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On the Obsolescence of Long-Run Rationality

David Allen Axelrod, Ph.D.

Montclair State University, Montclair, NJ, USA
axelrodd@montclair.edu

ABSTRACT: The rapid pace of technological change challenges assumptions concerning the economic "long-run". Consequentially, it disrupts the optimal psychological balance of emotion, reason, intuition and faith in our decision making. This is described in terms of the microeconomic conception of "runs", decision frames defined by the scope of what is variable in the production process and endogenously determined. The four types are: market period, short, long and very long. These relate to time horizons that have parallels in terms of mindsets and the production of experiences. We show how a decrease in time between tech advances causes a sublimation from the short-run to the very long-run, thereby making long-run analysis obsolete. Further, these changes are associated with increased uncertainty about the future that is associated with increasing myopia. This can trigger a substitution out of reason into either emotion-based and/or intuition-based choice, as well as a greater demand on faith to maintain behavior. The implication is an exaggerated bifurcation in society between people driven by emotions to mediate the moment, and those reliant on vision and faith in technological progress to make their plans seem reasonable.

KEYWORDS: Long-Run, Uncertainty, Obsolescence, Microeconomics, Faith, Myopia

Introduction

In 1923 Keynes wrote, "But the long run is a misleading guide to current affairs. In the long run we are all dead. Economists set themselves too easy, too useless a task if in tempestuous seasons they can only tell us that when the storm is long past the ocean is flat again." (Keynes 1923, 80) In essence, it is a statement that the long run neoclassical economic analysis of the time was obsolete in the face of uncertainty and rapid structural change. Our paper elaborates on this obsolescence in the light of technological advance and its relationship to mind and society from a holistic economic perspective (a similar approach is well developed in *Holonomics* (Robinson and Robinson 2014)). It will not look at how to make a profit from the changes, or specific markets, or impact on employment. Rather it will consider the future in economic theory and decision-making frameworks, which has implications for psychology and modes of decision making. Indeed, the rapid advance of information technology led Vinge (1993) to write of a coming "singularity" where AI and computers would surpass human intelligence within thirty years. Kurzweil (2005) went further out, suggesting 2045 as the date of transcendence.

However, before such an inflection point, we could expect changes in the optimal balance of efforts between natural and artificial intelligence. Even if such a singularity occurred, leading to an absolute advantage by computers in all areas of human mental processes, there would still be the aspect of comparative advantage to consider. Comparative advantage refers to employing a resource how it is least disadvantaged, thereby still increasing overall production. Computers would have a comparative advantage in calculation, data processing, and logic, the quantitative side of economic reason. Humans would have a comparative advantage in the realms of emotions and intuition. This would lead to a specialization of mental labors. We already observe this as people outsource mathematical calculation and data memory to apps and servers (OECD 2012), and increasingly rely on emotions and faith to guide their decision making (Lerner et al. 2015, and Schieman 2011). Indeed, the field of behavioral economics has made great progress by accepting the "bandwidth" constraints of the human brain and mind (Mullainathan and Shafir 2014). There are also larger implications for decision making at the societal level, with serious consequences for democracy (Puaschunder 2019).

All of this finds its origins in the twentieth century when the limits of knowledge were explicated. While economics was dealing with Keynes and the role of risk, in 1927, physics saw Heisenberg develop the "Uncertainty Principle" expressing the limits on measurable observation (Busch, Heinonen, and Lahti 2007). For logic, 1931 saw Gödel prove the limits of mathematical deduction with his Incompleteness Theorems, taking us to the edge of recursive, self-referential systems being inconsistent (Raatikainen 2021). Then, Simon (1955) challenges that our ability to make decisions rationally is bounded by the information we have, and our capacity to process it. The fin de siècle economics of Walras' 1877 *Elements of Pure Economics* (1954, English Translation), while still foundational, falters, as his bifurcation of persons and things ceases to describe the confounding of the consumer and product in the era of social media (Tabora 2019). These are all relevant, since they are various forms of uncertainty that constrain our capacity to make decisions rationally.

