Two-Population Social Cycle Theories

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Abstract

Discerning family resemblances in the world of theories can be useful for several reasons. For one thing, noticing that two theories share the traits of a family of theories may help us to understand each of them better. Secondly, noticing the family resemblances may help us to model them more easily. In particular, the modern software development technique of object-oriented programming leverages family resemblances among different software "objects" to increase the ease of development, and so dovetails very well with the effort to pick out "families" on a more theoretical level. In this paper, we note the large family of two-population social cycle theories, all based on a pattern of disruptions and adjustments akin to the well-known predator-prey model.

Keywords: social cycle theory, predator-prey, Lotka-Volterra, business cycle theory, agent-based modeling.

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1 Introduction

"there is a rhythm of sentiment which we can observe in ethics, in religion, and in politics as waves resembling the business cycle."—Vilfredo Pareto (2000, p. 31)

This paper sets out to describe and begin modeling what we argue is a related group of theories of social cycles, all built on the framework of two populations, each of which disrupts the other, and adjusts to those disruptions, leading to the emergence of cyclical patterns in society. We find all of these theories akin to the well-known predator-prey model.

Discerning family resemblances[2] in the world of theories can be useful for several reasons. For one thing, noticing that two theories share the traits of a family of theories may help us to understand each of them better. Secondly, noticing the family resemblances may help us to model them more easily. In particular, the modern software development technique of object-oriented programming leverages family resemblances among different software "objects" to increase the ease of development, and so dovetails very well with the effort to pick out "families" on a more theoretical level. The usefulness of such an effort is, we believe, on evidence in several prominent, earlier undertakings of this type: For instance, David Lewis's work *Convention* (2002) seeks to identify the essential characteristics common to the various phenomena we call conventions, as well as to note how, despite sharing those characteristics, we can identify certain common variations among types of conventions, based on how they differ in embodying those essential elements. Similarly, Thomas Schelling (2006) analyzes and classifies families of situations involving cooperation and conflict where

[2] See Wittgenstein (1953) on the idea of family resemblances. Alexander et al. (1977) explores the idea of families of design similarities in the realm of architecture, calling the result "a pattern language."

people are making interdependent decisions.[3] And Gottfried Haberler (1946) sets out a detailed schemata of business-cycle theories attempting to place them into a family tree.

We will begin our effort by analytically isolating some essential patterns common to theories of social cycles. We will then employ these patterns to create a simple, four-way classification scheme of such theories. We next note that our interest lies in the theories in one of those four boxes. We will next seek for very simple examples of cycles fitting into that box, work our way up to more complex instances, and seek to note the family resemblances we find along the way. On our journey, we will examine:

1) Adam Smith's theory of cycles in fashion.

2) The Aristotelean-Polybian theory of anacyclosis.

3) Giambattista Vico's theory of a cycle of civilizational forms.

4) Vilfredo Pareto's theory of circulation of the elites.

5) Financial-market models of value investors and trend followers.

6) Hyman Minsky's financial instability hypothesis.

7) Joseph Schumpeter's theory of creative destruction and economic development.

8) R.M. Goodwin's theory of the business cycle.

It should be noted that only the eighth member of the list was chosen *because* it had a two-population model: in the other cases, we had already picked the theories before noticing this pattern.

We wrap things up by showing how detecting this family resemblance has aided us in developing agent-based models of several of these cycle theories.

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[3] In fact, Schelling proposes a family of cycle theories we might term "thermostat theories" (2006, pp. 83-89), which involve simple overshooting, and contrast nicely with the family we intend to present.

2 Our Fundamental Concepts, and the Resulting Classification Scheme

Abstracting the essential nature of cyclical phenomena in the natural world has attracted some attention. For instance, Alfred North Whitehead, discussing such cycles, wrote:

> In the Way of Rhythm a round of experiences, forming a determinate sequence of contrasts attainable within a definite method, are codified so that the end of one such cycle is the proper antecedent stage for the beginning of another such cycle. The cycle is such that *its own completion provides the conditions for its own mere repetition*. (1958, p. 21, emphasis ours)

The emphasized portion of the above quote is very important for us: for there to be true, endogenous social cycles, there have to be patterns of social activity the completion of which provides the conditions for their own repetition. In particular, what we mean by a true and endogenous social cycle is different from the fact that people will tend to flock to the beach in the summer, and the ski slopes in the winter, that they tend to use more artificial lighting in the evening than in the day, or that harvest festivals are in the fall while lamb is eaten in the spring. A social scientist may be curious as to why, say, people go to the beach or why there are harvest festivals at all, but given these things exist, it is pretty obvious why they happen when they do. While, as we will see in our subsequent schema, these are *true* cycles, the generation of the cyclicality is clearly exogenous to the social world. We may march through the same typical sequences of events repeatedly, but the fault is in our stars, or our solar system, or the Big Bang, or God. But the basic cyclicality is not a social product, and the social component consists in the chosen response to a cycle beyond human control.

