Corporate Prototypes in the Age of Arduino

[1]Daniel C. Simon and [1]Greg DeJong
[1]Nexteer Automotive Corporation, Saginaw, MI 48601-9494, USA

Abstract

The process of turning concepts into a physical working part has been unnecessarily prolonged using traditional fabrication materials and methods. Many industries have had titans usurped by relying on stagnating technology, lagging behind in innovative products. Today this innovation lag has been bypassed by the rapid prototyping revolution brought on by the widespread availability of open source hardware and software. Products such as the Arduino, Raspberry Pi, and Beaglebone are being used to speed up the development loop, allowing designers and engineers to learn and gather experimental data faster than ever. This paper details the use of these open source components for proof-of-concepts and beyond, citing examples from industries such as telecommunications, robotics, and space exploration.

Key words: open source; prototyping; development; Arduino; innovation

1. Introduction

The ability to adapt to change is arguably the main driver in determining the success or failure of businesses [1]. This applies to established business as well as startups [2]. This ability, for hardware companies, can also be described as product actualization, innovation, or iteration. If there is no product or service to sell, there is no company. As companies form, or age, they find the need to develop additional or improved products and/or services. The focus of this paper is on the physical product development, specifically proof-of-concept development, that takes place in new and aging companies; including how the process has traditionally been performed, highlighting a few successes and failures around the world.

2. Sources and Methods

In order to gain a better understanding of what businesses have done in the past, and what they are currently doing, to create proof-of-concepts a large search of government statistics, business publications/books, news stories, development blogs, and corporate press releases were gathered. From these sources the most applicable and recent were chosen.

3. Business Trends

Looking at research expenditures one would assume that innovation comes at a high price. The USA spends the largest amount of any country on research and development, accounting for 32.2% of global research spending in 2011; a worldwide breakdown can be seen below in Figure 1 [3].

*Corresponding author: Address: Nexteer Automotive Corporation, Saginaw, MI 48601-9494, USA