It will be useful to address a methodological issue at this point. In first-year courses, students are presented with the distinction between "positive" and "normative" economic statements (Asarta & Butters 2019). Positive statements are fact like, and can be tested against empirical evidence or logical consistency. Normative statements contain subjective judgements. Being able to distinguish between the two can be very useful. However, for our purposes, the following distinctions are suggested: descriptive, predictive, prescriptive, and proscriptive. These are summarized in Table 1. The reader is invited to consider these various ways of interpreting what our paper presents. The obsolescence of long-run rationality has as much to do with Greenspan's (2008) "flaw in his model" being an idealized expression of how markets *should* operate, as it does with rapid structural changes happening in the economy.

Table 1. Suggested Economic Statement Types

Type	Aspect	Modality	Example
Descriptive	Historical	What Happened	The 2019 inflation rate was 1.8%
Predictive	Scientific	What Will Happen	The 2025 inflation rate will be 5%
Proscriptive	Political	What Should Happen	The 2025 inflation rate should be 2%
Prescriptive	Managerial	Deciding What Happens	Sell Treasury Bills to reduce inflation

Economic "Runs"

A microeconomics course will also introduce the cost of production as distinguished by four runs: the market period, the short run, the long run and the very long run (Asarta & Butters 2019). Table 2 summarizes the four runs.

Table 2. Economic "Runs"

Run	Quantity Produced	Inputs	Production Function	Decision Making
Market Period	Fixed	Fixed	Static	Maximize Revenue
Short	Variable	Mixed	Static	Maximize (R– VC)
Long	Variable	Variable	Static	Maximize (R –TC)
Very Long	Variable	Variable	Dynamic	Tech. Change as a Cost

The "market period (or immediate run)" is when all inputs of production are fixed. One cannot change the amount one has produced, and hence the cost of production is fixed. An example is the day of a farmer's market, where whatever one has grown or baked is the fixed supply for the day, and all one can do is try to maximize the revenue generated from that supply. The "short-run" has some fixed inputs (like size of manufacturing plant, number of

robots, retail store lease, etc.) and some variable inputs (labor, raw materials). Here there is some flexibility over how much to produce and there are variable costs based on the quantity produced. The "long-run" assumes the quantity of all inputs are variable, so there are no fixed costs (a time horizon where all contracts end, and can be renegotiated). However, all three of these assume a static production function. The production function embodies the technology available to turn inputs into finished products and services. Economists use the term "very long run" to refer to a scenario where even technology can change (think research and development).

The firm is assumed to be profit maximizing, where profit equals revenue minus total cost. Both revenue and cost are a function of Q, the quantity produced and sold. Cost always increases as quantity supplied increases. Total Cost (TC) is decomposed into fixed cost (FC) and variable cost (VC), where TC = FC + VC. Variable cost refers to those costs that vary with Q. Fixed cost do not vary with Q. Quantity demanded decreases as price increases. However, depending on the underlying demand, there may be a quantity at which revenue is maximized.

The optimal choice of how much to produce, which inputs to use, and selling price, changes based on run. In the market period, since Q is fixed, only price might be variable, and thus set to maximize revenue (since all costs are fixed). This can imply wastage of unsold product, and can show up as food chains throwing out food at the end of the day instead of giving it away free. Short-run analysis can be used to explain why firms might operate at a loss (exigencies preclude being profitable) as they maximize revenue (R) minus variable costs (VC), represented in the nomenclature as *Max (R - VC).* Long-run analysis can be used to explain the number of firms operating in an industry, based on the assumption that they never have to operate at a loss. Here it is the maximization of revenue minus total costs, *Max (R - TC).* These are essential for understanding why some businesses attempted to operate early during the pandemic (e.g., they had to pay leases anyhow, so better to make a little bit back), and then, over time, as fixed costs became variable, many chose to go out of business and not renew leases, so as to avoid unnecessary losses. The very long run framing considers structural changes and technological advances, for example remote work infrastructure and vaccines. So, businesses could *imagine* a future beyond lockdown, and hence enough prosperity to be willing to invest and expand.