What is of particular interest to the social scientist are cycles that arise endogenously in the social world. And not just that: are there purely social cycles that occur without being

intended by anyone? So, if a village holds a maypole dance, there is not much of a puzzle as to why the dancers keep winding up in the same places: that is what they intended to do. But if an economy repeatedly arrives at a high level of unemployment, or a political regime keeps cycling through periods of order and of chaos, then those events are far more curious. Presumably, no one has arranged to have periodic business downturns or regular episodes of violent disorder, but there they are.

A possible explanation to the puzzle of why such states recur is, "Well, stuff happens." This is largely the approach to the business cycle taken by proponents of Real Business Cycle Theory: the economy suffers a shock, things get worse for a bit, the economy adjusts, things get better, and at some time in the future another shock occurs. The appearance of cyclicality is an illusion, produced by "random waves" (see Chatterjee, 2000).

That sudden "shocks" hit the system is an interesting possibility, and we do not wish to dispute that it may even be true. But many prominent social theorists claim to have detected *truly*, *endogenously*, and *spontaneously* (unintentionally) cyclical social phenomena, and to have identified the cause of the cyclicality. Our research questions are, "What family resemblances, if any, do we find amongst such theories?" and "How can recognizing these resemblances help us to model them?"

2.2 A Simple Classification Matrix

Our working hypothesis is that all social cycles, and thus all plausible theories of such cycles, are characterized by patterns of disruptions and adjustments. A disruption we define as an event that interferes with the smooth progress of the plans of one or more social actors. Adjustments are the means by which agents whose plans were disrupted respond to that disruption in order to continue toward realizing their goals as best they can in light of the new circumstances confronting them.

As a first step toward understanding the occurrence of cycles in social life, we distinguish stabilizing from destabilizing adjustments.[4] A stabilizing adjustment creates, over the time frame in question, a series of further adjustments by others, that are, at each moment of time, of a lesser magnitude than the adjustment under examination. A de-stabilizing adjustment, on the contrary, creates over the time frame in question a series of further adjustments that are, at each moment, of a greater magnitude than the adjustment under examination.

Based on this distinction, adjustment processes may induce a cycle if they result in a significant period of largely destabilizing adjustments followed by a significant period of generally stabilizing adjustments. To generate a recurring, endogenous cycle, this pattern of adjustments must itself, somehow, lead to a situation in which disruptions similar to those that started the cycle are the likely result of agents' efforts to realize their goals. So in examining various cycle theories, one thing we will look at whether the disruptions that generate the cyclical behavior are endogenous to the theory, or appear from outside its scope.

We might formalize this notion using the simple logistic equation that is often used for population growth, $dD / dt = rD (1 – D / K)$, where D is the number of people experiencing destabilization, r is the rate of destabilization, and K is the "carrying population," which here we can intuitively interpret as a limit to how much of the population can be destabilized by others' adjustments at one time: certainly, by the time over half the population is involved in

[4] Similarly, Haberler (1946, p. 276) wonders whether there are self-reinforcing processes that will bring the system further away from equilibrium whenever it is disrupted (exogenously or endogenously).

responding to a previous destabilization, that leaves less than half the population to be destabilized by that adjustment, assuming the adjusters are not engaged in self-destabilizing.[5]

A separate question is whether a theory provides a reason why truly cyclical patterns should occur at all. Here, the question is whether we can expect something similar to the initial disruption to recur, whether or not its source is endogenous or exogenous to the theory.[6] If a theory gives us a reason to expect recurring patterns of disruptions at semi-regular intervals[7], then we classify it as a "true" cycle theory; if not, it is a "pseudo" cycle theory.

We believe it is important to distinguish these two dimensions of cycle theories because logic does not forbid, and history provides examples of, cycle theories that posit true, exogenous cycles: cycle theories pointing to sunspots and other such extra-human factors were once fairly popular. In such theories, because, say, sunspots wax and wane in a cyclical pattern, the effects they are purported to have on human economies can cause them to cycle in a similar fashion. The cycle is clearly caused exogenously: no one ever posited that business activity could cause sunspots! On the other hand, a theory is both endogenous and a true cycle theory when the pattern of adjustments to an initial disruption is such that we can expect those

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[5] Of course, there are many complexities that could be introduced here, such as the possibility that, even while the majority of actors or trying to self-stabilize, their actions are meanwhile defeating the plans of others: collective action problems, such as the Keynesian "paradox of thrift," are of this nature. But nevertheless, even processes like that have some inherent limit: If everyone tries to save more, but instead has their income reduced, than cannot gone on forever: it is a safe assumption that aggregate income will never go to nothing as a result of an attempt by everyone to increase their savings.

[6] How similar this subsequent disruption ought to be to the original one will be a matter of detail internal to particular cycle theories.

