**Cliodynamics: Its strengths and weaknesses**

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**Abstract**: Cliodynamics is a new term for the quantitative study of historical dynamics. It was coined in 2003 by Peter Turchin, and this article examines Turchin’s own work in this discipline to ask how useful this study is, and how strong are its practices. The main conclusion drawn is that, while the study of cliodynamics has generated some interesting new theories, it is not different enough from previously existing practices to require its own name.

In the past seven years, a “new” sub-discipline of history has arisen. Called “Cliodynamics”, from Clio the Greek muse of history; this practice attempts to apply data mining and mathematical modeling techniques to investigate historical dynamics. Popular variables to consider include: time, population, geography, stability v. instability, and the formation of societies. Although there are many quantitative historians, there are few who consider themselves to belong to this new discipline. This is due in part to the fall in popularity of “big scheme” history, and also to the fact that there already exist such disciplines as clio*metrics*, which tends to focus on quantitative economic history.

However, just because a discipline is new, this does not mean that it is worthwhile. Before accepting new ideas and theories it is important to look at them with a critical eye, and examine their merits. This paper attempts to do so by asking if cliodynamics is a useful attempt to apply data mining techniques to history. To explore this inquiry, we will consider: How useful is this practice? What can we learn from it? How strong are the data mining techniques? And finally: How strong are the historical techniques? These questions will be examined by looking at the discipline in general, while focusing on the works of Peter Turchin, the historian who coined the term “cliodynamics” in 2003.

It is easy to understand the potential importance of this practice. Modern demographers already look at the same types of variables as cliodynamicians, however the sources used by demographers are limited. They tend to access the types of census and tax records that are only available in modern, industrialized nation-states. At best, these records go back 200 years for the nations that industrialized earlier. However, when the source of data is limited in this way, it is never possible to know whether the patterns you find are universal, or if they are only inherent in the modern, industrialized nation-state system from which you are pulling your information. Also, due to the limited time frame, long-term patterns may not be readily apparent. For example, a sine wave with a very long period may appear to be exponential growth when only a small portion of the cycle is available for study.

Cliodynamics can also prove useful in the lessons it gives indirectly. Like all fields, quantitative historians have their fair share of problems and issues. As with much of historical practice, two major issues are how to get data that was never recorded, and how to deal with the “dirtiness” of the resulting data. The way these problems are met can provide valuable insights and inspiration to data mining in general, specifically in the pre-processing of information.

The first problem; that of obtaining data which was never explicitly recorded, is something that social scientists have become very adept at through the years. By applying these techniques to data mining, they reveal the possibilities available for acquiring secondary data, setting an example for other data mining practitioners. Two examples of these techniques, as utilized by Turchin, can be found in the usage of coin hoards and Novgorod street paving. The coin hoard method was actually first developed and tested by Michael Crawford. He realized that the general populace was more likely to bury their wealth during times of instability. Furthermore, the more violent or instable the time period, the more likely the owner would die before they had a chance to dig up their hoard. Coins are extremely easy to date. Therefore we can conclude that the more coin hoards that are discovered from a particular era, the more instable that era was. Turchin takes his data for the variable “instability” from coin hoard measurements.

The second method of obtaining data from secondary sources is the use of Novgorod street paving to discover population information. During the medieval era, the city of Novgorod repaved their streets about every 20 years, by laying a new layer of wood down directly over the pre-existing layer. This had to be done so often because mud and muck would build up on the streets completely covering the original paving. Using dendrochronology by looking at the pattern of the tree rings, a piece of wood can be dated to the exact year the tree was cut down. Therefore, we know the exact year the streets were re-paved. Furthermore, we can look at how much muck was between each wooden layer. If there is a thicker layer of muck, a higher population can be assumed, and vice versa. Turchin therefore uses the amount of muck in a layer to track the variable of relative population.

Obviously, when you obtain data from these types of sources, it can be rather dirty. Quantitative historians therefore have to find ways to manage this issue. David Herlihy’s work dealing with the Florentine catasto (tax census) of 1427, reveals two ways to look at this problem, specifically when dealing with an issue called “age rounding.” This process occurs when people do not know their exact age and therefore have to guess. Generally people tend to round their ages to either culturally significant numbers (i.e. 18 or 21 for Americans) , or to numbers that end in a 0 or 5. The younger a person is, the less pronounced the age rounding. For example, it would be unlikely to guess a 3 year old’s age as 5. Contrarily the older a person is, the more pronounced the rounding: People might go straight from guessing their age as about 80 to about 90, without ever rounding their age to 85.