It is important to distinguish a long-run decision from the limit of short-run decisions over time. It is tempting to conceive these as the same. They are not. Short-run decisions always have some fixed cost. As long as revenues exceed variable costs, the firm continues to operate, even if at a loss. If the losses are ongoing, they do not leave the industry as a business decision. They are forced out when they no longer have the assets to cover the fixed costs. Since long-run decisions have no fixed cost, a firm would leave an industry whenever operating can only produce a loss. They do not wait until they are forced out. Clearly, it would be beneficial for the owners of a firm to be able to make decisions from a long-run perspective.

We visually represent the static production function runs in terms of the amount of fixed cost relative to the market run, in Figure 1.

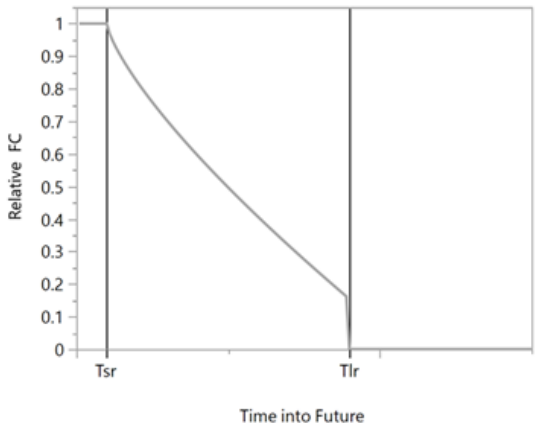

Figure 1. Relative Fixed Cost over Time

The market run occurs between 0 and T_{sr}, the short-run between T_{sr} and T_{lr}, and the long-run from T_{lr} on. The very long run is excluded for now, to clarify how time becomes identified with the operational context of economic runs. It will come back with a vengeance.

Three Types of Time

Time enters decision making in three distinct ways: as a resource or product, as a distance to an event, and as a constraint on decision making. These can also be understood as time within a moment, time between moments, and time over a moment. We shall consider each, and their implications. A nice summary on the neuroscience of the brain, and its relationship to our perception and use of time, can be found in *Your Brain is a Time Machine* (Buonomano 2018).

First, time is a resource or product. It is often understood in labor economic or human resource terms. Businesses seek to efficiently use the time they've hired, whether a janitor, a teacher, or an executive. Likewise, individuals and households attempt to produce leisure time so as to savor and enjoy that which they have bought from their labor's compensation, which is based on their wage rate (w). Time, as quantity of labor (L), becomes one of the inputs that are optimized based on the choice of economic run. The quantity of capital is represented by K. In the standard short-run model, firms optimize L (which is variable) given K (which is fixed) so as to maximize (R – VC). More realistic models may include unearned income from wealth, time and monetary costs for working, time used for home production, and budget effects on firm optimization, among others. Possibly the most visceral presentation of labor time as a resource is in the movie *Metropolis* (1927), in particular the scenes of workers on the machines.

Second, time is a distance to an event. One way this shows up is in financial present value calculations. The more distant into the future the realization of a cost or benefit, the less it is factored into a decision. This is referred to as temporal discounting, and also shows up in consumer behavior as how myopically they make choices. The steeper the discounting, the narrower the myopia. It can also be described as a time horizon, the distance into the future after which consequences are ignored. Policy debates over climate change and sustainability often are grounded in differing time preferences/discounting. The standard formula for the present value of stream of net income (NI) is

$$PV(NI) = \sum_0^T [(R_t - TC_t) * (1 + \delta)^{-t}] = PV(R) - PV(TC) \quad (1)$$

where T =the time horizon, t = the time into the future, and δ = discount rate. Note the exponential decay of discounting. This is to assure self-consistency of the decision made. Self-consistency is the criteria that if the future is realized as planned, then the plan will not change (Strotz, 1955). Since TC = VC + FC, we get PV(TC) = PV(VC) + PV(FC). This implies that a present value calculation that includes the present through the time horizon, will have some fixed cost, and thus the standard long-run model is not consistent with it (hence Keynes criticism). It would require ignoring what happens during the near term, to generate having no fixed costs. Letting LRPV be the Long Run Present Value, as an equation it would be:

$$LRPV(NI) = \sum_{T_{lr}}^{T_{vlr}} [(R_t - TC_t) * (1 + \delta)^{-t}] = LRPV(R) - LRPV(TC) \quad (2)$$

Note the introduction of the term T_{vlr}. This is required since long-run analysis assumes a static production function. It represents the time into the future when that assumption no longer holds.