[7] How regular is "semi-regular"? Again, we believe that is best answered within particular theories.

adjustments, over some semi-regular time frame, to finally result in something resembling the initial disruption to be brought about by those very adjustments.

This gives us a 2-by-2 matrix of cycle theory classification, from which we intend to explore the type of theories contained in the top left box, or true, endogenous cycles:

	Endogenous generation	**Exogenous generation**
True cycle	Ex: Circulation of the elites	Ex: Ski season / swim season
Pseudo Cycle	Ex: Arab oil embargo	Ex: Random shocks produced by extreme weather events

3 A Simple Social Cycle Example: Merging onto a Highway

We will now proceed by fleshing out our ideal types with some plausible content. We start with a fairly simple example of a social cycle, examining what occurs when drivers are forced to merge onto a busy highway at low speeds. This shall help clarify our scheme and visualize the concepts of adjustment and disruptions. We demonstrate how the concept of disruption and adjustment can give way to behavior that on aggregate produces a cyclical pattern.

Above, we have defined stabilizing adjustments as those that generate further adjustments by others, that are, at each moment of time, of a lesser magnitude than the adjustment being evaluated, and de-stabilizing adjustments as those that prompt subsequent adjustments of greater magnitude. But estimating the magnitude of adjustments necessary in response to some disruption, in order to judge them stabilizing or de-stabilizing, often could prove to be a tricky matter. One of the attractions of the present example is that it reduces this

problem to the relatively easy one of measuring deviations in driving speed from an initially planned speed: In one phase of the cycle, we have de-stabilizing adjustments: those adjustments are increasing the total deviation of driving speed from driver's preferred speed. The adjustments are stabilizing in the phase of the cycle when that total deviation is decreasing, e.g., drivers are returning to the speed they preferred before the initial disruption. And note that in the present example, the phases of the cycle, for drivers as a whole, are spread out geographically, not chronologically: while some drivers nearing an entrance are entering the "downturn" phase of the cycle, others well past the entrance are simultaneously in the "recovery" phase. (But individual drivers see the cycle chronologically.)

So let us picture a busy highway with entrances and exits every mile. The entrances are not well-designed: there is no lane for smoothly merging into traffic while getting up to speed, but a stop sign at the end of the entrance ramp. (This, in fact, is pretty much a description of the Merritt Parkway in Connecticut as of 30 years ago.) What this means is that every time heavy traffic nears an entrance, there occurs a cluster of disruptions, as people enter the existing traffic at a slow speed and force those already on the highway to adjust.

Imagine a car, in this situation, entering into the right lane, the lane in which you are driving, at low speed, a short distance ahead of you. You typically have two adjustments to this disruption that might enable you to avoid a collision (which is likely to be the worst disruption possible!):

1) You can slam on your breaks; or
2) You can shift over to the left lane.

Which of these (if either) is stabilizing and which de-stabilizing will depend upon the traffic pattern around you. Now, imagine there are four cars following closely behind you in the right lane, but the left lane is empty. Then, hitting the breaks is de-stabilizing, since your adjustment will result in a greater magnitude of adjustments in its wake—in response to my

breaking, four other cars must similarly adjust, resulting in four times the magnitude of adjustment. Shifting lanes will be a stabilizing adjustment, since in response to your move, no one else has to do anything—there is zero times your adjustment as a result of your choice.

But if traffic is heavy, say at rush hour, either adjustment is usually de-stabilizing, since the left lane is also packed with cars. In such circumstances, the disruption of a driver merging at a low speed inevitably will produce a cascade of further disruptions, as the adjustments made by drivers breaking for merging automobiles thwarts the plans of other drivers who wish to continue at a steady speed. Thus we get a logjam around the entrance ramp. This is the downturn phase of our cycle.

But, gradually, the adjustments begin to produce dovetailing plans again, as drivers re-establish comfortable spacing between themselves and other vehicles, and regain the speed they had before the disruptions at the entrance ramp. This is the recovery phase of the cycle. But just as our recovery is nearly complete, another wave of disruptions occurs — we have reached the next entrance ramp.

Here we have a simple social cycle with a period of roughly one minute (if the non-disrupted driving speed is about 60 miles per hour), exhibiting the characteristics of our ideal type very clearly. What's more, this is very much like what driving on the Merritt Parkway really was like thirty years ago, demonstrating that even such a simple model can capture an important aspect of a real-world phenomenon.

What we have just described is a genuine cycle: there is a good reason for us to expect the pattern to repeat at quite regular intervals. But its source is exogenous: the disruptions arise from outside the flow of traffic on the highway itself. The placement and design of the entrances is the cause of the disruptions.[8] In this respect, it is similar to a sunspot theory of the

[8] See Kerner (2009) for an analysis of traffic that includes endogenous generation of such jams.

business cycle. (Although the entrances were placed where they were by human beings, those humans were external to the traffic flow, and so exogenous to the cyclical activity.) Let us turn our attention to genuine cycles that are also endogenous.