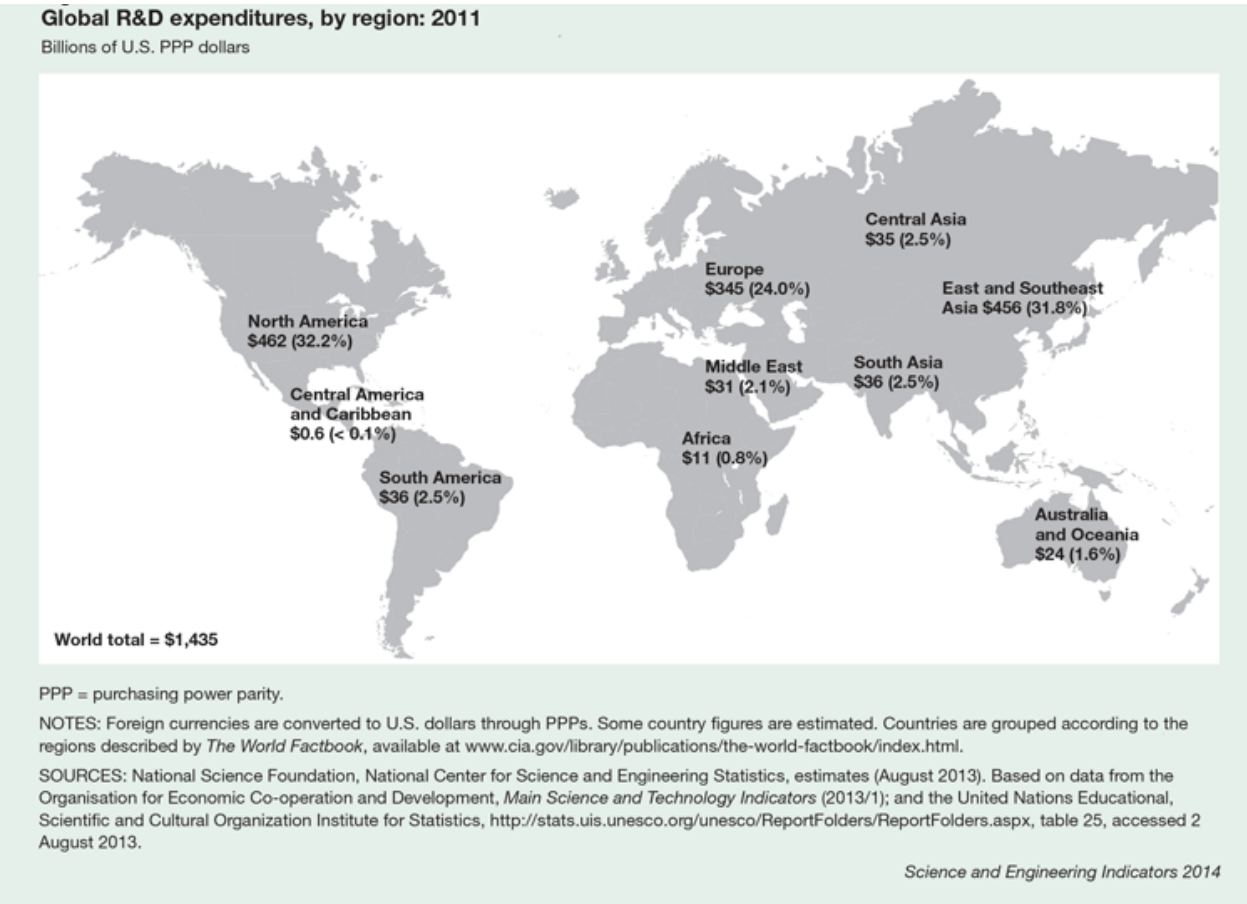

Figure 1. Global research expenditures worldwide for 2011 [3].

3.1 A Brief Look at Startup and Corporate Testing and Proof-of-Concept Costs

There are several areas that research and development divides money into: personnel, facilities, materials, software, hardware, etc. This paper focuses on the software and hardware side of expenditures, and for sake of brevity only gives a few examples of software costs.

Data acquisition and analysis tools can be a large portion of a research team budget; even just the software required for such activities are expensive. A brief example of common data acquisition and analysis software costs can be seen in Figure 2.