Herlihy deals with the problem of age rounding in two ways. The first is to look at pre-processing from a new perspective. In the usual method of binning, the bins start from 0, and are all of equal amount of years (ex. 0-4, 5-9, 10-14). However when mixed with age rounding, this leads to extremely dirty results. For example, a 29 year old would likely guess their age to be 30, thus removing them from the 25-29 year old bin and placing them into the next one. To solve this issue, Herlihy decides to make the first bin smaller than the others. Knowing that people are unlikely to have to round the age of an extremely young child, Herlihy sets his bins as: 0-2, 3-7, 8-12, 13-17, 18-22, etc. Although the data dealing with toddlers is now harder use, for the general population, this helps clean the data, because it ameliorates the effect of age rounding. With this method, people are much less likely to round their age to a number outside of their bin.

Another way Herlihy handles this issue, is to not consider it a problem at all. Instead of looking at the data as dirty, he examines the dirt itself to see if there is useful information to be found in it. For example, he noticed that daughters’ ages tended to be rounded to a number that was considered an ideal age for a first marriage, and that wealthy families were more likely to have exact ages for their members. These are both useful pieces of information, which are only discovered when a researcher opens their eyes to the information hidden in the dirt.

Therefore, a general overview of cliodynamics reveals that it can be a useful endeavor: It helps advance the theories of modern demographers by examining if they are part of a larger trend, and it displays resourcefulness in the collection and pre-processing of data that can be emulated by data miners of other disciplines. However, we still must consider how strong the data mining and historical techniques involved are. To do this, we will examine a set of writings by Peter Turchin, coiner of the term “cliodynamics”, and also contrast these papers with a much older book written by David Herlihy.

Turchin is an easy to read and prolific writer, and though his works are generally well-researched, he is overly self-referential. His work in general is interesting because he has adopted the practice of using training sets and test sets. This is very rare in historical practice, because of the general trend towards specificity. The main downside of his works in general is that he always enters the data mining process knowing exactly what he is looking for. Although this is useful in the search for that specific information, he never opens up any new possibilities by introducing other variables, or experimenting with other data mining methods.

The first article we will examine is “Toward Cliodynamics”, by Peter Turchin. This basic argument for the discipline begins by giving a brief historiography of the practice of history. Among other trends, Turchin mentions that since the second half of the 20th century, the general opinion among historians has swung against the possibility of practicing history as if it were a “science”. The belief is that history is fundamentally different from the natural sciences in that humans have free will, and historical processes are too complex to predict. Turchin disagrees with this: He argues that analytical history was dismissed too early, back when computer systems were weak and unwieldy. He asserts that more meaningful work can be done today, due to the availability of strong computational power to handle complex systems, advances in nonlinear dynamics, complexity science and chaos theory, and a qualitative increase in amount of data available for testing theories. However he does note that due to the limitations of historical data and the complexity of the dynamical pattern, we need to employ an appropriately coarse-grained procedure. As we shall see, this procedure generally ends up being model fitting.

This article had a well-constructed argument that was highly researched, listing a total of 41 references. Of course, keeping with his tendencies toward self-reference, nine of those references are for Turchin’s own work. Although Turchin does a good job arguing for the use of cliodynamics, he fails to explicitly give any examples as to *how* this study should work. This is especially noticeable, since he does in fact mention some of the theories he has developed, but again, without ever mentioning his methodology. Furthermore, although he mentions advances in fields such as complexity science and chaos theory as helpful to the study of cliometrics, in his own work he never uses any such advances. Therefore, this argument is a moot point. Structurally, one negative aspect of this article is that all the visualizations were placed in the very end, without any reference to them. By the time a reader notices them, it is too late for them to be of any use.

The article “Long Term Population Cycles in Human Societies” presents a theory of “secular cycles” which is probably the most substantial contribution of cliodynamics to the understanding of historical forces. The disconnect that this article notices is that demographers began entertaining density-dependent models much later than population ecologists working with non-human animals. When they finally began considering the issue, they still tended to focus on first-order feedbacks, which are short-term in nature. Turchin therefore decided to use mathematical modeling to examine second-order feedbacks. These are more long-term patterns, with the most common example being the Lotka-Volterra predator-prey cycles.

