Learning about the innovation process through 20 point Stories

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Motivation

Why a 20-point story? Well, we all love to read stories. But there is more to it than that. We tend to worship heroes: James Watt for steam engine, Steve Jobs for iPod, Ratan Tata for Nano etc. All these people are indeed great innovators and deserve the credit. However, when we say, "Steve Jobs innovated iPod" we tend to ignore the process behind the innovation which is usually far more complex. So here is an attempt to depict the innovation stories in sufficient details and yet not more than 2-3 pages long so that we begin to appreciate the process of innovation. And what do we do with the details? We want to explore if we can improve organization's innovation capability systematically.

We will use a number of tools and models to analyze the story. We will ask questions like: What was the source of innovation? How did the initial experimentation happen? Who funded it? What kind of demo was shown and when? How did the business model exploration happen? Where did its first few customers come from? What kinds of collaborations happen? And did it eventually make money? How sustainable was the competitive advantage (if any)? Every story may not answer all the questions, but we will ask them anyway. We are interested in both kinds of stories: concept to cash and concept to crash.

As we ask these questions, we will begin to see that James Watt had to leave the experiments for several years and work because he ran out of money. Or it was Tony Fadel who came looking for sponsorship to Apple with the business concept of iPod. The objective is not to show that anyone can become Steve Jobs or Ratan Tata nor is it to show that everything depends upon luck. The objective is to learn the process of innovation such that anyone or any organization can become better at it, systematically.

Story: Boulton-Watt steam engine[1]

1 In 1712 Thomas Newcomen erected a steam engine that combined for the first time a piston-in-cylinder arrangement and a basic motive principle involving the formation of a vacuum within the cylinder through the induced condensation of steam. This engine saw exhaustive use in English coal mines especially for pumping water from the mines.

2 In the winter of 1763-64 John Anderson, professor of natural philosophy at Glasgow University, brought a small model of the Newcomen engine for repair to James Watt, twenty-eight year old mathematical instrument maker to the University. Watt was perplexed by several aspects of the model's operation, especially by the unexpectedly large quantity of steam consumed.

3 Watt started experimenting with the engine during the free time he got from his regular duties. After a year of experimentation he recognized that there is a paradoxical deficiency in the Newcomen engine. To utilize the steam efficiently, during the unpowered-stroke, the cylinder

[1] Sources: 1. Invention and Innovation in the Watt-Boulton Steam-Engine Venture, F. M. Scherer, Technology and Culture, Vol 6, No 2 (Spring 1965), pp 165-187. 2. Wikipedia page on Matthew Boulton, en.wikipedia.org/wiki/Matthew_Boulton

had to be kept at 100^{O} C. But during the power stroke considerable cooling water had to be injected into the cylinder, this tended to cool the cylinder below 100^{O} C.

4 Then one day, when Watt was strolling on the Green of Glasgow early in 1765, came his famous insight: he would condense the engine's steam not in the operating cylinder, as Newcomen and all his followers had done, but rather in a separate condensing vessel to which it would be drawn by a pump or by other means.

5 The following day Watt began work on a small (1.75 inch cylinder diameter) model to test his separate-condenser idea and in his own words, "in three days, I had a model at work nearly as perfect … as any which have been made since that time".

6 Watt's funds were quite limited, but he was able to finance several models and experiments during 1765 and 1766 by borrowing from his friend Prof. Joseph Black. During this period Watt built three models: the original test model with 1.75 inch brass cylinder but no steam jacket; a 1.4 inch sheet-iron cylinder model with steam jacket; and a model with a 5 or 5 inch copper cylinder and a wooden steam jacket. Watt was a loner and found it difficult to delegate anything or negotiate with anyone.

7 From summer of 1766 to January 1768, Watt found it necessary to engage full time in more remunerative activities (mainly surveying), and thus made little progress on his steam-engine experiments. Nevertheless, by spring of 1768 Watt's debt to Black and a former partner had accumulated to more than 1,000 pounds. At that time Watt entered into a partnership with Dr. John Roebuck, who paid off Watt's debts and the cost of a patent, receiving in return two-thirds share in the invention. Roebuck was principal partner in an iron works that produced major components for Newcomen engines. He had also become committed to a coal-mining venture where pits had flooded and Newcomen engines available were not powerful enough to remove the water.

8 There followed a second period of active experimentation, during which an 18-inch diameter model was erected and, with somewhat disappointing results, tested at Roebuck's Kinneil residence.

9 From early 1770 Roebuck was into financial difficulties and from early 1770 till May 1774 Watt went back to a full time job of surveying. Roebuck tried to get his creditor and a Birmingham manufacturer, Matthew Boulton into the partnership. However, Boulton felt that Roebuck's plan of supplying the engine to three neighboring counties too limiting.