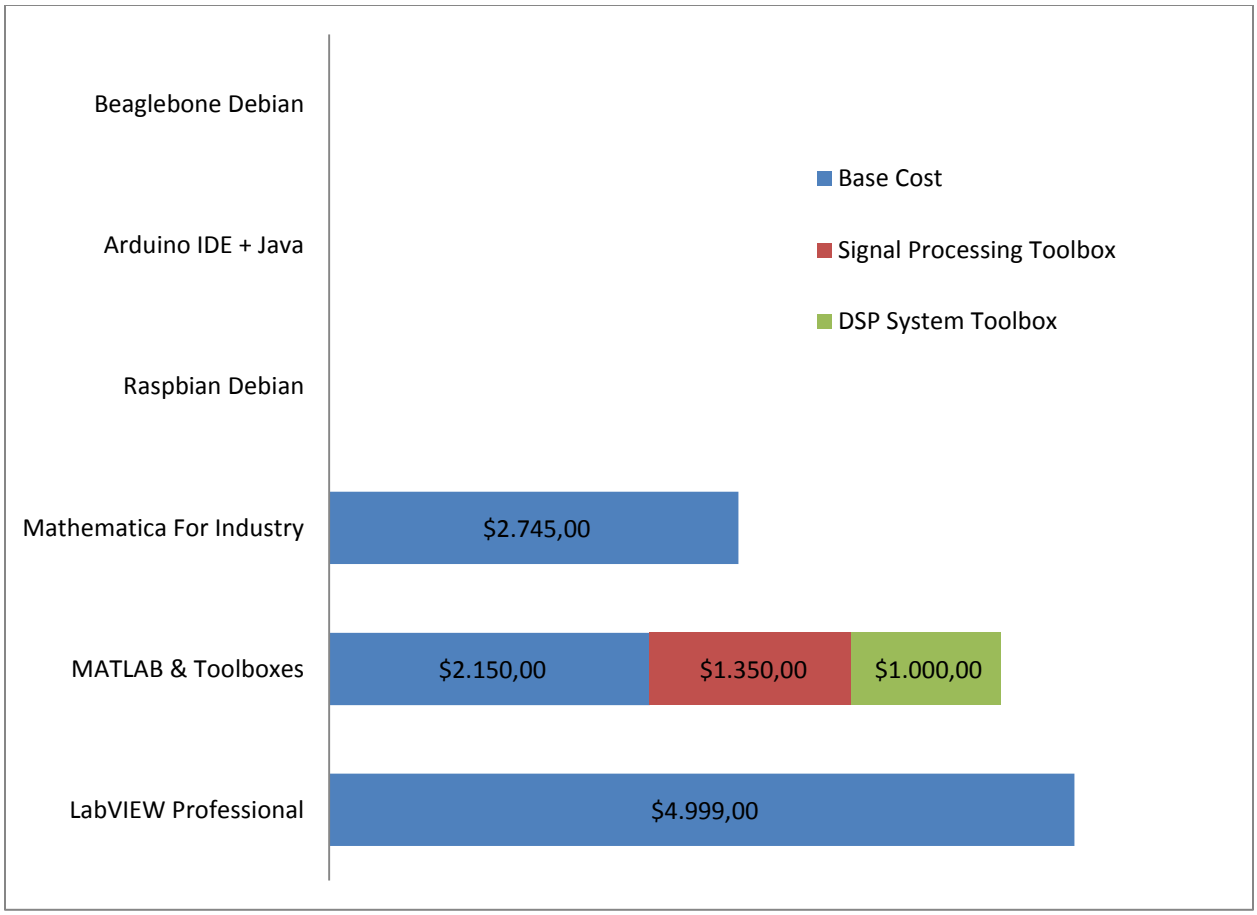

Figure 2. Example costs of software products for data capture and/or analysis [4] [5] [6].*

While this type of software is but one example of areas that research and development may divide their budget, the contrast from open source software to established company software is stark. This type of cost difference is not as drastic in the hardware side of data acquisition and analysis, but is fairly similar. Some prime examples are the dSpace research kits, which will typically cost around $20 thousand for an automotive compatible standalone kit [7]. On the open source side, an Arduino Uno R3 costs around $30 [8].

Obviously the cost of research and development can grow quite rapidly if pursuing traditional software and hardware. With such high costs there is high risk to companies when their product fails, as is discussed late in the next section.

3.2 Recent Failures from Lack of Innovation

There are several reasons that companies may fail; anything from executive level incompetence to not paying the correct amount in taxes to becoming technologically stagnant. While there are always large statistics for births and deaths of private sector companies, these are mainly

* Prices for Beaglebone Debian, Arduino IDE + Java, and Raspbian Debian are represented as $0.00, not accounting for costs of internet availability or a host PC for download

startups, not decades old multinationals, and are represented simply as totals. The latest data from the USA shows only 115,603 businesses aged twenty or more years, 653,647 aged less than one year, and 501,184 aged at one year [9]; a more detailed breakdown can be seen below in Figure 2 [10]. Some of these companies may in fact be much older than twenty years, but are not reported as such; for example, the average life expectancy of a Fortune 500 company is actually between 40 and 50 years [1].