4 Identifying a Family of True and Endogenous Social Cycle Theories

After having outlined a very basic examples of a genuine social cycle, we move on to analyze more complex theories of social cycles. If we detect a similar basic pattern in a significant family of these more complex theories, this will be a finding of some importance, especially for enabling re-use of large elements of a model of one of these theories in modeling another one. Space will not permit us to present any of these theories in detail. Instead, we shall present the theories in a nutshell to seek the mechanism producing the cyclical pattern for some core theories of the social sciences.

a. Adam Smith's Theory of Fads in Fashion

We don't follow fashion
That would be a joke
You know we're going to set them, set them
So everyone can take note, take note—Adam Ant and Marco Pirroni, "Goody Two Shoes"

We will begin to analyze fads in social customs, such as fashions, using the ideal types posited above. We will analyze one famous example from the literature.[9] Adam Smith commented on fashion as follows:

> Fashion is different from custom, or rather is a particular species of it. That is not the fashion which every body wears, but which those wear who are of a high rank, or character. The graceful, the easy, and commanding manners of the great, joined to the usual richness and magnificence of their dress, give a grace to the very form which they happen to bestow upon it. As long as they continue to use this form, it is connected in our imaginations with the idea of something that is genteel and magnificent, and though in itself it should be indifferent, it seems, on account of this relation, to have something about it that is genteel and magnificent too. As soon as they drop it, it loses all the grace, which it had appeared to possess before, and being now used only by the inferior ranks of people, seems to have something of their meanness and awkwardness. (Smith, 1790, Part V, Chapter 1)

Following Smith, let us posit a population consisting of two types of people: there is T, is a small group of people who are trend-setters. They want to be on the leading edge and want to have (wear, exhibit, etc.) what only some others have and to be recognized for this by their

[9] We think it is important to clarify our intent here: there exists an extensive social science literature on fads and fashion, which we will largely ignore. That is because our aim, in this section, is not to present a superior theory of fads to existing alternatives, but to show how our ideal types can be employed to construct a plausible theory of fads, with the aim of elucidating the types themselves. Therefore, it is of little importance to us that there may be some theory of fads that captures empirical reality better than Smith's theory: if such a theory exists, it would not lessen the value of our example for our purposes at all.

peers. F is a large group of people who are followers. They want to have what everybody else has (wears, etc.).

In a fad, first the population of T mutually coordinates around some fashion or other cultural element, φ. What they wish is to identify themselves as members of T by adopting φ while other members of T *but only other members of T* do so.

As φ becomes widespread amongst T, the members of F begin to notice it doing so. The plans of the members of F have been disrupted. What they want is to have what everybody else has, to wear what everyone else wears, and especially if those others are the trend-setters. The more members of F learn about the new fad, the more members of F realize they are behind the times. Therefore, they adopt φ in an effort to *adjust* to the *disruption* the adoption of φ by the members of T created in their plans. The initial coordinative adjustments of the members of T around the new fashion turns out to be destabilizing as it results in a series of adjustments that are greater than the initial adjustment for the members of F.

But what is a desirable situation to members of F is very displeasing to members of T: if the "rubes" have adopted φ, then it is no longer hip. The adoption by the members of F itself is a *disruption* of the plans for the members of T. As φ diffuses through F, members of T find themselves no longer on the cutting edge, so they *adjust* plans again by seeking for some new "cutting edge" fashion to adopt. When they do so, we are back at the start of the cycle above. But since the adjustment of members of F results in a series of smaller adjustments than did those of the small group of T, the adoption of the fad can be characterized as *stabilizing adjustments*.

Once again, we can look to population biology to formalize our intuitions here in a simple way: in this case, the Lotka-Volterra equations relating predator and prey populations. In this case, the trend-setters are the “prey,” and the followers the “predators.” (Of course, we

imply no normative judgment here of whether trend-setters or followers are better people!) So, we have:

$$dx / dt = x(\alpha - \beta y)$$

$$dy / dt = -y(\gamma - \delta x)$$

where x are the trend-setters adopting a fad, and y are the rest of the population that follows the trend-setters. This system of equations can produce wave-like cycles with the followers' cycle lagging that of the trend-setters, as we would wish it to.

This analysis is, of course, highly simplified: We really have an entire spectrum of people from extreme trend-setters who are happy to, say, wear something no one else at all wears, to followers so sluggardly that they are barely now adopting fashions from a decade ago. But the two-population model captures the essence of the phenomenon: the widespread adoption of the fashion generates the actions that will lead to its abandonment. The cyclical movement is endogenous to the phenomenon itself.

