venture capitals develop specialized models in order to measure accurately their fair market value.

2.1 Venture Capital method

The VC method was developed by Harvard Professor Bill Sahlman [9] in 1987 and calculates a valuation using the venture's anticipated value and ROI. Its core is presented below:

Return On Investment (ROI) = Terminal Value / Post-money Valuation (1)

Post-money Valuation = Terminal Value / Anticipated ROI (2)

Where, Terminal Value is the anticipated selling prize of the company 5-8 years after the investment and Anticipated ROI is the multiple that the company is expected to produce in return. Most Angels and venture capitalists know that half of their investments will fail, so they expect a return in the range of x10 to x30.

2.2 Dave Berkus method

This method was developed in the mid-1990 by Dave Berkus [1], an angel investor. It ascribes a certain amount of money depending on the progress of the startup on certain key characteristics, the sum of which becomes the pre- money valuation of the company, as shown below:

Characteristic	**Add to Pre-money Valuation**
Quality Management Team	Zero to $0.5 million
Sound Idea	Zero to $0.5 million
Working Prototype	Zero to $0.5 million
Quality Board of Directors	Zero to $0.5 million

Product Rollout or Sales	Zero to $0.5 million

Table 1: Dave Berkus Valuation Model

Its problem is that it is only useful for early stage investments. Once a company starts making revenues, we use them to project future cash flows and the value of the company.

2.3 Scorecard method

The Scorecard method [8] is the most popular among angel groups in U.S. This method compares the company's pre-money valuation to the median angel-funded startup venture in the same region and sector. The pre-money valuation is based on a number of factors that receive different weights, depending on the investor's perception of the company. Thus, the investors adopt a clearer view of the company's value in its sector.

2.4 Risk Factor method

The Risk Factor method was designed by Ohio TechAngels and it breaks down the risk into 12 sub-categories that are graded from – (minus) $500 thousand to $500 thousand, and their sum forms the pre-money valuation, as shown below:

Management	Competition risk
Stage of the business	Technology risk
Political risk/Legislation	Litigation risk
Manufacturing risk	International risk
Sales and marketing risk	Reputation risk
Funding/capital raising risk	Potential lucrative exit

Table 2 : Risk Factors

++	Add $500 thousand
+	Add $250 thousand
0	Do nothing
-	Subtract $250 thousand
--	Subtract $500 thousand

Table 3: Risk Scoring

Although each of these methods are fair and commonly used, the best way to determine a company's valuation is to use multiple methods to ensure a fair market valuation.

3. Factors That Affect Valuation

The biggest challenge in startup valuation is the determination of the key factors that influence the value of the firm. This is an under-developed area for research literature, especially for new technologies (Davila, Foster and Gupta, 2003). However there are certain factors, both qualitative and quantitative, that have been tested from venture capitalists and proven to have a substantial effect towards a firm's valuation.

Firstly, according to Sandberg (1986), new ventures that entered industries with high product differentiation tend to have more improved economic performances than others. Based on that, investors have a tendency to lean towards ventures that offer, not only innovative products but also pluralism of new products to the market. This means that investors will evaluate higher ventures with higher differentiation of products in their industry. Furthermore, the likelihood of funding these ventures increases even more, when their products are granted patents (Baum and Silverman, 2004).This poses a great challenge in new technologies, such as IoT, where the latest innovation is the key to success.

Secondly, for new ventures' foundation and expansion, creating a network has always been significant (Dubini and Aldrich, 1991). A well established social network creates lucrative opportunities for acquisitions (Lechner, Dowling and Welpe, 2005) because it offers Intel about intangibles and things that do not appear in a spreadsheet that could unveil the hidden value of a venture. Moreover, a new venture requires legitimacy, when approaching other businesses. Since it has limited operating history and accomplishments, it is hard to create the perception of quality and trust (Stuart, Hoang and Hybels, 1999). A well connected network bridges that gap by extending endorsements by existing firms or by influencing the perception of quality of the venture, and thus its value. Finally, it offers access to resources at a lower cost than the open markets that helps the firm throughout its life (Larson and Starr, 1992).

In addition, the importance of an experienced entrepreneur and a cohesive management team, on new ventures, has grown dramatically lately. This is explained because it amplifies the chance of innovation and improves the quality of products and services of the venture. In their study about Silicon Valley startups, Burton, Sorensen and Beckman (2001), found that previous experience of the management team in startup foundation, increases the likelihood of funding in the early rounds. It should be mentioned that venture capitalists tend to overestimate the influence and the abilities of entrepreneurs while underestimating the effect of situational factors (Ross, 1977), leading to high valuation and failed investments. Thus, they should be very careful not to overemphasize the “people” factor when valuating new ventures.

Finally, As far as the age of the venture, Armstrong, Davila and Foster (2006) in their paper about the valuation of venture backed equities found that the number of years since a company’s foundation and the number of investment rounds that they have been financed, have negative effect at their valuation. However, they have positive effect on the risk of loss related to capital investments.

In order to determine the valuation of an IoT startup,we examine lot of factors, both qualitative and quantitative.

<u>Quantitative factors :</u>

1) Total Funding : The total amount of funding that a compant has raised, independently of the round. The categories of funding rounds are angel investing, seed investing, convertible debt, debt financing, grants, product and equity crowdfunding and funding series from A to G. The majority of the examined companies complete a seed investment and a funding Series A but venture and debt financing are also common in the industry.