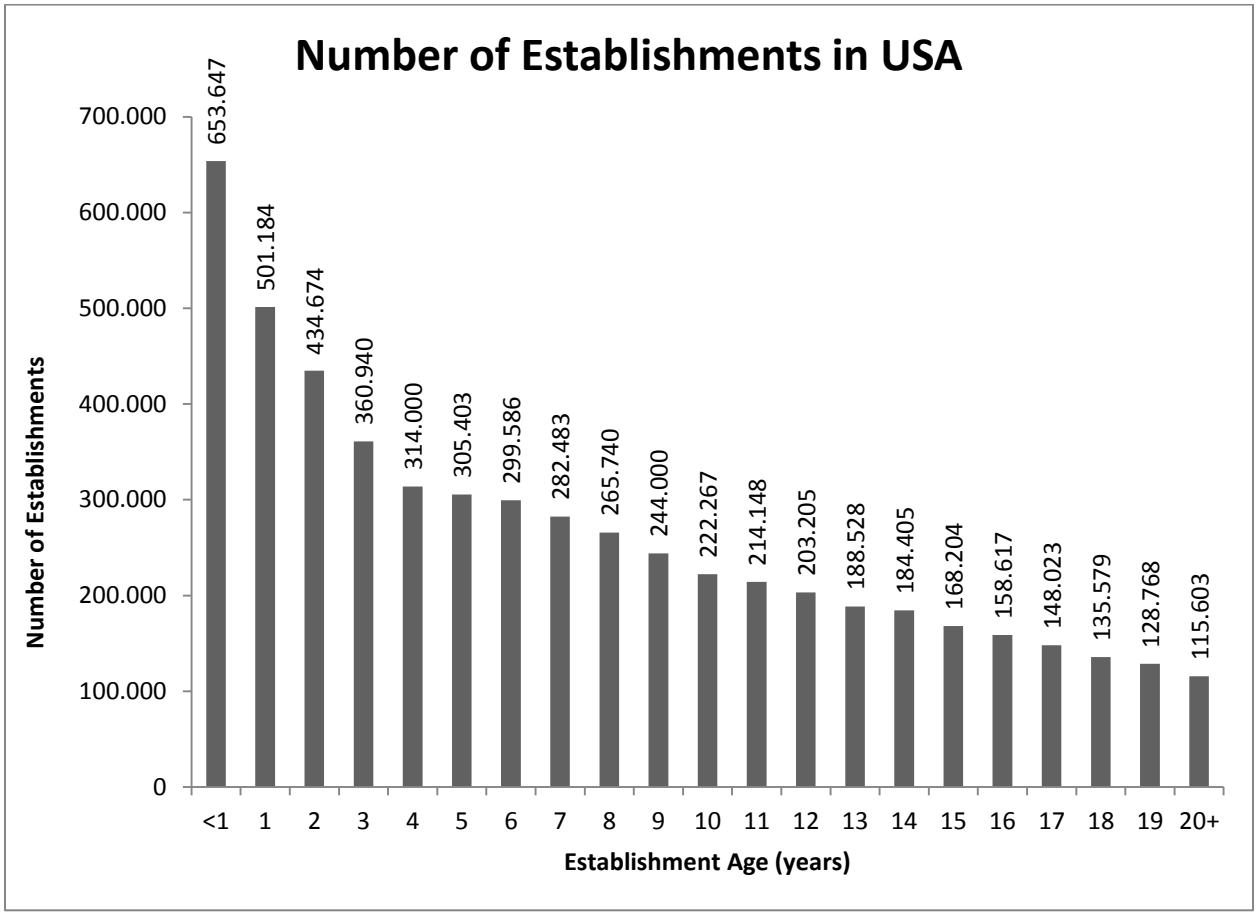

Figure 3. Age of business establishments in the USA [10].

When large companies fail it tends to make international headlines and draws out critics to speculate on the cause of the failure. This paper will not partake in the debate over why such companies fail, but will merely cite examples where the authors believe there is general consensus that lack of innovation was the main driver.

One recent, mainstream example of this kind of failure is RIM's[†] failure to adapt to market demands, continuing to make a phone that consumers perceived to be outdated [11]. Going just a year earlier provides HP's[‡] TouchPad, essentially a mimic of other products on the market at

[†] Research in Motion
[‡] Hewlett-Packard

the time, which caused the company to write off $885 million in assets plus $755 million in winding down its software operations [12].

3.3 Recent Successes Due to Innovation

There have been a few examples of businesses performed well that can be at least partially credited to the innovation that has been displayed in their products. These can be separated into established organizations and startup organizations, as both have different goals in mind.

3.3.1 Established Organization Successes in Innovation

Established companies are always looking for an edge, a way to increase their profits and push out competition. The use of open source technology is a way for companies to test new ideas without having to stay beholden to a board of directors or shareholders as their costs are near negligible compared to their total budgets. When companies have no experience in open source technology they turn to Universities for aid. Recently the telecommunications industry has done just that for help in creating low cost proof-of-concepts and product implementation [13].

Even government organizations such as the ESA[§] have made excellent use of open source technology, implementing a Raspberry Pi into their StarTiger dropship for landing rovers on Mars and other celestial bodies. The Raspberry Pi helped the project keep to the original eight month timeline while allowing for advanced technical goals such as vision-based navigation and hazard detection/avoidance [14]. While an organization such as the ESA does not have profit margins to maintain or investors to keep happy they do have a limited budget for research and development, making open source technology extremely appealing.

3.3.2 Startup Success in Innovation

Startup companies have had poor track records in the USA [10]. While there are many factors in making a startup successful, having a refined product or service is always required.