Third, time is a constraint on decision making. Deadlines impact how much we can reflect and consider alternatives. This in turn affects how we make our decisions. In his highly acclaimed book, Kahneman (2011) describe two modes of thinking, "fast" and "slow." Fast refers to decisions requiring an immediate response (e.g. a car runs a red light in front of you). Slow refers to decisions that be can be more reflective (e.g. where to go on vacation next year). Recognizing this bifurcation, and how our brains embody it, is an enlightening advance in understanding the challenges of rationality for humans. However, we shall use a further

gradation to help us along. Table 3 suggests correspondences between time frame, type, nervous system structure, personal decision making, and firm decision making.

Table 3. Decision Making Correspondence

Time Frame	Type	Nervous System Structure	Personal Decision Making	Firm Decision Making
Very Short	Act: Reflexive	Brain Stem/ Spinal cord	Physical	Market Period
Short	Choose: Mediate, Non-reflective	Limbic System	Emotional	Short-Run
Long	Decide: Mediate, Reflective	Cerebral Cortex	Rational	Long-Run
Ambiguous	Meta-Choices: Recursive	Neuroplasticity	Transcendental	Very Long-Run

In very short time frames, at most 1-2 seconds, there must be an immediate, or reflexive, response to a stimulus. How our physical body is "wired" at that moment, determines how we *act*. For example, the reflex test of a knee tap. There is not enough time for brain processes to access anything deeper than the brain stem. This aligns with the market period where it is "sell" or "don't sell" the product on hand. There is no capacity to produce different alternatives. With a little more time, reflexes can be mediated by emotional processes, typically centered in the limbic system. There are now some options. However, there is not enough time to reflect on the alternatives. One gets to *choose*, but they have to choose quickly. With increasing time before acting, before having to choose, there is increased potential to *decide*. Deciding is reflective deliberation as rational decisioning making (associated with the cerebral cortex in humans). This aligns with long-run decision making where variability of mental resource usage provides wider optimization of behavior, although *how* we can make those decisions is fixed. This would include aspects like tastes, preferences and commitments. To round out the correspondences, there are transcendental decisions, recursive *meta-choices* about how we make decisions. As for the brain, this is the realm of neuroplasticity and how the brain rewires itself (Doidge, 2007). This aligns with very long-run technological advances that change the production function itself. The time frame is ambiguous because of choices yet to be made.

Consider Figure 2, which visualizes the dynamic of awareness and decision making.