10 In 1773 Roebuck became bankrupt, and in 1774 Matthew Boulton acquired Roebuck's two-thirds share in the invention. Boulton felt that Watt's engine could remedy the problems at his Soho factory, for summer water shortages made his water wheels inoperative & necessitated the expense of horses to propel the machinery. In 1774 Watt turned his full-time attention to the engine business. Under their partnership agreement Boulton financed the firm's development expenses and paid Watt an annual salary of 330 pounds plus expenses.

11 By 1774, less than 10 years of patent's term was remaining and that was a concern for Boulton (he expected it would take more than that to commercialize the engine). A request was made to extend the patent term in December 1774 and after heated debate the petition was enacted into law and the patent's term was extended up to 1800.

12 In 1774 John Wilkinson patented a new type of boring mill which significantly increased the accuracy to which cylinders could be fabricated. This improved the efficiency of Watt's engine further.

13 In 1776 the first successful prototype was demonstrated with a 50-inch water-pumping model for a mine and a 38-inch model for blowing John Wilkinson's blast furnaces. Both engines ran well and lead to favorable publicity.

14 From 1776 the firm began to install engines elsewhere. The firm rarely produced the engine itself: it had the purchaser buy parts from a number of suppliers and then assembled the engine on-site under the supervision of an engineer from their firm. The company made its profit by comparing the amount of coal used by the machine with that used by an earlier, less efficient Newcomen engine, and required payments of one-third of the savings annually for the next 25 years.

15 This pricing scheme led to disputes, as many mines fuelled the engines using coal of unmarketable quality that cost the mine owners only the expense of extraction. Mine owners were also reluctant to make the annual payments, viewing the engines as theirs once erected, and threatened to petition Parliament to repeal Watt's patent.

16 In 1779 the firm hired engineer William Murdoch, who was able to take over the management of most of the on-site installation problems, allowing Watt and Boulton to remain in Birmingham. The county of Cornwall was a major market for the firm's engines. It was mineral-rich and had many mines.

17 On a 1781 visit to Wales Boulton had seen a powerful copper-rolling mill driven by water, and when told it was often inoperable in the summer due to drought suggested that a steam engine would remedy that defect. Boulton wrote to Watt urging the modification of the engine, warning that they were reaching the limits of the pumping engine market: "There is no other Cornwall to be found, and the most likely line for increasing the consumption of our engines is the application of them to mills, which is certainly an extensive field."

18 Watt spent much of 1782 on the modification project, and though he was concerned that few orders would result, completed it at the end of the year. One order was received in 1782, and several others from mills and breweries soon after.

19 As a demonstration, Boulton used two engines to grind wheat at the rate of 150 bushels per hour in his new Albion Mill in London. While the mill was not financially successful, according to historian Jenny Uglow it served as a "publicity stunt par excellence" for the firm's latest innovation. Before its 1791 destruction by fire, the mill's fame, according to early historian Samuel Smiles, "spread far and wide", and orders for rotative engines poured in not only from Britain but from the United States and the West Indies.

20 Between 1775 and 1800 the firm produced approximately 450 engines. It did not let other manufacturers produce engines with separate condensers, and approximately 1,000 Newcomen engines, less efficient but cheaper and not subject to the restrictions of Watt's patent, were produced in Britain during that time.

21 In 1785, Watt wrote to Boulton on November 5, “On the whole, I find it now full time to cease attempting to invent new things, or to attempt anything which is attended with any risk of not succeeding, or of creating trouble in the execution. Let us go on executing the things we understand, and leave the rest to younger men, who have neither money nor character to lose.” Watt retired in 1800, at the age of 64, when their partnership agreement expired. Boulton, at 70, became engrossed in a coin-minting venture.

22 Watt, who started in business by borrowing, left an estate of 60,000 pounds at his death in 1819. Boulton's estate in 1809 was 150,000 pounds.

Analysis of the Boulton-Watt steam engine story

1. **What was the source of innovation?**

   Let's look at the source for each of the three main players in this story: Watt, Roebuck and Boulton. For Watt, the itch came from observing the inefficiency of the Newcomen engine and he started scratching it. The question might have been, "Can I make this engine more efficient?" It was an engineer's itch and in all likelihood, nothing to do with its business potential. (pt 2)

   For Roebuck the interest had a direct link with his business where he had seen the pain of the workers when the pits get filled with water and Newcomen engine is not able to do anything. (pt 7)

   Boulton, an owner of a large factory, had experienced the pain in managing his factory where he had to use horses to propel the machinery in summer. (pt 10)

   Under the pain, wave and waste model, I would classify the sources as "waste" for Watt and "pain" for Roebuck and Boulton.