This stands in sharp contrast to an exogenous fashion cycle: the change in clothing worn, in temperate climates, from winter to summer. This, also, is a true cycle, but the driver of the cycle is something quite outside of the realm of fashion, namely, the relative movements of the earth and the sun.

b. The Aristotelian-Polybian Cycle of Constitutional Forms

First, the Greek philosopher Aristotle, and later the Greek historian Polybius, based on Aristotle's ideas, formulated a theory of anacyclosis, or the cycling of political constitutions. While Aristotle (1992) presents a very complex and subtle analysis of constitutional changes, Polybius's is a simplified version, so we will focus on the latter.

Polybius describes the basic cycle of political forms as follows:

> Now the first of these [political forms] to come into being is monarchy, it's growth being natural and unaided; and next arises kingship derived from monarchy by the aid of art and by the correction of defects. Monarchy first changes into its vicious allied form, tyranny; and next, the abolishment of both gives birth to aristocracy. Aristocracy by its very nature degenerates into oligarchy; and when the commons inflamed by anger take vengeance on this government for its unjust rule, democracy comes into being; and in due course the licence and lawlessness of this form of government produces mob-rule to complete the series. The truth of what I have just said will be quite clear to anyone who pays due attention to such beginnings, origins, and changes as are in each case natural. For he alone who has seen how each form naturally arises and develops, will be able to see when, how, and where the growth, perfection, change, and end of each are likely to occur again. And it is to the Roman constitution above all that this method, I think, may be successfully applied, since from the outset its formation and growth have been due to natural causes. (1924, Book VI)

The causal process can be boiled down as follows:

> Sketched in rather broad strokes, the mechanism goes roughly as follows: the simple good regime degenerates into its vicious form, because the new generations, the king's children, for example, take their advantages for granted and give into their appetites, and thus they provoke the revolt that brings about the new simple regime that will in its turn undergo the same alteration and the same fate. (Manent, 2013, p. 180)

Here, we again have two populations, the rulers (who may be only the king, or the aristocracy, or the majority of the people) and the ruled (who may be everyone but the king, everyone but the aristocracy, or those in the minority in a democracy), with the actions of one population disrupting the plans of another, and causing that second population to make adjustments and leading to a constitutional change.

At the start, the political regime is well-accepted by the ruled. The rulers are glad to be in power. The ruled, on the other hand, accept the rulers and political regime as long as the rulers maintain a decently functioning social order providing civil peace.

After some time, being in power produces the urge in the rulers to expand their influence, and little-by-little they treat the ruled worse. The rulers begin to place their self-interest above their interest in the good of the polis. For a while this abuse may go unnoticed. At some point the majority of the ruled feel unhappy with the rulers. In order to keep stability the rulers may need to repress the ruled even more. This will amplify the tensions between the two groups. The ruled begin to want a new constitution.

The cycle theory is again one of disruption and adjustment. The initial disruption is the rise in the rulers' self-interestedness. The more the rulers use their position for their own gain, the more people will find the situation displeasing and become hostile toward the ruler. Thus, we have a stream of adjustments that cause greater adjustments over the time period in question. At a point the rulers will be pushed out and a new constitution is installed.

The cycle finally comes around to the beginning again when democracy turns into mob rule, as described by Aristotle:

> From inspection of the other cases also you can see the changes take place pretty well after the same manner: in order to win the favour of the multitude they [demagogues] treat the notables unjustly and cause them to unite. Sometimes they make them split up their possessions or income in order to finance their public duties; sometimes they bring slanderous accusations against the rich with a view to confiscating their money. (1992, p. 311)

This sets the stage for a return to monarchy.

c. Vico's Cycle of Civilizational Forms

Giambattista Vico was an 18th-century Neapolitan thinker. For some time his work languished in obscurity, but interest in it was revived by thinkers such as Marx, Nietzsche and Joyce. One of his most famous contributions is his cyclical view of history. On examining Vico's cycle of civilizational forms we find that it also displays the pattern of two populations disrupting each other and adjusting to the disruptions in order to produce the cycle. For instance, cities themselves arise from the interaction of two distinct populations:

> *The origin of cities*, which developed from extended families which included both children and servants. We find that cities were naturally founded on two communities, the nobles who commanded and the plebeians who obeyed: for these two parts make up the entire polity or law of civil governments. I shall show that the first cities could not have arisen at all merely on the basis of simple nuclear families. (1999, pp. 16-17)

As civilizational forms progress from the Age of the Gods through the Age of Heroes to the Age of Men, governmental forms progress from theocracy through aristocracy to democracy. The two-population model drives the changes. For instance, Vico describes the impetus driving the change from aristocracy to democracy as follows:

> The plebeians of the heroic age now grew numerous and warlike besides, which frightened the [aristocracy], who must have been very few in a commonwealth comprising so few citizens. By the force of their numbers, the plebeians began to enact laws without senate authority, so that the commonwealths changed from aristocratic to democratic. (1999, p. 441)

