Creative Destruction in the Philosophy of Technology

Alex Ledger

1 Old Thoughts on Creative Destruction

1.1 Marx and Schumpeter

This section introduces creative destruction. Creative Destruction has its roots in economics, and as such, this section will present creative destruction in its economic form.

Neoclassical economic theory, the most popular economic theory, is built on top of the idea of equilibrium. Most simply, an economy has supply of things and demands of things. Supply and demand interact with each other, creating tension between economic processes. The economy remains in flux until supply and demand reach a happy equilibrium. At a happy equilibrium, supply and demand remain more or less constant until something disrupts the system.

The supply and demand theory doesn't explain one crucial observation: economies grow. In a neoclassical economic framework, an economy reaches equilibrium and stabilizes. Once an economy stabilizes, the only way for it to grow is via exogenous inputs, for example, increased supply of raw materials.

However, we observe that economies grow faster than the net exogenous inputs. What could explain this? Better worded: what explains endogenous growth in an economy? After a close reading of Marx, Schumpeter came to the idea that innovation and entrepreneurship are the drivers of endogenous growth [Jaffe and Trajtenberg, 2002]. Innovation and entrepreneurship introduce new value into the economy that did not previously exist, contributing to an overall increase in social wealth. Schumpeter also observed that new technologies (that is, the results of innovation) and new firms often displace old technologies and old firms. The new technologies and new firms are economically better - specifically they have a lower marginal cost or are more desirable widgets - and the old technologies lose economic value and

the old firms lose profits. If the old technology and old firms lose sufficient value or profits respectively, then they cease to remain part of the economic system.

This the idea of creative destruction. The old displaces new; the better, more efficient version makes the old, costly version economically unviable. For example, the smartphone, a sophisticated little computer with the power to text and call, destroyed the economic viability of the dumb-phone.

1.2 Caballero and Jaffe

In our readings for philosophy of technology, Caballero and Jaffe introduced us to concept of creative destruction. Their aim is to formalize the idea of creative destruction and knowledge spillovers and complete empirical investigations:

> "Our aim in this paper is to create a framework for incorporating the microeconomics of creative destruction and knowledge spillovers into a model of growth, and to do so in such a way that we can begin to measure them and untangle the forces that determine their intensity and impact on growth" [Jaffe and Trajtenberg, 2002] (90)

Caballero and Jaffe view the economy in a Schumpeterian way: "Schumpeter recognized that innovation was the engine of growth, and that innovation is endogenously generated by competing profit-seeking firms" (90). In the economy, a firm that operates with constant marginal cost, i.e. a firm that does not innovate, will see their profits decline. If a firm's goods are more substitutable for new goods, then the firm will see their profits decline more quickly.

To Caballero and Jaffe, creative destruction is specifically the effect of new innovation on the economic "value" of existing products. They measure the effect of innovation on industries by using market value data and patent data on 567 large U.S. firms. They found that:

> "In an average sector at an average year a firm that does not invent sees it relative value to that of the industry erode by about 4%." [Jaffe and Trajtenberg, 2002]

That is, there is approximately 4% destruction of pre-existing technology on average per year. Different industries observed varying levels of destruction. On the high end, the pharmaceutical industry observed 25% destruction per year, yet multiple sectors observed 0% destruction.

We find Caballero and Jaffe's method to be interesting and the results to be useful, but the story is not yet complete. The model that Caballero and Jaffe use to compute creative destruction[1] is complicated and computed over a short number of years. However, the findings are consistent with intuition. 4% destruction on average per year is a reasonable number, and it is to be expected that pharmaceuticals see a high level of destruction relative to other industries. The source of profits of pharmaceutical firms, drugs, requires a large amount of capital investment, and a firm's failure to continue to research results in other firms pulling ahead.

Further research could be done on the economic side of creative destruction. First, one could further investigate the nature of the technologies that are being destroyed, characterizing the nature of the destruction (e.g. is it intra-firm created, extra-firm created, expected destruction, unexpected destruction, and so on.). Second, it would be interesting to measure creative destruction using other methods, for example using research and development expenditures. Third, it would be interesting to see how the industries are affected by the varying degrees of creative destruction, and the way that the firms innovate.

We greatly appreciate Caballero and Jaffe's results, and use them to motivate our research and argue about the effects of creative destruction.

