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The Hard Edge of a Soft Science:
The Impact of the Newtonian-Quantum Paradigm Shift in the Sciences on Political Science Theories and Methods

by

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ABSTRACT

This work examines the scientific paradigm, as defined by Thomas Kuhn, as a major contributor to developments in political science. In particular, it explores how the predominant paradigm in the sciences has contributed to political theories and methods. At the beginning of the twentieth century, the Newtonian paradigm in the sciences, which has had an important influence on political science, was replaced by the Quantum paradigm. Since the 1960s, the impact of this Newtonian-Quantum shift has emerged in many areas outside of the sciences, including political science.

Changes in political theories and methods are studied in relation to the Newtonian-Quantum paradigm shift in the sciences. Definitions of the Quantum and Newtonian paradigms are developed and the shift in the sciences is described. The expected impact of this shift on political science theories and methods is outlined, and an exploration is made of three areas: political economy, feminism and theories of methodology.

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INTRODUCTION

The social sciences, historically, have emulated both the intellectual and methodological paradigms of the natural sciences. From the behavioral revolution, to the applications such as cybernetics, to a predominant reliance on the certainty and stability of the Newtonian paradigm, the social sciences have followed the lead of the natural sciences. This trend continues as new discoveries in the natural sciences have led to a reconsideration of the relevance of the Newtonian paradigm to all natural phenomena.

Euel Elliot and L. Douglas Kiel, *Chaos Theory in the Social Sciences*

This work is as much about designing a tool as it is about proposing a theory. This tool provides a means by which to examine changes in political science theories and methods over the past three hundred years. It is a new and alternate view of these changes that does not suppose that other interpretations are wrong. Developments in knowledge are highly multi-dimensional. Any theory of interpretation only takes a limited number of these dimensions into account. Through the development of a tool that utilizes the Newtonian-Quantum paradigm shift, an alternate set of dimensions is incorporated. Part I begins by identifying what a paradigm and a paradigm shift are in the context of this approach. This is followed by definitions of the Newtonian and Quantum scientific paradigms. Given that these definitions are unique to this discussion, an extensive description of these concepts is provided. The potential impact of these scientific paradigms on political science theories and methods is presented along with general examples of what it looks like to view political science through them. Part I ends with a proposition regarding what a more detailed examination of theories and methods should reveal when examined through the lens of the Newtonian-Quantum paradigm shift. Part II then takes up the challenge by surveying changes in methods and theories in specific

areas of political science. Finally, part III includes final observations on the use of the Newtonian-Quantum paradigm shift as an exploratory construction, including a discussion of methodological limitations and choices.

In examining the impact of the Newtonian-Quantum paradigm shift in the sciences on political science, it is necessary to decide consciously where to look. For example, one could focus on the epistemology and ontology of theories such as positivism, post-modernism and realism. However, such an examination quickly becomes an analysis of the philosophy of science. Studying the meaning of a shift in the sciences for theories from the philosophy of science is a perfectly respectable pursuit, but not the one intended here. Alternately, a broad examination could be made of political theories such as liberalism, behaviouralism and Marxism. Nevertheless, it might be unwise to ignore the epistemological and ontological underpinnings of these types of theories. Thus, this work focuses both on political theories and their philosophical foundations. However, it is not the conclusions of these theories that are of interest. It is the guidelines these theories provide to the research done in their names or the perspectives they provide – e.g. feminist research or a Marxist perspective. In the sciences, the answer to the question 'is light a wave or a particle?' is of less importance to the paradigm than how one goes about answering the question and how one reacts to answers, such as 'in some instances it acts like a particle and in others like a wave.' This is not to say that the conclusions of a theory are not closely tied to the boundaries that the theory places on viewing the world – clearly they do – but the more immediate impact of a paradigm will be seen by examining those boundaries, not their consequences. In this vein, feminist theories, theories of political economy and theories which take methodology as their

primary focus, are included in this study. This is not intended to be an exhaustive discussion of the impact of the paradigm shift on political science or even on the three areas selected. The intent is to provide examples and build support for this particular way of viewing changes in political science theories and methods.[1]

[1] A Glossary of Terms is included before the Bibliography. The terms defined are those not defined within the text but can have a multitude of meanings or are particular to the subject matter of this work.