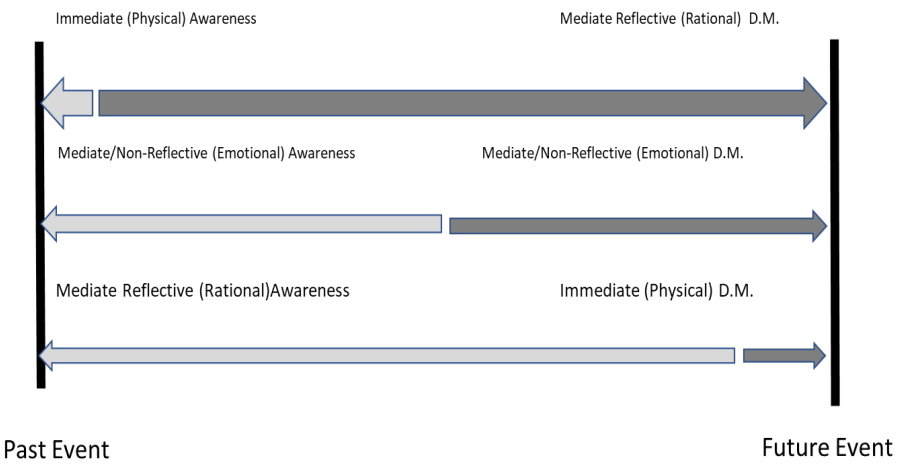

Figure 2. Dynamic of Awareness and Decision Making Between Events

Immediately after an event is the physical awareness of it. As time passes, emotional awareness becomes available, and a little further on rational, reflective awareness. While this expanding awareness of the past proceeds, the reverse occurs in regard to decision making over future events. When there is much time before the moment of action (future event), the behavior can still be mediated by rational reflection. As the lead time diminishes, this is lost and mediation can only occur from non-reflective emotions. Eventually, in the last moments, mediation is no longer possible, and behavior is determined by the immediate, physical "wiring" of the moment. This describes a very human experience: increasing comprehension of what we have done, and yet feeling as if we are helpless to change. Moreover, as the time between events shrinks (the same as events occurring more frequently), access to rational processes is lost.

The only way out of this would be by inducing a transcending decision maker, as if they had an "eternal" perspective from outside the flow of the person's events. A perpendicular view as it were, where the long-run's reflection on reflection through time, collapses into a single moment. The bright flash of insight from borrowing the seemingly dimmed light of the future. The capacity for intuition, and the faith to embrace it, overcomes the slog of reasoning and hesitancy to decide. The long-run may be measured against time, but the very long-run is measured against imagination. Figure 3 visualizes this. It is intended to suggest there is a trade-off. As one transforms the perception of what is feasible in the future, one also transforms the perception of what was feasible from the past.

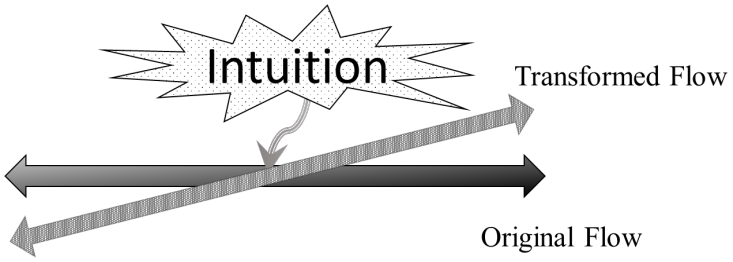

Figure 3. Intuition and The Transformation of Flow of Awareness/Decisions

Lest this seems too imaginary, it relates directly to economic theory via the principle of "revealed preference" or RP (Samuelson 1938). RP is based on inferring a consumer's preferences based on their actual behavior. It assumes a consistent preference structure, and relies on knowledge of what was feasible, by taking the observed purchase and considering it preferred to any other alternative that was also affordable. While there has been significant progress since then to synthesize it with bounded rationality (Tipoe, Adams, and Crawford 2021), recognizing that if the self understands its own preferences based on what they had done, any change in the perception of what had been feasible in the past would impact the understanding of those preferences. Sometimes being able to change what you can do in the future requires rethinking what it was you "really" wanted in the past. Further, there is some neuroscientific evidence that supports that brain activity does work this way (Van Hoeck et al. 2013).

Another interpretation of the transcending decision maker is more recognizable, a different person. Whether family, friend, colleague, or neighbor, they see you from the outside, at a distance. Sometimes an honest conversation with a person that knows you well does make a difference. This also relates to some interesting neurobiology: that the brain region associated with interpersonal decision making is also associated with temporal discounting (Soutschek et al. 2016). All of the above raises an important policy issue, should we set social temporal discount rates (used in present value calculations of major development and infrastructure projects) based on observed interest rates via revealed preference, or do we set them on how we wish to account for the well-being of our future selves? We can see some of this as far back

as Ramsey's *A Mathematical Theory of Saving*, "One point should perhaps be emphasized more particularly; it is assumed that we do not discount later enjoyments in comparison with earlier ones, a practice which is ethically indefensible and arises merely from the weakness of the imagination…" (Ramsey 1928, 543).

Demand-Side Technology and Producing Experiences

Pine and Gilmore (2011) conceive of experiences as products of the economy. They explicate a model describing the progression of economic value from commodities, through goods and services, upward toward experiences. Using their primary example of Disneyland, they describe the workplace as a stage, with the consumers as an audience. In the last chapters of their book, they conclude by elaborating on the transformation economy, where the value is generated by guiding a person through a series of experiences which leaves them transformed.