Mathematical modeling describes a system by a set of variables and equations that establish relationships between the variables. Turchin’s models are dynamic (meaning that they consider the variable “time’) and involve differential equations, which reveal change over time. Turchin first establishes equations to define variables, and then uses a curve fitting process to manipulate the mathematical model into an accurate representation.

From this work, Turchin concludes that there are long-term population oscillations around a gradually rising level. Socio-political instability oscillates with the same period but shifted in phase, leading to a pattern in which there exists strong state stability during population growth. On the other hand, instability peaks at the mid-point of a population decline.

Out of all of Turchin’s theories, this one seems to have the strongest data mining practices. Like many quantitative historians, Turchin did an excellent job of taking the information he had access to, and turning it into the information he wanted to measure. For example, he used per capita taxation rate, population, and proportion of surplus collected as taxes as inputs to measure a variable he called “State Resources.” It was also very well-researched. However the model doesn’t seem to be overly strong, and we cannot know for sure HOW strong it is, since Turchin performed no model evaluation techniques, to discover the accuracy or statistical significance of his results. This article seemed to be the most difficult one to read, but this is probably due to the complexity of the math, and not the writing skills of the author, since Turchin normally writes in a very understandable manner.

In the next article we will examine, “Coin Hoards speak of population declines in Ancient Rome” co-authored by Walter Scheidel. Turchin takes his theory of secular cycles and applies it to the puzzle of Roman population in the first century BCE. At this time, there was a huge jump in population census records. Historians agree that this is partially due to granting citizenship to peninsular Italian allies. Counting people from a larger area, obviously leads to a higher final count. But this addition only covers a fraction of the jump. Roman historians have debated whether the rest of the population jump is due to large population growth (“high count hypothesis”) or due to some change in census methods, perhaps to allow for counting women and children (“low count hypothesis”).

As discussed earlier, Turchin believes that coin hoards are related to instability which is related (via secular cycles) to population. Therefore, since there is coin hoard data available for the time period in dispute, the modeling provided by the secular cycles can help provide evidence as to which hypothesis is correct. To accomplish this Turchin uses 250-100 BCE as a training set, then projected model up to 50 CE. From this projection, Turchin is able to conclude that the low-count hypothesis is correct.

It appeared that the projected model closely matched with the low-count hypothesis, providing a piece of strong evidence in an ongoing debate. However, there were no model evaluation techniques to see if it truly was statistically relevant. It also falls short in attempting any other theories or modeling methods. The biggest critique is that Turchin only looks at the variables he already believes to be significant. There is no exploration for other explanations besides his pre-established theory. This is especially noticeable because this theory requires quite a large jump in reasoning: It relates coin hoard frequency to instability, which is then related to population via secular cycles. When such a massive leap in logic is required, it is important to make sure there are no simpler methods or explanations. Structurally, this paper utilized a helpful technique in which it pulled out all of its methodology discussions and placed them at the very end. This is useful, in that the reader does not have to switch back and forth between thinking about historical theory, and data mining practice.

The next article is entitled “A Theory for the Formation of Large Empires”. Here Turchin notices that while many historians explore the reasons for the fall of empires, fewer look at why they arise in the first place. This is curious, because the formation of these massive empires seem to be extremely unlikely in the first place. There have been about 60 agrarian states that consisted of over one million square miles. Examples include certain dynasties in Egypt and Persia. Turchin decides to use China as a training set, since China has an extremely long-lived history with a relatively large number of dynasties that ruled massive agrarian states.

Looking at each instance individually Turchin comes to the conclusion that agrarian states arose next to a steppe frontier which was occupied by pastoral nomads. Because of their environment, the nomads did not have the resources to support themselves, and thus had to raid agrarian settlements. The agriculturalists would then have to scale up their own settlements to protect themselves from the nomadic raiders. Turchin proposes a handful of processes, such as immigration or alliances, which would result in larger settlements. The nomads would then have to increase their own raiding power to be effective against the larger agrarian settlements. Thus we can see that the interaction between nomads and agriculturists leads to a “scaling up” of power for both, resulting in a dynamic feedback in both directions. To test this theory Turchin uses the remaining agrarian states as a test set, and examines each individually. He hypothesizes that he should expect rough synchrony between two cultures, in which they grow at roughly the same rate and time.