2 Creative Destruction in the Theory of Technology

2.1 Situating Creative Destruction in Theory of Technological Evolution

The aim of this section to situate creative destruction in the theory of technological evolution. Many authors have different ideas of technological evolution; however, the important component for this discussion is that there is some selection process by which fit technologies remain relevant to society. The aim of the selection process is an open question. Economists like Jaffe believe that technologies are selected because of their potential for economic profits [Jaffe and Trajtenberg, 2002]. Social constructivists believe that technologies are selected because of a complex causal web involving society, social conventions, economics, history, psychology and so on [Pinch and Bijker, 1987]. For our treatment of technological evolution, we do not believe it to be too important *how* selection occurs, but rather, it is

[1] The model is not communicated in this paper

important *that* selection occurs. With this in mind, we use Brian Arthur's simple explanation of selection: technologies that are useful to humans are selected [Arthur, 2009]. We say that a particular technology has use-value corresponding to how useful the technology is to society, humans or the economy.

We now give a formal description of the selection process using the idea of use-value. At a point in time, there exists a set of technologies in society - call this set of existing technologies $\mathcal{T}$. Each technology $t \in \mathcal{T}$ has use-value at this point in time. Suppose that a new technology u is created. Upon the creation of u, the use-value of each technology t in $\mathcal{T}$ is subject to change. The use-value of t may increase, indicating that u complements t: u and t function well together and make each other more valuable. The use-value of t may stay the same, indicating the u and t are not related. Or the use-value of t may decrease, indicating that u substitutes t: u may perform the same job as t, and hence decrease the use-value of t, or something along these lines (the causal relationship can be complicated - e.g. u may be complementary to a replacement of t) [2]. Creative destruction is concerned with the third case: where a new technology u reduces the use-value of an old technology t.

In order to further understand creative destruction, we compare the negative selection process in technological evolution to the negative selection process in biological evolution. Interestingly, biologists identify a similar process to creative destruction in the selection of species. The phenomenon is called *competitive exclusion*. Competitive exclusion is the idea that if two species are competing for the same resource, then one of the species will overcome the other, forcing the other species to adapt or die [Wikipedia, 2016]. In recent years, observational, experimental and simulation-based evidence has surfaced to cause biologists to question the simplicity of competitive exclusion. We did not examine the new evidence close enough to explain here, but it seems that the general idea of competitive exclusion remains true.

There is a strong a parallel between creative destruction and competitive exclusion. To use the terms of biology, two technologies cannot coexist and rely on the same resources for their use-value, so one must either die or adapt. To biologists, the subject which is adapting is the species, and there is no straightforward analog of a species in technology. Technologies, in contrast, do not die or adapt per se, rather they become irrelevant. When a

[2] We assume that use-value is 1-dimensional value: a use-value can go up or down, but not left and right. This simplification appears to be fine, but in the future, it may be useful to think of use-value as a vector in vector space, allowing for more abstract relationships.

technology responds to competition, the technology births new technology, and that new technology is more fit than its parent.

The story of competitive exclusion applies well to the story of creative destruction. Does the opposite hold true? A technologist (us) would say that upon the creation of a new species (or upon the creation of a new adaptation of a species) the use-value of all other species are affected, and species whose use-values decline are in some sense destroyed. The use-value in this context is fitness - reproductive success. The species whose fitness declines sufficiently may become extinct; otherwise, the species adapt, changing their fitness. The story of creative destruction also seems to apply well to competitive exclusion.

The one caveat in both stories is the usage of use-value and fitness. The definition of use-value given at the beginning of this section focuses on how useful a certain technology is to society. Use-value has no clear causal relation to the reproductive power of a given technology. A technology's use-value is likely correlated to its reproductive power (although that would need to be tested empirically). That being said, there are examples of technologies whose use-value remains high but do not reproduce. The best example of this is the MRI. The MRI was invented in the 1970s, and since then it has been used widely (i.e. high/constant use-value). However, there are few innovations on top of the MRI (i.e. low reproductive success). It is quite possible that the MRI is an anomaly, and that in general, reproductive success is strongly correlated to use-value. We believe this to be true. Thus we assume use-value is highly correlated to reproductive success, and as such, use-value is a sufficient metric of fitness.

2.2 Implications on the Theory of Technology

This section discusses the implications of creative destruction on the theory of technology.

The first implication of creative destruction is that faster invention creation results in faster destruction. The reason for this hearkens back to Brian Arthur's idea of primitives. Arthur reasons that new technology is the product of a new combination of technological primitives. At a given time, there exists a set of primitives. A new technology is created out of recombining the existing primitives, then the new technology is added to set of the primitives. Creative destruction suggests that when a new technology is created and added to the set of primitives, the new primitives may be complemented or substituted (i.e. their use-value goes up or down). If a primitive's use-value sufficiently decreases, then the primitive may become

irrelevant to society and cease to be a primitive.