The conditions for the repetition of the cycle come about through the degeneration of the democratic form of government as the majority become "like beasts," and the subsequent

regeneration of civil life by a second, remnant population that returns to the simplicity of the start of the cycle:

> Like beasts, such people [in late democracy] are accustomed to think of nothing but their own personal advantage, and in their extreme fastidiousness, or rather pride, they are filled with bestial rage and resentment at the least provocation. Although their bodies are densely crowded together, they live like monstrous beasts in the utter solitude of their private wills and desires… [causing] their obstinate factional strife and desperate civil wars to turn their cities into forests and their forests into human lairs… Eventually, the few survivors, finding themselves amid an abundance of life's necessities, naturally become sociable. Returning to the pay but it's simplicity of the early world of peoples, they naturally become religious, truthful, and faithful. (1999, pp. 488-489)

Thus we find ourselves back in the Age of the Gods.

d. Pareto's Circulation of the Elites

Vilfredo Pareto is best know to economists for his work on social welfare (Pareto improvements, etc.), but he also wrote extensively on political sociology. Of particular interest to us is his theory of the circulation of the elites in society. Here again, we find a two-population model, where the adjustments of one population to the disruptions caused by the other population drive the cycle. In Pareto's case, the two populations are a currently ruling but decrepit elite, and a new rising elite class, poised to take over.

The decline of the old elite, for Pareto, follows a quasi-biological law that dictates that social groups decline with age just as organisms do. Of the predicament of the current but declining elite Pareto says:

> 1. The declining elite becomes softer, milder, more humane and less apt to defend its own power.

> 2. On the other hand, it does not lose its rapacity and greed for the goods of others, but rather tends as much as possible to increase its unlawful appropriations and to indulge in major usurpations of the national patrimony.
>
> Thus, on the one hand it makes the yoke heavier, and on the other it has less strength to maintain it. (2000, p. 59)

It is these increasing disruptions that drive the new elite to fight (whether through violence or political means) and eventually displace the old. As an elite declines, its best tend to join the rising new elite instead of sinking with the old: "When… a gentleman is faced with the dilemma of either proving the malpractices of his class such as embezzlements of banks… or of his joining the socialists, he is irresistibly driven towards the latter" (2000, p. 73).

Naturally, however, the youthful vigor of the new elite will not last:

> For the time being, the new elite is flexible and open to all, but after the victory the same that happened to others will happen to it also: after victory, the elite becomes more rigid and more exclusive. (2000, p. 86)

It is clear that this sets up the same conditions that led to the rise of the new elite in the first place. And thus Pareto's two-population model returns to a point where the cycle will repeat.

e. Investment Behavior and Financial Market Cycles

> *"It is well known at the Stock Exchange the public at large buys only in a rising market and sells in a declining one. The financiers who, because of their greater practice in this business, use their reason to a greater extent, although they too sometimes allow themselves to be swayed by sentiment, do the opposite, and this is the main source of their gains."—Vilfredo Pareto (2000, p. 94)*

Our two-population model can also be found in theories of boom-and-bust cycles in asset markets.[10] Let us posit that there are two types of investors who work in "exchange alley:" V is the small group of value investors, who rely on a Graham-and-Dodd-style (2008) analysis of fundamental values. T is the trend followers, who rely on chart techniques and trends or simply popularity to decide on asset purchases (see Greenwald et al 2001). V and T behave similarly to the trend-setters and followers in the fashion example.

First, our value investors V identify an asset with fundamentals that suggest a higher value than is reflected by the market price. If prices have been stable for a long time, then based on chart-technique, the assets have not been very desirable to T and there are no gains to expect from a technical rally. As enough members of T have divergent expectations from the value investors V, when some value investors show demand for the assets, T sells to V.

For both groups the situation seems to be improving: the members of V believe they are purchasing more valuable assets while the members of T believe they are selling assets that are no longer desirable. As the members of V bid away shares for a price that is above the old market price from the members of T the price of the assets increase.

The adjustment causes a series of further adjustments in the following periods when T sees that the market price of the assets rising. As they either simply follow a trend, or use trend-following chart-techniques to analyze the profitability of the assets, the data now suggests that prices are likely to rise further and the asset has become more desirable. The new outlook is a disruption for T. In response, more and more members of T repurchase the asset at a price higher than the members of V thinks it should be, assets are handed over from V to T, and prices rise even higher.

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[10] Gracia (2004) reaches a similar conclusion.

Once again, everybody seems happy. V sold at a higher price and T has a seemingly desirable asset. The outcome is pleasing from the point of view of V and T. The members of V, however, now have already sold all of the assets they have to sell, the members of T have now bought, and there no longer is anyone to drive the price up further.