New resources for rapid prototyping have been an enabler for startup companies to thrive in an otherwise harsh environment. One needs to look no further than the Pebble smartwatch or the Fitbit fitness tracker. Both of these innovations were prototyped using Arduino; Fitbit using it for day-to-day prototyping [15] and Pebble for the original proof-of-concept [16]. The success of Pebble has been widely covered, with over 1 million watches sold in its short history [17], resulting in over $43M in revenue in 2013 alone [18], and it continues to push innovation instead of resting on its laurels [19]. Meanwhile Fitbit has impressed investors to such a degree that they have completed several rounds of funding [20], raising $43M in one single round [21].

The Pebble watch has taken the idea of open source a step further than hardware and has even gotten its market involved in the design process, allowing for a vote on the available colors they would make before even contacting plastic manufacturers [22].

[§] European Space Agency

4. Discussion

Established companies could continue to shorten their development time and lower costs by embracing open source technology, even if through a conduit such as a University. There will likely be an increasing amount of pressure on companies globally to lower development costs as more investors become aware of the benefits of open source technologies.

The outlook for startups continues to improve as the makers of open source products have begun partnership programs formed specifically to aid in the design and construction of new, innovative products that use their technology. Arduino has implemented a special program for just such a goal [23]. Others, such as Raspberry Pi, have thriving communities that are focused on other longer term goals, such as education [24].

The unique discovery from this paper is that open source technology not only appeals to current business needs, but also fits well with established reasons that businesses succeed from decades old research [1].

5. Conclusion

Open source will continue to influence how research and development is performed in corporate settings, and will likely have an even larger impact as time goes on. A greater number of startup companies will likely form as a result of the low cost of entry that open source provides, but there will likely continue to be low success rates within the first few years of their existence. However, as a whole, open source will likely be an enabler for companies who succeed in their infancy to live long, successful lives.

6. Acknowledgements

The authors would like to thank Mike Richardson, Frank Lubischer and Jeff Zuraski for allowing this study to take place. Further thanks go to Nexteer Automotive in general for the support they give to engineers who wish to better themselves and their field.

References

[1] A. d. Geus, "Prologue," in *The Living Company*, Boston, Massachusetts, Harvard Business School Press, 1997, p. 215.

[2] T. Prive, "11 Reasons Startups Succeed," Forbes, 29 March 2013. [Online]. Available: http://www.forbes.com/sites/tanyaprive/2013/03/29/top-11-reasons-startups-succeed/. [Accessed 5 March 2015].

[3] N. S. Board, "Science and Engineering Indicators 2014," National Science Foundation, Arlington, VA, 2014.

[4] [Online]. Available: http://www.ni.com/labview/buy/.

[5] [Online]. Available: http://www.wolfram.com/mathematica/pricing/industry-individuals.php.

[6] [Online]. Available: http://www.ni.com/labview/buy/.

[7] [Online]. Available: https://www.dspace.com/en/pub/home/products/hw/micautob.cfm.

[8] [Online]. Available: http://www.amazon.com/Arduino-Board-ATmega328P-Microcontroller-ATmega16U2/dp/B006H06TVG.

[9] B. o. L. Statistics, "Business Employment Dynamics - Second Quarter 2014," U.S. Department of Labor, Washington DC, 2015.

[10] B. o. L. Statistics, "Business Employment Dynamics: Establishment Age and Survival Data," United States Department of Labor, 19 November 2014. [Online]. Available: http://www.bls.gov/bdm/bdmage.htm. [Accessed 5 March 2015].

[11] N. Perlroth, "The BlackBerry as Black Sheep," The New York Times, 15 October 2012. [Online]. Available: http://www.nytimes.com/2012/10/16/technology/blackberry-becomes-a-source-of-shame-for-users.html?_r=0. [Accessed 5 March 2015].

[12] MarketWatch, "12 Worst American Product Flops," MarketWatch, 10 April 2015. [Online]. Available: http://www.marketwatch.com/story/12-worst-american-product-flops-2015-04-10?page=12. [Accessed 10 April 2015].

[13] C. R. Gallen and J. S. Reeve, "Using Open Source to realise an NGOSS Proof of concept," 2006.

[14] European Space Agency, "Dropship Offers Safe Landings for Mars Rovers," European Space Agency, 3 July 2014. [Online]. Available: http://www.esa.int/Our_Activities/Space_Engineering_Technology/Dropship_offers_safe_landings_for_Mars_rovers. [Accessed 5 March 2015].