This is a very interesting theory, and the article really holds the attention. In fact, Turchin mentions this theory when talking about the interesting developments that come from cliodynamics. However, in practice, his methodology was not based on modeling or data mining at all. Instead he looked at each example individually, and looked for patterns using his own knowledge. This is no different from what historians have been doing for ages, and although his results are unique, I would not consider his methodology to be anything new that required a new “fancy word”. The only way it fits with the other cliodynamics studies is that it uses a training set and a test set. In fact, it doesn’t even really fit the definition of cliodynamics that Turchin himself proposes. On its own merits, this is a brilliantly written article. However, to call this theory a product of cliodynamics is just plain deceptive.

To find out if Turchin is really doing anything new, we can look at previous historians and their efforts, to see if there is any significant difference. One of the first efforts to digitize a massive historical database was undertaken by David Herlihy and Christiane Klapish-Zuber, author of *Tuscans and their Families*. This book examines the patterns found in the Florentine catasto (tax census) of 1427. This was a massive census effort undertaken for taxation purposes. The Florentines recorded the names, families, ages, income, holdings, location and marital status of every individual under their domain. These records were painstakingly entered into a database (using punchcards!), and after studying the results, the work was published in 1979. Herlihy obviously did not have the computer power that Turchin argues makes such a big difference in modern quantitative history.

Despite using older technology and methods, Herlihy still manages to find vast quantities of useful information. For example, the previous discussion on age rounding comes from Herlihy’s work. He was especially gifted at finding useful patterns in the “dirt”. Although both Turchin and Herlihy succeed in finding useful historical patterns via quantitative history, there are, of course, some major differences. Herlihy is less interested in “big picture” theories and focuses only on the data in the catasto, and how it relates to its specific circumstances of time and location. He does not use the catasto as a training set, and then apply his theories to test sets of other tax censuses, as Turchin would have done. Also, Herlihy uses a completely different methodology. While Turchin relies on mathematical modeling, Herlihy prefers statistical analysis, which he also interprets into visualizations.

As a final point, I would like to bring up War & Peace & War: The Life Cycles of Imperial Nations, (Part III- Cliodynamics), also by Peter Turchin. This is a general discussion on cliodynamics. Turchin defines the core of the practice thusly: “The basic premise of the discipline is that history is shaped by great impersonal forces – not by actions of single individuals, but by actions of whole collectives of them.”

Whether this is true or not, Turchin asserts that a good theory is not necessarily absolutely correct…A good theory is *productive*. Cliodynamics is a productive framework, so therefore, even if its main argument is incorrect, the discipline still holds merit.

This book segment has some similar properties as “Toward Cliodynamics”, in that while it gives many theoretical examples, it never really discusses methodology. On top of that, Turchin seems to focus rather obsessively on something he called *asabiya*, more commonly referred to as “social capital,” and he delves deeply into Richard Putnam’s attempts to quantify this variable. Although it would be interesting to use this type of variable in a cliometrics problem, Turchin never actually does in any of his studies. This makes the whole discussion seem rather pointless.

In conclusion, we can clearly see that a quantitative study of history *can* yield important results, however, the coining of a new term, “cliodynamics”, is unnecessary. This name is only used by a few people, and furthermore the practice of cliodynamics is not significantly different enough from other quantitative history studies to demand a new term. In fact, older technologies and techniques yielded results just as well. Furthermore, adding a new word that few people use tends to confuse rather than clarify.

While studies in “cliodynamics” do discover interesting historical patterns, it seems like they do not always use data mining best practices. Little is done to reveal how statistically significant any findings are, and all Turchin’s studies utilize the same method, mathematical modeling. Of course, Turchin is only one of a few practitioners of cliodynamics. A further study of the other cliodynamicians could reveal if the trends noted in his work are discipline-wide, or just limited to his own studies.

Since one of my disagreements with his work is that it only looks at the variables that the historian already believes to be significant, I think some interesting future work in the field would be to enter *all* known variables of a problem into an artificial neural network and see what relationships could crop up this way. One of the main advantages of neural networks is that the user does not need to know ahead of time what type of relationships they are looking for. This could vastly expand historical theories, beyond those that can be thought up by well-trained historians.

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