While this can show up in many ways, from an economic perspective this would include changes in satisfaction with their material life and preferences over behavior. It suggests that the economist's utility function can be interpreted as the production function of a subjective experience. Indeed, the mathematical assumptions of both are quite similar. For consumers, the very long run would refer to a dynamic utility function, which could be dependent on the choices they make now (Pollak 1978). It becomes a technological change in the production of experiences. This is very much the realm of neuroplasticity, where the brain is the means of production. Of course, this can be expanded to a well-being function with utility, pleasure, sentiment, profit, freedom, etc. as inputs. As such, personal growth, counseling, self-help, spiritual guidance, and similar activity, would be understood as the R & D for technological advance.

Which brings us to the distinction between supply-side and demand-side technology. Supply-side is the standard economic conception of technological advance as transformation of the production function, which implies more productivity, lower cost, and increase in supply. The demand-side refers to the capacity to change how consumers value a product and/or the purchase experience, and advances are associated with increased demand. To be precise, we should distinguish between value arising from the consumer finding greater satisfaction (subjective experience), and value as a measure of the inclination to buy (behavior). The conflating of the two simplifies the story telling, but obfuscates the demand side analysis. Marketing and advertising are essentially efforts to transform the consumer's *behavioral* preferences. The conflation retains the narrative of the consumer as a rational decision maker, by assuming they have the internal resources to reflect on the outcomes of their choices and modify their behavior appropriately. As suggested by Figure 2, in times of rapid change this breaks down. For example, by creating time pressure on a customer, a sales person can collapse the customer's time horizon/preference through triggering an emotional response (Zboja, Clark, and Haytko 2016). Hence, the necessity to develop behavioral economics, and the marketer's appealing to the consumer's divine nature.

The Very Long-Run and Fixed Cost

We showed earlier how using present value calculation to account for benefits and costs into the long term, still leaves some fixed cost in the analysis. In the static technology runs, where there is no cost to avoid obsolescence, we do see how the share of fixed cost decreases as time horizon grows, and decision making becomes more long-run-like. Similarly, as temporal discounting increases so does the share of fixed costs, and decision making becomes more short-run-like. So, even if there remains some fixed cost in the analysis, at least there are conditions under which long-run rationality is approached.

This is not the case in a world where technology changes. Since we described how the very long-run is more accurately a distance in imagination and creativity, rather than a distance in

time, it does need to be far in the temporal future. To be precise (and referencing equation 2), if $T_{vlr} < T_{lr}$, then LRPV is undefined and can not be used as a decision making criteria.

In a dynamic technology model, since the firm must invest in the technology before using it for any amount of production, replacement acts like a fixed cost. So, fixed cost share is dependent on the expected costs around obsolescence. One aspect is the cost of adopting the new, and disposing of the old, technology. Another arises from the firm choosing to continue using the old technology, thereby facing loss of competitiveness and decrease in productivity, as well as an accelerated depreciation of their physical capital. In other words, as technology changes there are costs whether one adopts or not, hence the fixed cost quality. Still, some firms (and households) might continue with obsolete technology for both pecuniary (high financial cost) and non-pecuniary (high psychological cost) reasons.

The expected costs are based on assumptions made about the future, since the technology does not even exist yet. Moreover, since those assumptions influence the decisions made, they can affect how the technology develops. This is the recursive nature of very-long run decision making. Thus, it is reasonable to describe these as "faith-based" assumptions intended to increase the probability, and reduce the uncertainty, of a positive outcome.

Figure 4 modifies the graph of relative fixed cost over time by adding an increasing fixed cost for obsolescence, both slow (short dash) and fast (long dash), as well as an upper bound for LR cutoff.