2) Number of employees : The size of each company is determined by the number of its employees. The sample is divided to 7 categories according to the size of each company. The following matrix indicates the categories of the companies according to their employees.

Category	**Number of employees**
1	1-10
2	11-50
3	51-100
4	101-250
5	251-500
6	501-1000
7	1000-5000

Table 4: Employee category

3) Time : Time is considered how many years has passed since the company's foundation.

Qualitative factors :

We describe as qualitative factors, milestones of the companies that had been achieved since its beginning. The milestones are divided into 12 categories and describe strategic achievements of the company that add value to the existed valuation of the companies. Matrix X condenses the cateogies of the milestones among with a short description.

Category	Description
Product	Launch of a new product or update on an existed one
Partnering	Partnership with another company or institution for ambiguous improvement and beneficial cooperation
Expansion	New marketplace entry (physical or virtual)
Finance	New fundings rounds or loans
Branding-PR	Winning competitions and top lists placements
People	Recruitment or departure of key people
Legal	Legal issues (lawsuits), patent fillings
Sales	Distinctive customers and agreements
Restructuring	Employees' dismissals
Suppliers	Agreements with distinctive suppliers
Acquiring	Acquirement of another company from the examined company

Table 5: Qualitative Factors

4. Data and methodology

4.1 Data

The primary research was held in 21 companies where the data set was complete. By the term “complete”, it is suggested that the valuation from the funding rounds was provided. Further data were being used for the fitting of the model. The data were taken from CrunchBase and VB Profiles. The valuation of the companies is considered the amount for the acquisition from another company or the estimated valuation from the last funding round.

4.2 Descriptive Statistics

	N	Mean	Std Dev	Median	MAD	Min	Max	Skew	Kurt	Std Err
Valuation	21	580.7	754.41	260	339.52	6	3200	2.03	4.2	164.62
Funding	21	146.47	215.05	76.08	89.82	1.6	983.8	2.8	8.05	46.93
Employees	21	3.86	1.68	4	1.48	1	7	-0.03	-1.28	0.37
Time	21	8.62	5.15	7	4.45	1	19	0.44	-1.18	1.12
Product	21	10.81	10.8	5	4.45	1	34	0.94	-0.68	2.36
Partnering	21	8.95	10.17	4	5.93	0	33	0.97	-0.31	2.22
Expansion	21	0.95	1.6	0	0	0	6	1.83	2.61	0.35
Finance	21	3.81	2.58	3	2.97	0	9	0.47	-1.08	0.56

Branding	21	1.86	2.94	1	1.48	0	13	2.56	6.97	0.64
People	21	1.38	1.66	1	1.48	0	6	1.36	1.19	0.36
Legal	21	0.67	1.98	0	0	0	9	3.52	11.86	0.43
Sales	21	1.1	1.95	0	0	0	7	1.77	2.1	0.42
Acquiring	21	0.52	1.08	0	0	0	4	1.88	2.7	0.24
Suppliers	21	0.05	0.22	0	0	0	1	3.95	14.28	0.05

Table 6 : Descriptive Statistics

The descriptive statistics for the 3 quantative variables indicates wide range in their values, showing that there is a variety of companies that are involved in the industry. From the qualitative variables, 3 seem to be more frequent among companies : Products, Partnering and Finance. All the variables are not distributed according to the normal distribution due to kurtosisi and aymmetry tests,fact that hardens further analysis on the topic.

4.3 Multiple Regressions

The main assumption for concluding to a final model is the positive relationship between valuation and testing variables. If the relationship between an independent variable and valuation is negative, then the testing variable is excluded from the model and the regression is ran again. After 4 regressions, we end up in a 6-factor model, where all the coefficients except intercept are positive.

Factor	Model I	Model II	Model III	Model IV
Intercept	-205.798	-228.485	-240.804	-240.581
Funding	-1.035			
Employees	219.235	136.907	86.676	88.877
Time	-46.467			
Product	-25.782			
Partnering	30.142 (*)	8.745	7.595	7.419
Expansion	82.984	90.134	147.392	127.146
Finance	69.192	-40.729		
Branding	90.585	46.960	67.017	65.889
People	-161.363 (*)			
Legal	183.417	25.782	-19.560	
Sales	-91.242			
Acquiring	345.680 (*)	294.139 (*)	301.746 (*)	304.452 (*)
Suppliers	217.603	286.316	195.453	190.827
Adjusted R^2	0.7857	0.6651	0.6779	0.6994

Table 7 : Multiple Regressions

Model IV is consisted of 6 factors, 1 quantitative (Empolyees) and 5 qualitative (Partenring, Expansion, Branding, Acquiring, Suppliers). Although the only statistically significant factor is Acquiring, we can use this model as far as all the factors have positive impact on valuation.

Valuation = -240.581 + 88.877*Employees + 7.419*Partnering +127.146*Expansion + 65.889*Branding +

304.452*Acquiring +190.827*Suppliers

5. Results

The philosophy behind the above model is to fill the gap between pre-money valuation with qualitative models and post-money valuation with quantitative models. The researcher can estimate the valuation of the IoT startup from its foundation and for the rest of its life. The model should not be used as a single source to estimate the valuation of a IoT startup and in combination with other valuation methods can result to more accurate and realistic results.

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