2. **How did the insights happen?**

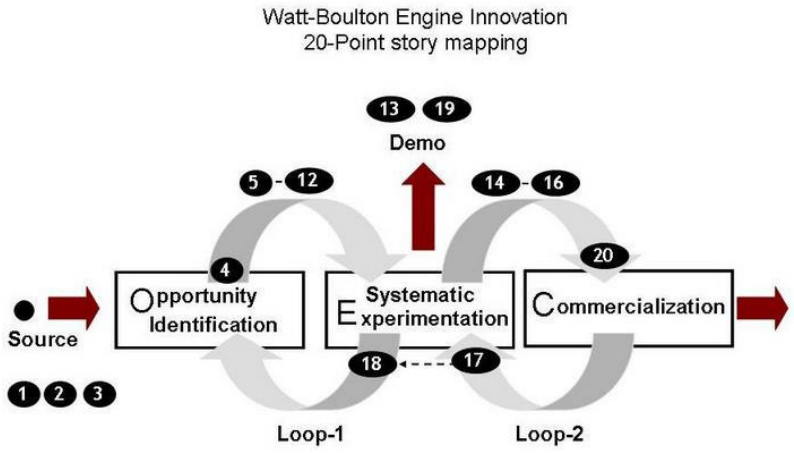
   There are two critical insights in the story. First one happens a year after Watt starts to experiment with the engine where he sees that the problem can be solved using a separate condensing vessel. (pt 4) Second critical insight came from Boulton in 1781 when he observed a limitation of their existing engine and urged Watt to work on a possible modification so that it becomes usable for mills. (pt 17)

3. **How was the opportunity estimated initially? How did it evolve?**

   It is not clear from the story if Watt had any commercial estimate from this venture. Roebuck

4. **How did the initial experimentation happen? Who funded it?**

   We use a three stage model consisting of (1) Opportunity identification (2) Experimentation and (3) Commercialization to (OEC or reverse-CEO). See the figure below.



We can map the story into following three phases:

- Phase-1 (itch to idea): Watt spent one year experimenting with the engine in his free time until he hit upon the idea of using a separate condensing vessel (pts 1-4).

- Phase-2 (idea to demo loop): This is a long period of 11 years between the initial insight and first demo in 1776. During this period Watt did not work on the engine (at least full-time) for 3-4 years due to lack of funds. His experiments included varying size of the cylinder (1.75 inch, 1.4 inch, 4 inch, 5 inch, 18 inch) and the material of the cylinder (brass, sheet-iron, copper and wood).

- Phase-3 (demo to cash loop): This was a period of 10 years when Watt would have done several improvements to the engine. Also during this period Boulton and Watt established the viability of a profitable business.

5. What kind of demo was shown and when?

In 1776 the engine was shown working in two places: one at Wilkinson's blast furnace and the other at a mine. (pt 13) The enhanced version of the engine was demonstrated in London sometime in second half of 1780s. (pt 19). The demos which Roebuck and Boulton saw before funding the project are also important.

6. How did the business model exploration happen?

There were two aspects of the business model that stand out:

- Boulton-Watt firm did not manufacture the engines in a central place. The engine was assembled at customer's place under the supervision of Boulton-Watt engineer. (pt 14)

- Initial pricing was based on measured benefit - one third of the savings of coal from earlier engine to the new engine for the next 25 years. It had its problems as customers used coal of unmarketable qualities and consumed more and paid less. (pt 14)

7. Where did its first few customers come from?

TBD

8. What kinds of collaborations happened?

There are three partnerships that stand out in the story:

- Watt-Roebuck partnership: This was an investor-engineer partnership. It ended before the product reached demo stage.

- Watt-Boulton partnership: In this partnership Boulton played two roles: (1) investor and (2) product manager. He identified newer markets (such as mills) and also suggested potential modifications to the product.

- Wilkinson and Boulton-Watt partnership: Wilkinson played the role of a complimentor as described Nalebuff and Brandenburger in Co-opetition. His improved cylinder design helped Watt-Boulton engine.

9. And did it eventually make money?

Yes. Both Watt and Boulton made money.

10. How sustainable was the competitive advantage (if any)?

Extension of patent term was a big advantage for Watt-Boulton partnership. They had monopoly of the new market until the patent expired. Of the total market of steam engines, Watt-Boulton managed to capture around 30%. It is not clear whether the growth of Watt-Boulton business was supply constrained or demand constrained.

11. Where all did "chance" play a role in this story?

- Professor bringing the Newcomen engine for repair to Watt was a chance event. How rare this event was is not clear from this story.

- Watt having an insight of solving the inefficiency paradox in Newcomen engine had an element of chance.

- Patent term getting extension after a heated debate had an element of chance. It is not clear if Boulton would have continued with the partnership had the patent's term was not extended.