PART I: THE NEWTONIAN-QUANTUM PARADIGM SHIFT

1.0 Defining a Paradigm and a Paradigm Shift

Wolfgang Pauli, in the months before Heisenberg's paper on matrix mechanics pointed the way to a new quantum theory, wrote to a friend "At the moment physics is again terribly confused. In any case, it is too difficult for me, and I wish I had been a movie comedian or something of the sort and had never heard of physics." That testimony is particularly impressive if contrasted with Pauli's words less than five months later: "Heisenerg's type of mechanics has again given me hope and joy in life. To be sure it does not supply the solution to the ridale, but I believe it is again possible to march forward."

Thomas Kuhn, *The Structure of Scientific Revolutions*

The common understanding of the term paradigm is as a 'filter.' All people view the world around them through such a filter. It eliminates those things we consider irrelevant and focuses on things we deem important. This filter also interprets events in a way that is consistent with how we already understand the world. This description of a paradigm is somewhat different from that of its originator Thomas Kuhn who understood it as follows: "These I take to be universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners."[2] While this seems to be a very limited definition, Kuhn's discussion of paradigms leaves room for a great deal of interpretation.

For Kuhn, a paradigm was strictly a phenomenon of the sciences. The paradigm through which a scientist interprets the world determines what one looks for and greatly influences how one interprets the results. Results which do not fit the prevalent paradigm may be ignored or explained away as irregularities. In this way the paradigm tends to be

[2] Thomas Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1962), x.

self-perpetuating. On occasion, however, enough irregularities build up that they cannot be ignored and the paradigm enters into a crisis. When this occurs a new paradigm tends to emerge – one which is consistent with the new observations. Suddenly the world is interpreted in a new way and all past experiences are seen in a new light. This change in perspective is called a paradigm shift.[3] Kuhn argued that the sciences had certain properties which other disciplines did not, properties that allowed for the formation of paradigms. The subsequent attempt to identify paradigms outside of the sciences has often employed a redefined concept of paradigm. It is not the intention of this work to repeat this procedure. Paradigm will be understood very much in the Kuhnian sense and only referred to as occurring in the sciences. The greatest departure from Kuhn is the argument that there are two overriding paradigms – Newtonian and Quantum.[4] No attempt is made to identify either a Newtonian or Quantum *political science* paradigm. The project undertaken here is the identification of the impact of the Newtonian-Quantum paradigm shift in the *sciences* on political science theories and methods. The assumption made in this statement, that scientific paradigms have an impact on the political sciences, will be clearly demonstrated. Why this impact may occur can be understood in many ways, including the following.

The Enlightenment witnessed a separation between science and philosophy. Science, the study of the physical world, subsequently advanced at a rapid pace that has only increased ever since. Philosophy, on the other hand, is not seen to have had the same progress. This suggests two explanations for why the social sciences have been so

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[3] John L. Casti, *Paradigms Lost* (New York: Avon Books, 1989), 40-43.

influenced by scientific paradigms.[5] The first is that the apparent advances in the sciences have led many to attempt to repeat this success in the social sciences by applying the same methods and techniques. It is also not unusual for scientists to postulate what the most recent discoveries mean in terms of other disciplines.[6]

The second explanation of the impact suggests a less conscious act. A scientific paradigm seeps through a culture producing a radical change in outlook, often in a rather unobtrusive way. While those who first discovered the principles of quantum mechanics were very aware of its revolutionary implications, the larger part of society (although impacted greatly) has not been as cognizant of the change. This is because although shifts are produced by a crisis within the prevalent paradigm, the actual shift in thought acts rather like evolution. There are always those who claim to have discovered a 'whole new paradigm' and print their views in journals and books. These publications may cause thought and some may agree with them but they are not a paradigm shift in themselves. It would be rare for an individual to go through a paradigm shift in one's own lifetime; it is from generation to generation that the shift occurs.

This work will refer to and define a 'Newtonian Paradigm.' However, this paradigm is not argued to have been created the moment Isaac Newton published *Philosophiae Naturalis Principia Mathematica* in 1687. In fact, examples of Newtonian thought can be found before this time. The shift in thought occurred over a period of time

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[4] Kuhn proposed different paradigms exist in different disciplines of the sciences. Furthermore, he suggested paradigms shift more often than supposed in this work.

[5] I have switched from the term 'Philosophy' to 'Social Science.' In fact, by the time 'Social Science' was employed, the methods of the sciences were already applied to philosophical studies.