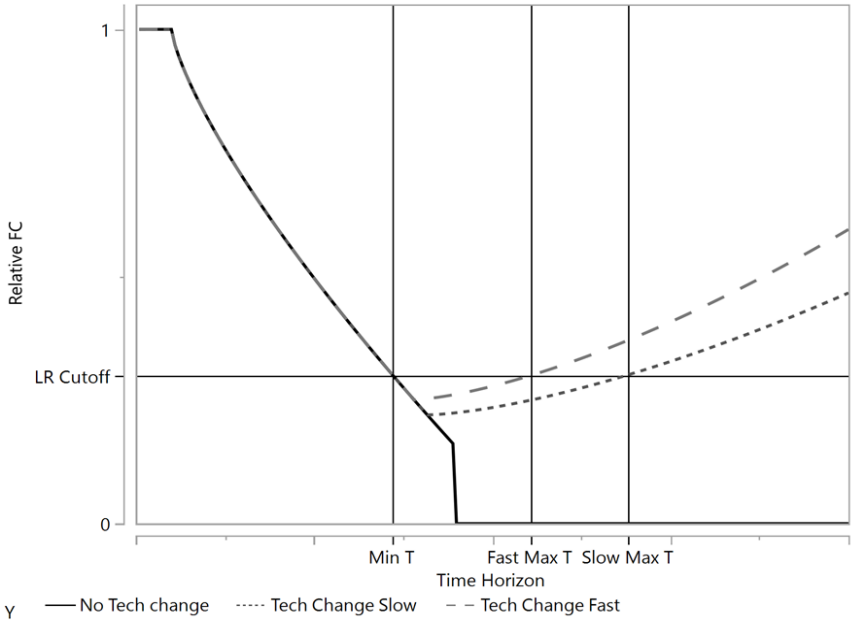

Figure 4. Relative Fixed Cost with Obsolescence, Before and After Acceleration

Although long-run rationality is invalidated (there are fixed costs), there is more. The time horizon associated with minimum relative fixed cost is closest to being long-run-like. We might expect that a decision maker committed to using long-run analysis would favor the use of that time horizon. If there is a maximum FC cutoff for using the long-run analysis, then there would be a time horizon range where it is applicable. For slower change it would be between Min T and Slow Max T. For faster change it would be between Min T and Fast Max T. So, we see as the rate of technological change accelerates, the cost of obsolescence increases, and the range shrinks. Thus, even if one were willing to accept the increasing predictive inaccuracies of a long-run analysis for some other benefit, there will eventually be a rate of change that precludes its usefulness. It becomes obsolete.

Recent neural network research (Lotter, Krieman, and Cox 2020; Spoerer et al. 2020) supports including prediction mimicry and processing limitations on time and energy resources for better emulation of human visual cognition. In essence, part of what drives how we perceive the world is not only the limitations of the human brain, and the brain's accounting for being limited, but also the brain's predicting how it is likely to perceive in the future (to aid in efficiently using those resources). If these continue to be confirmed, it reinforces a sublimation from short-run analysis (static production function) to very long-run analysis (dynamic production function). Part of "Future Shock" (Toffler 1970) is the loss of comfort from having a transitionary phase when a fixed set of inputs are all variable before coping with a variable set of inputs to be fixed.

Uncertainty and Myopia

Along with faster technological change, there is increased uncertainty of planning optimality. This arises since the cost of adapting new technology also depends on the cost of disposing of old technology. That includes the obvious wasting or recycling of a physical object, but also include the retraining of users. When technology advances slowly, say major changes every 40 years, then people might only need to be retrained once in a lifetime. If the rate of change is on the order of a year or less, businesses and workers may find it too costly to keep up with the latest technology. Increasing uncertainty about the future would be associated with increasing myopia (Axelrod 2017). This implies shorter time horizons and/or steeper discounting in decision making, leading to a potential myopic trap. In practical terms, those who cannot afford to keep up with the latest developments, stay permanently behind and could end up adopting new technology less frequently as their resources are affected. Since psychological energy, as in the resources required to process events and control behavior, is also limited, another implication is a reduction of investing one's mind toward expressing autonomy in the world (Axelrod 2019). When keeping up with the future outside becomes too much, one specializes in savoring their past within.

Another effect of increasing uncertainty is that it generates greater variance of expected profit. This increases the probability of loss, even if the expected profit is held constant. In the real world, the probability of loss is greater than zero, which contradicts the long-run assumption of no firms operating at a loss. This suggests an upward bias in terms of number firms operating and the total production in the industry.