Assuming that the group of T holds all these assets and the initial valuation of the group of V is unchanged, no one in the group of V is willing to buy assets at this higher price anymore. Members of the group of T might keep on trading stocks at ever-increasing prices within the group. But already the group of T holds assets that are less valuable (according to the value investors) than they believe. Once prices stop rising, the trend-followers' views about the desirability of the assets worsen, so that they want to sell. But now neither T nor F wants to buy at the current price, forcing the price down. The cycle starts over again once prices fall below the fundamental value calculated by the value investors V, returning us to our initial situation.

f. Minsky's Financial Instability Hypothesis

Multiple triggers have been posited that may drive business cycles, such a rise or shortfall in demand, a supply shock, a monetary policy shock, or technological advances in a specific sector. Kindleberger (2000, pp.38-41) argues—more generally—that to produce substantial boom periods that eventually turn bust, an event or change has to be important enough to substantially change the "horizons" and "expectations" of market participants, i.e., to present a major *disruption* requiring *adjustments* that are at first, anyway, de-stabilizing. From an historical perspective he finds wars, revolutions, monetary policy changes, bank deregulations, but also financial innovations such as derivatives to be capable of radically changing expectations in the market and producing cycles. To explain the stages of the cycle and financial crises he draws on Hyman Minsky's theory of financial instability.

In Minsky's model the financing structure of an economy cycles due to the tension between two populations. Minsky initially assumes a state of stability of the financial structure. Following a crisis, there is a high degree of risk aversion. On the one hand, households are hesitant to borrow from banks. On the other hand, banks are scared of the risks entailed in lending and will ask for good collateral. Therefore, at first, there is only some hedge financing and risks in the economy are limited due to large safety margins. But during the period of recovery of an economy debts can be repaid. It seems that going into debt pays off and safety margins may be too high (Minsky 1982, p. 65). The amounts of hedge financing increase as households can validate debt.

When views on the right amount of leverage and safety margins start to change, the financial structure is disrupted. The shift in beliefs is *destabilizing* as more and more risks are accumulated over time that increase the likelihood of a necessary later *adjustment*. The economy starts to gradually move "from hedge to speculative and Ponzi finance" (Minsky 2008, p. 233). Like in a two-population predator-prey model, the increase in hedge financing has put the ground for its decline and the rise of speculative financing.

During the upswing of the cycle an increasing number of people turn optimistic. Debt financings increases asset prices and investment. The economy moves into a speculative boom. The stream of adjustments during which the financial structure becomes more and more leveraged and dependent on changes in financial markets ends when, e.g., interest rates in financial markets rise so that serving the debt becomes harder. In such a way, speculative finance can turn into Ponzi finance that depends on rolling over the debt. But if interest rates prevent rolling-over debt, businesses will have to reduce borrowing and investment. Asset prices fall. Given that the financial structure has moved to a point at which much of financing is speculative, banks may be unwilling to extend loans altogether (Minsky 1982, pp. 66-67).

At this point, households and firms start to pay down debt and try to build liquidity. Banks deal with losses, shorten balance sheets and contract credit. A destabilizing deflationary spiral continuous unless monetary and/or fiscal policy stimulates aggregate demand enough to stop the balance sheet recession (Minsky 1992). When investment and stock markets pick up again, households, banks and businesses gain through rising equity prices. Optimism spreads again and the debt cycle begins anew.

In Minsky's model, "profit opportunities within a robust financial structure make the shift from robustness to fragility an endogenous phenomenon" (Minsky 2008, p. 234). Therefore, Minsky's theory is both endogenous, at least once the central bank is included in the model to revive the economy, and a true cycle, since there is a good reason to think it will often do so.

g. Schumpeter's Creative Destruction and Economic Development

Joseph Schumpeter's famed theory of economic development (1934, 1942) combines psychological, sociological, technological and economic elements to explain the medium to long run development in a capitalist society. The dynamic entrepreneur is at the center of the theory and the engine of progress.

According to Schumpeter:

> The opening up of new markets, foreign or domestic, and the organizational development from the craft shop to such concerns as U.S. Steel illustrate the same process of industrial mutation?—if I may use that biological term—that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism. (1942 [2008], p. 83)

In Schumpeter's theory dynamic entrepreneurs are alert to profit opportunities and willing to take the risks needed to implement technological innovations. If they are successful, economic development is fostered.

The theory describes a cycle that once again is based the disruptions and adjustments of two distinct populations. Before Schumpeter's dynamic entrepreneur introduces a technological innovation the economy proceeds smoothly. The entrepreneur's innovation disrupts plans of other economic actors in the economy and induces multiple adjusting changes in the economy. First, both consumers and competitors face uncertainty about how the new situation affects their plans. Therefore, the following adjustment process may take time and comprise multiple feedback loops.