[6] Neils Bohr used his extension of the Heisenberg's uncertainty principle, called complementarity – the idea that there are pairs of concepts which cannot be exactly defined at the same time – to include justice

and encompassed the works of many great scientists and philosophers going as far back as Galileo's Law of Uniform Acceleration, discovered in 1604. Furthermore, while this work refers to the impact of the scientific paradigms on political science, the influence is not unidirectional. For example, it is probable that the intellectual environment of an emerging liberal society was as much a factor in the formation of the Newtonian paradigm as the paradigm was in supporting liberalism.[7] Moreover, the mechanistic view of the Newtonian paradigm was strongly bolstered by the rise of industrialization, "and divine dice-shooting seems hardly enough to account for the fact that the Age of the Machine enthusiastically embraced scientific theories that pictured the entire universe as a machine."[8] From this perspective, a paradigm is not strictly the product of science but it is in the sciences that the paradigm is formed and articulated. This articulation expedites the influence of the paradigm. Thus, we talk of the impact of the scientific paradigm on the social sciences.

When explaining the impact of the quantum paradigm shift on political theories and methods, it may be asked whether those in the social sciences understand quantum mechanics or chaos theory. The answer is that it is irrelevant; the impact can occur without those involved being aware of its origins. To illustrate, it is fair to say many, if not most, Canadians hold liberal beliefs. However, the majority of these individuals have never read Thomas Hobbes, John Locke, John Stuart Mill or any contemporary political

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and legality, emotion and rationality. Robert Gilmore, *Alice in Quantumland* (New York: Copernicus, 1995), 47.

[7] Paul Gross and Norman Levitt, *Higher Superstitions: The Academic Left and its Quarrels with Science* (Baltimore: John Hopkins University Press, 1994).

[8] Alvin Toffler, introduction to *Order Out of Chaos: Man's New Dialogue with Nature*, by Ilya Prigogine and Isabelle Stengers, (New York: Bantam Book, 1984), xiii.

theorists. In addition, many of these individuals would have difficulty defining liberalism and its underlying tenents and beliefs; some may not even have heard the word, and some who have heard the word may deny having liberal beliefs while it is apparent they do. Although understanding the basis of a belief might make it clearer in the minds of those who hold it, it does not necessarily make the belief any stronger. In the same way, it is not necessary to understand the scientific discoveries and theories that motivated the emergence of a paradigm in order to view the world through it.

2.0 Defining the Paradigms

Small wonder that, at the end of the eighteenth century, the century that witnessed the unfettered progress of Newtonian science, Pope could exclaim:

Nature and nature's laws lay hid in night:
God said, Let Newton be! And all was light.

Pope could not know indeed that

'T was not for long: for Devil, howling, "Ho,
Let Einstein be!" restored the status quo.

Alexandre Koyre, Newtonian Studies

2.1 Aristotelian

Before the seventeenth century, the sciences were not in a position to possess a paradigm – certainly not a single one. However, the preceding scientific period is often referred to as Aristotelian – in large part because of the prominence of Aristotle's deductive method. Using this method, science logically deduced laws from hypothesized first principles. These first principles were often produced from general observations about the universe. They were not the sort of specific observations produced through careful measurements. These first principles were also not subject to experimental tests.

> Oddly enough, despite Aristotle's main occupation as an observational biologist, the biggest flaw in his entire world picture was that he advocated no experiments or even use of observations to serve as a check on the validity of his underlying premises. Basically, his was an epistemology in which one inferred specific instances (conclusions) from general observations (premises).[9]

The concept of cause and effect is very much connected with Newtonian thinking. Nevertheless, the concept is not the exclusive domain of the Newtonian paradigm. Cause and effect was established in writings before Newton - for example, Aristotle's *Metaphysics*. Writers of this time, however, tended to look at cause and effect in a normative way. For Aristotle there was always a first cause which should direct

everything we do. Philosophers often discussed the *telos* of a system and attempted to understand cause and effect in order to understand the purpose of a system and to manipulate the system towards that end. In political philosophy, writers often compiled a large number of examples and commonly held axioms to show why one form of government was better than another or why one form of government was ideal. Predictions on the outcomes of a particular system were deduced from generally untested observations or on rules established through religion. In this way, logical reasoning was deductive. What this type of thought process did not attempt to do was induce general principles of government from specific, tested observations. In other words, it was not inductive or experimental, in the way that Newtonian thought is.

Another change that distinguishes the Aristotelian era from the Newtonian paradigm is the idea of progress – that things are continually moving forward. Pre-Newtonian thought tended to view events as cyclical or with a beginning and an end. Newtonian thought strives to free itself from the normative belief in a universal purpose. Consequently, it is able to view events as always moving ahead without an end or purpose.