Now consider that more and more primitives are being created. Then more existing primitives are liable to lose their use-value and be destroyed. Technology is subject a phenomenon like Newton's third law: the more technology there is, the greater the push-back on old technology.

The second implication of creative destruction is that there could be a net-decrease in technology. Consider the range of possible technologies that given set of primitives allows or leads to. Since primitives are destroyed as new primitives are created, it is possible that the range of primitives decreases - there's no clear justification for believing the range of possibilities monotonically increases.

That being said, as far as we are aware, a net-decrease in technology has not been observed. Yet this is an idea that worried Marx and Schumpeter, albeit their concern was with capitalism not technology. Marx and Schumpeter worried that capitalism would destroy itself; large amounts of creation would lead to overwhelming amounts of destruction, and consequently, the system would collapse on itself.

As an example, imagine if there were many sudden innovations to the internet. The internet is a highly complex, abstract, layered, decentralized web of interactions on which much technology relies. One could imagine that we, society, decide to improve the internet, but improve it such that the old infrastructure is destroyed and the new infrastructure insufficient or incomplete. We have buried ourselves into a hole. We don't have reliable technology to use. We can't simply reimplement the old internet because it is too intertwined, too complicated. And we can't use the new internet because the new technology turned out to be too complicated or be insufficient. In the end, more was destroyed than created.

3 Philosophical Considerations of Creative Destruction

This section discusses philosophical considerations of creative destruction. We outline three philosophical implications.

First, creative destruction makes technology more unpredictable. Creative destruction suggests that when a new technology is created and added to the set of primitives, pre-existing technologies may be removed from the set of primitives. When one is trying to predict the future path of technology, the primitives available in the future may be missing primitives that are present now, making the task substantially more complex.

Second, creative destruction introduces a feeling that technology is dangerous. Marx and Schumpeter worried that society would create so much that it would consume and destroy itself, and this is a possibility with technology. In section 2, we outlined an example of how the internet may be destroyed if there is too much innovation too fast. New technology, introduced and implemented in the wrong way, could undermine the technological infrastructure that has been built up. With the technological infrastructure gone, it's not difficult to imagine the negative social repercussions.

Third, we have the perhaps unfortunate situation where there is constantly new technology. New iPhones, new computers, new drugs. With the creation of each new invention, creative destruction theory says that old technology may be destroyed. The old technology, which is likely less expensive now, is now inaccessible: all that exists is the new, expensive technology. The implication is that the poor are left with nothing. The poor cannot afford the new technology, and the old technology, which they may be able to afford, no longer exists.

The most pressing area where we see this problem is the pharmaceutical industry. There are two phases for a drug on the market. The first phase is where the drug is patented, the firm has a monopoly on it and prices are high. The second phase is after the patent expires, and the drug enters the public domain. Unfortunately, poor people don't benefit from drugs being in the second phase, because the existence of the new technology disincentivizes firms from selling post-patent drugs [3].

4 Conclusion

Creative Destruction, the idea that new technologies make existing technologies less relevant, fits in nicely with the technological theory of evolution. In particular, creative destruction explains a portion of the selection process, and how new technologies affect the fitness landscape of existing technologies. Moreover, creative destruction has a strong analog in biological evolution, competitive exclusion. Creative destruction and competitive exclusion share many commonalities and few differences, suggesting that at least some part of technological selection is quite similar to biological selection.

Creative destruction also brings three philosophical considerations to the table: (1) technology is complex and unpredictable, (2) technology is potential dangerous to itself and (3) the nature of technology is classist, harming

[3] There are many post-patent drugs that are sold on the market, but remarkably fewer than the number of useful, invented drugs.

the poor in some instances. We consider the third point to be most important and most easily observed. Technology has the power to do great good and great harm. The good and harm can stem from individual technologies themselves, in the way that technology that cures cancer is great, but drones that kill humans are arguably bad. Zooming out, the nature of technology and how it evolves has a devastating effect on the poor. The poor cannot afford the new technologies, and the new technologies often cause firms to not produce old technologies because they are not economically viable, leaving the poor without anything. Here, it is the process by which technology is created and evolves which harms the poor, not the technology itself.

References

[Arthur, 2009] Arthur, W. B. (2009). *The nature of technology: What it is and how it evolves*. Simon and Schuster.

[Jaffe and Trajtenberg, 2002] Jaffe, A. B. and Trajtenberg, M. (2002). *Patents, citations, and innovations: A window on the knowledge economy*. MIT press.

[Pinch and Bijker, 1987] Pinch, T. J. and Bijker, W. E. (1987). *The social construction of facts and artifacts: Or how the sociology of*, volume 17.

[Wikipedia, 2016] Wikipedia (2016). Competitive exclusion principle.