If the innovation earns the entrepreneur a pure profit, others will sell less than they planned, a monopoly may lose its monopoly rents, or the innovation will make some industries obsolete. Once other, less innovative entrepreneurs understand the reason for the innovator's profits they will adopt the innovation to arbitrage away the profit opportunities via imitation. They, too, want to make the gains. While imitation helps spread the innovation throughout the economy it also drives down the profits of the dynamic entrepreneur as the technological advance is absorbed throughout the economy. So, again, we have a two-population model, with the innovators creating changes that their followers respond to, creating a new equilibrium.

h. R.M. Goodwin's Growth Cycle

We finally turn to a case of a business cycle theory that has very explicitly made use of the predator-prey model and the Lotka-Volterra equations. In the initial statement of this model, after a page of mathematically positing relationships between output, capital, wage rates, productivity and employment, Goodwin writes:

> In this form we recognize the Volterra case of prey and predator… to some extent the similarity is purely formal, but not entirely so. It has long seem to me that Volterra's problem of the symbiosis of two populations—partly complementary, partly hostile—is helpful in understanding what the dynamical contradictions of capitalism, especially when stating any more or less Marxian form. (1967, p. 55)

One would guess from Goodwin's statement above and his Marxist background that the two populations would be the capitalists and the workers, with the capitalists obviously taking the role of predators. But one would be wrong: in Goodwin's actual model, the populations are not really populations at all: the "prey" turns out to be the employment rate, while the "predator" is the worker's share of output. But Goodwin still sees a relationship between the formal model to the actual populations of workers and capitalists:

> [A] low growth rate leads to a fall in output and employment to well below full employment, thus restoring profitability to its average value because productivity is now rising faster than wage rates. This is, I believe, essentially what Marx meant by the contradiction of capitalism and its transitory resolution in booms and slumps. It is, however, un-Marxian in asserting that profitability is restored not (necessarily) by a fall in real wages but rather by their failing to rise with productivity. Real wages must fall in relation to productivity; they may fall absolutely as well, depending on the severity of the cycle. The improved profitability carries the seed of its own distraction by engendering a too vigorous expansion of output and employment, thus destroying the reserve army of labour and strengthening labour's bargaining power. This inherent conflict and complementarity of workers and capitalists is typical of symbiosis. (1967, p. 58)

Since Goodwin's original paper, he and others have done further work within this framework. For instance, Mehrling (1986) added game-theoretic foundations to the original model, while Desai et al. (2004) fix some problems in the mathematics that had allowed wages to be over

100% of output and employment to rise over 100%, and Sportelli (1995) seeks to eliminate the instability in Goodwin's original model.

In any case, this paper can be seen as a generalization of this insight of Goodwin's: not only the Marxist business cycle theory, but many other cycle theories can be modeled starting with the predator-prey foundation.

5 Putting This Family Resemblance to Work in Modeling

We are currently working on testing out the power of noting this family resemblance in Indra, an agent-based modeling system we are constructing.[11] On top of a basic framework for creating agents we have constructed a basic predator-prey framework. Using that as a further platform for development, we have duplicated the main idea of Adam Smith's fashion model. And now we are proceeding to try to capture the dynamics of the value-investor/trend-follower model for financial markets.

So far, the results born out our intuition that keeping the family resemblance of these models in mind is a great aid in implementing them on a computer. Where is our predator-prey model took almost 350 lines of code to implement, by using object-oriented programming techniques and inheriting the second model from the first, we were able to add the fashion cycle model with only another 200 lines of code. As we proceed to implement further models from this family, we expect to see an even greater degree of code re-use in the future. The ability to be re-use large amounts of code is a key goal in software engineering,

[11] The source code for the Indra system, including the models we mention here, is available at: https://github.com/gcallah/Indra

not only, or even mainly, because of the initial time savings in development that it provides, but more so for its savings over the lifecycle of a project, as the common code can be enhanced in a single place, and benefit all of the models using that common core.

And implementing these models in an agent-based framework is of value for social theorists, we contend, as a computer-based implementation allows for a tremendous increase in the theorist's ability to explore the "world in the model." As Mary Morgan puts it, "Economists (just like their astronomer forebears) understand that a model stands in for their economic universe to enable them to explore certain properties of that world represented in the model" (2012, p. 33). In doing just such exploration, we have often been struck by just how sensitive these models are to slight variations in the parameters used to set up the model and start it running. Recognizing family resemblances amongst models enables researchers to set up, and begin exploring, new variations with much greater ease.

6 Conclusion

We have described a broad range of cycle theories using the concepts of disruption and adjustments. Many important theories are true endogenous social cycle theories in which adjustment processes themselves give rise to new disruptions or the theory provides a reason why the cycle should recur. Further, analyzing the theories we have found that many social cycle theories seem to fit with a two-population disruption and adjustment model similar to the well-known predator-prey model. Finally, we have demonstrated that the recognition of this family resemblance among these theories enables us to create a general modeling framework for creating agent-based models of these social cycle theories.

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