Limitations of the Profit Motive

The profit motive itself is insufficient to assure progress in the very long-run. Technological advance might decrease the average cost, but if expected revenues also fall due to increased competition, investing in research and development becomes less attractive. The existence of patent and copyright laws are intended to assure sufficient technological progress by benefitting the inventor/author (Shavel and van Ypersele 2001). There is something deeper, though. For the theory of long-run profit maximization to apply, total costs must include "implicit costs", such as normal profits (what could have been made in other industries), risk-premia and other compensating differentials. Often ignored is the necessity to include "implicit revenue." This would include, but is not limited to, the utility or enjoyment value of producing (in contrast to the utility of consuming). In other words, owners that love their work could find it optimal to produce more than the quantity that would maximize accounting profits.

The overall impact of implicit revenue depends on whether the firm is experiencing economy or diseconomy of scale. A small firm, such as a startup, will likely find their average total cost falling as they increase production. In this case, having an owner and employees who are excited by their work, and prefer to do more, will be beneficial as it reinforces a competitive advantage. On the other end of the spectrum, a large firm operating at the upper limits of

maximum efficiency would face increasing average total costs if its decision makers generated implicit revenue from greater production. From an accounting standpoint, the firm might be better off with an executive indifferent to how much is produced (but NOT indifferent to how much profit is made). Further, if there is a decreasing implicit revenue based on cumulative lifetime production, similar to decreasing marginal utility with increasing consumption, then we might expect an inverse relationship between time at an occupation and implicit revenue from production. In this case, a person could be enthusiastic when a novice, and eventually only work diligently enough to maximize financial income.

Economic Faith and the Very Long Run

Faith enters the picture as the capacity to hold a belief, or maintain an action, in the presence of evidence that generates uncertainty about the truth of that belief or outcome of that action. Thus, another way to handle uncertainty is to compensate for it by investing faith in how technology will change, and one's ability to keep up with it. This can range from the confidence of tech leaders and visionaries, to an ill-fated attempt at an actual AI deity-based religion (Harris 2017). While this does not assure a superior outcome, it does allow one to rationalize the opportunity cost to keep pace with the changes. This enables the decision maker to remain technologically competitive, at least temporarily.

Faith would also be another scarce resource, for all involved. Thus, the ability to afford the tech and the training is dependent on the ability to borrow money or sell equity shares, which will depend on the faith the lenders and investors have in the person or business. Consider how during the 1990's dot.com bubble, and continuing through to current tech and app start-ups, the stock valuation of companies has been wildly exaggerated relative to actual profit and loss statements (Ming et al. 2020). The socioeconomic dynamic then leads to a bifurcation in society among those making decisions within the bounds of what is immediately feasible, and those requiring a continuing mutual expression of faith to make decisions based on what could be feasible in the future. This requires not only the physical investment to invent new technology and the educational/training investment to use it, but also a spiritual investment to maintain a very long run view. Indeed, there is evidence that those who hold these "faith-based" beliefs about technological progress have greater life satisfaction (Stavrova, Ehlebracht, and Fetchenhauer 2016). In a way, given the neuroplasticity of the brain, choosing to invest one's "faith capital" is an act of technological progress itself. We can look to *I am a Strange Loop* (Hoffstatder 2007, 176) to capture this, "… it leads us straight to the conclusion that the most efficient way to think about brains that have symbols — and for most purposes, the *truest* way — is to think that the microstuff inside them is pushed around by ideas and desires, rather than the reverse."

Conclusion

As structural transformation of the economy accelerates, uncertainty about the future increases. Part of this is due to accelerating technological change, that will also propagate fixed costs further out the planning time line. It is a combination in conflict with the assumptions embedded in long-run economic analysis. Decision makers will be driven in one of two directions. The first is a more myopic, short-run view, tending to avoid the holistic costs of adopting new technology (both material and spiritual), and reinforcing negative emotional responses to change. The second is a more faith driven, very long-run view, that will accept the greater fixed costs, and thus requires a growing community to sustain it. Hence, the skill sets and worldview of long-run economic rationality will become less useful, and eventually obsolete, in a society split into reactionary cost-cutters, and faith-based technophiles.

And yet, the aspiration for a sustainable economy, with a stability of resources, culture, and institutions, if realized, would be the raison d'etre of the long run model. A strange loop indeed!

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