[15] T. Igoe, "Fitbit: Arduino in the Workplace," Arduino SRL, 18 February 2011. [Online]. Available: http://blog.arduino.cc/2011/02/18/fitbit-arduino-in-the-workplace/. [Accessed 5 March 2015].

[16] P. Kuber, "Pebble Was Prototyped Using Arduino!," Arduino SRT, 10 May 2012. [Online]. Available: http://blog.arduino.cc/2012/05/10/pebble-was-prototyped-using-arduino/. [Accessed 5 March 2015].

[17] K. Allen, "Pebble rolls with more than 1M smartwatch shipments: Report," CNBC, 2 February 2015. [Online]. Available: http://www.cnbc.com/id/102389470. [Accessed 5 March 2015].

[18] A. Levy, "Pebble smartwatch sales surging, profits huge: VC backer," CNBC, 11 June 2014. [Online]. Available: http://www.cnbc.com/id/101751543. [Accessed 5 March 2015].

[19] L. Goode, "Pebble Launches New Color Smartwatch, Says It's 'Gearing Up For Battle' With Apple," CNBC, 24 February 2015. [Online]. Available: http://www.cnbc.com/id/102451040. [Accessed 5 March 2015].

[20] J. Wang, "How Fitbit Is Cashing in on the High-Tech Fitness Trend," Entrepreneur, 27 July 2012. [Online]. Available: http://www.entrepreneur.com/article/223780. [Accessed 5 March 2015].

[21] L. Goode, "Fitbit CEO on Why Turning the iPhone Into an Activity-Tracker Doesn't Hurt Fitbit," Re/Code, 3 January 2014. [Online]. Available: http://recode.net/2014/01/03/fitbit-ceo-on-why-turning-the-iphone-into-an-activity-tracker-doesnt-hurt-fitbit/. [Accessed 5 March 2015].

[22] Pebble Team, "Color Voting is Now Open!," 6 July 2012. [Online]. Available: https://www.kickstarter.com/projects/597507018/pebble-e-paper-watch-for-iphone-and-android/posts/261271. [Accessed 5 March 2015].

[23] Z. Romano, "Building Strong Partnerships With Arduino at Heart Program," Arduino SRL, 26 November 2013. [Online]. Available: http://blog.arduino.cc/2013/11/26/building-strong-partnerships-with-arduino-at-heart-program/. [Accessed 5 March 2015].

[24] Raspberry Pi Foundation, "Raspberry Pi: About Us," [Online]. Available: http://www.raspberrypi.org/about/. [Accessed 5 March 2015].

[25] F. Kunze and H. Bruch, "Age-Based Faultlines and Perceived Productive Energy: The Moderation of Transformational Leadership," 11 October 2010. [Online]. Available: http://sgr.sagepub.com/. [Accessed 5 March 2015].

[26] P. G. Northouse, "Skills Approach," in *Leadership: Theory and Practice*, Thousand Oaks, California, Sage Publications, Inc, 2004, pp. 35-64.

[27] P. G. Northouse, "Style Approach," in *Leadership: Theory and Practice*, Thousand Oaks, California, Sage Publications, Inc, 2004, pp. 65-85.

[28] P. G. Northouse, "Path-Goal Theory," in *Leadership: Theory and Practice*, Thousand Oaks, California, Sage Publications, Inc, 2004, pp. 123-145.

[29] P. G. Northouse, "Transformational Leadership," in *Leadership: Theory and Practice*, Thousand Oaks, California, Sage Publications, Inc, 2004, pp. 169-201.

[30] UN Office for the Coordination of Humanitarian Assistance (UN OCHA), "EMERGENCY FIELD COORDINATION TRAINING (EFCT)," December 2007. [Online]. Available: http://www.interworksmadison.com/emergency-field-coordination-training-efct-2/. [Accessed 5 March 2015].

[31] UN Office for the Coordination of Humanitarian Assistance (UN OCHA), "Leadership Style Questionaire," November 2005. [Online]. Available: http://ofd.ncsu.edu/wp-content/uploads/2013/01/Leadership_Style_Questionnaire__Reading.pdf. [Accessed 5 March 2015].

[32] M. Brounstein, Managing Teams for Dummies, For Dummies, 2002.