One of Newton's greatest contributions to science was the use of mathematical representation. Through his use and development of mathematics, principles that would otherwise have been expressed in words could be represented by simple mathematical expressions. This trend continued throughout the Enlightenment until even the lines and circles used by Newton were replaced by equations. From a paradigmatic point of view, the importance of this development was the increased separation between a

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[9] John Casti, 19.

representation and that which is being represented. It has been suggested that prior to the Enlightenment this distinction was not as clear – that the *representation* of the Holy Spirit, for example, was often taken to have the power of the same and in fact was the same.[10]

2.2 Newtonian

There is no clear cut-line that demarcates the beginning of the Newtonian paradigm but certainly there was evidence of it in the work of Galileo at the start of the seventeenth century. In 1660, the Royal Society was established in England, and in 1703 Newton was elected president, marking the beginning of a period dominated by his ideas.[11] The Enlightenment, a later manifestation of the Newtonian paradigm, began in the eighteenth century. It is very important to once again make clear that the Newtonian paradigm and Newtonian thought are not synonymous with the ideas of Newton himself. Isaac Newton is the most famous and the most representative scientist of this paradigm. However, as indicated, fundamental aspects of the Newtonian paradigm were evident before Newton was born. Furthermore, there are aspects of the Newtonian paradigm that are not consistent with the ideas of Newton himself.

From a Newtonian point of view, the actions of, or events within, a system or organization are completely predictable. There is a fundamental belief in cause and effect which leads us to believe that if we know the initial conditions or original state of the system and the proper equations or theories describing the system, we can determine the

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[10] Richard Trexler, "Florentine Religious Experience: The Sacred Image," *Studies in the Renaissance* 19 (New York: The Renaissance Society of America, 1972): 8-11.

[11] Alexander Hellemans and Bryan Bunch, *The Timetables of Science* (New York: Simon and Schuster, 1988), 146-150.

outcome (effect) of any action (cause) within it. If a system appears complex it is simply that it has a complex set of equations driving it.

This understanding of the universe does not require, however, a knowledge of first causes – for example, the cause of gravity. If first causes can be discovered through observation then it may be a worthwhile pursuit but not a necessary one. The proof of their existence through the predictable observation of their effects is enough.[12] This is an excellent example of the divergence of the Newtonian paradigm from the ideas of Newton himself. While the knowledge of first causes makes little difference to Newtonian mechanics, Newton himself believed that there was a first cause, God. Later Newtonian thinkers did not agree. Etienne Bonnet de Condillac and Destutt de Tracy are two such thinkers who claimed that there are in fact no first causes. They argued that the belief in such is an Aristotelian failing.

The irrelevance of first causes is required by another aspect of the Newtonian paradigm – that is, all knowledge must be determined through objective observation. This, in turn, explains the Newtonian requirement that the whole be examined through observation of its parts. From a Newtonian point of view, it is possible to break a system down into its parts, determine forces driving those parts and then recombine the parts and forces to produce the more complex whole. This is called reductionism.

A Newtonian view of the world is also materialistic. A phrase often quoted in Hobbes' *Leviathan* and an excellent example of political theory written from a

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[12] For a discussion of the Newtonian debate concerning first causes see Keith Baker, *Condorcet: From Natural Philosophy to Social Mathematics* (Chicago: The University of Chicago Press, 1975), 87-95.

Newtonian paradigm, is *matter in motion.*[13] A system in this view is composed of a set of indivisible particles which are set in motion by some first cause. Newton described this view clearly in his *Opticks*.

> All these things being consider'd it seems probable to me, that God in the Beginning form'd matter in solid, massy, hard impenetrable, movable Particles, of such Sizes and Figures, and with such other Properties, and in Proportion to Space, as most conduced to the End for which he form'd them: and that these primitive Particles being Solids, are incomparably harder than any porous Bodies compounded of them: even so very hard, as never to wear or break in pieces; no ordinary Power being able to divide what God himself made one in the first Creation ... And therefore that Nature may be lasting, the Changes of corporeal Things are to be placed only in the various Separations and new Associations and Motions of the permanent Particles.[14]

Once this matter has been set in motion, the Newtonian paradigm tells us that it continues to move according to preset rules which drive the universe. This has been compared to the components of a clock which, once wound up, will continue to tick on in a predictable manner. Consequently this paradigm has been referred to as the watchmaker concept of the world:

> The image handed down to us by the giants of seventeenth-century science is often referred to, rightly, as that of a 'clockwork Universe', obeying inexorable laws. But the correct image is not that of a modern clock or wristwatch, ticking away the seconds one by one. Rather, we should imagine a great cathedral clock of the seventeenth century, driven by a huge pendulum in accordance with Huygen's design, with many interconnecting cogs and gearwheels that do not just tick away the time but which drive a complicated mechanism to set in motion sophisticated tableaux involving moving figures of the saints, striking bells and other mechanical activity at appointed hours. *That* is the kind of complex clockwork that seventeenth-century science envisaged underpinning the dance of the planets around the Sun and other natural phenomena.[15]

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[13] For example, Thomas Hobbes, *Leviathan*, ed. Herbert W. Schneider (NJ: Prentice Hall, 1958), 25-26.
[14] Issac Newton, *Opticks*, 4th ed., (New York: Dover, 1952), quoted in Peter Gibbins, *Particles and Paradoxes* (New York: Cambridge University Press, 1987), 4.
[15] John Gribbin, *Schrodinger's Kittens and the Search for Reality* (New York: Little, Brown and Company, 1995), 46.

In this way, any system viewed from a Newtonian paradigm, once set in motion, is completely predictable and deterministic. Although a system may be so complicated that we may not be able to follow it, this is a consequence of our limited mental capacity and not a consequence of the system itself. Thus, given sufficient intellect, or computing power, and given an accurate measurement of a system, a mapping of the system backward or forwards in time can be made with complete accuracy. From any point onward the system follows a set path determined by predictable rules. Nothing is left to chance. This was expressed by the Marquis de Laplace in 1816:

> We ought to regard the present state of the universe as the effect of its anterior state and as the cause of the one to follow. Given for one instant an intelligence which could comprehend all the forces by which nature is animated and the respective situation of all beings who compose it - an intelligence sufficiently vast to submit these data to analysis – it would embrace in the same formula the movements of the greatest bodies of the universe and those of the lightest atom; for it, nothing would be uncertain and the future, as the past, would be present to its eyes. The human mind offers, in the perfection which it has been able to give astronomy, a feeble idea of this intelligence. Its discoveries in mechanics and geometry, added to that of universal gravity, have enabled it to comprehend in the same analytical expressions the past and the future states of the world.[16]

From this point of view, when a system fails to do as we predicted then it is supposed that we have not properly derived the equations to describe it and all we need to do is break it down further and add more variables. Chaos, according to Newtonian mechanics, is just a high degree of complexity.

It is important to note that the Newtonian paradigm does not describe a monolithic set of beliefs. Within the paradigm, many debates have been fought. Described here are the essential themes, hammered out over three hundred years of

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[16] Pierre Simon, Marquis de Laplace, *Philosophical Essay on Probabilities*, 6th ed., trans. Frederick Wilson Truscott and Frederick Lincoln Emory (1951), quoted in Peter Gibbins, 4-5.

Newtonian thinking. The limitations of the Newtonian view did not go unnoticed. One limitation was noted by Blaise Pascal even before it had been established:

> If man began by studying himself, he would see how incapable he is of going beyond himself. How could a part comprehend the whole? He will hope perhaps to know at least the parts to which he bears some proportion. But the parts of the whole are all so closely connected and linked one with another that I believe it impossible to know one without the other and without the whole.[17]

In stating this view, Pascal was not actually arguing for something non-Newtonian. Rather, he was lamenting "the inability of the human mind to penetrate beyond its own confines to the essence of the universe, its essential relations and ultimate purposes."[18] Over one three hundred years later, the Quantum paradigm would point to a similar problem, although this time with the offer of a solution – an alternate view of the world.

2.3 Quantum

In science, a new way of looking at things has emerged. A combination of concepts from relativity theory, quantum mechanics and chaos theory, it is called the Quantum paradigm. In this world, cause and effect are fuzzy and largely irrelevant; things are not predictable, only probable; things cannot be separated from the system because they only exist in so far as they interact with the system; and chaos is not a high degree of complexity but a whole new level of order.

One of the simplest and most often used examples given to provide a taste of how the Quantum paradigm differs from the Newtonian one is the double slit experiment. This

[17] Blaise Pascal, quoted in Keith Baker, 91.
[18] Ibid.

example starts with an experiment often used to demonstrate the wave nature of light.[19] First, consider a body of water with a wall passing down the center. This wall has a very narrow opening in the center of it. As waves move along the surface of the water and crash up against the wall they pass through the hole. They emerge out of the hole in a circular array as if the waves had been created by a pebble that had been dropped right where the hole was. We now consider the same set up except with two small holes in the wall; one just right of center and one just left of it. Again, as waves crash up against the wall they pass through the two holes in two circular arrays as if two pebbles had been dropped simultaneously right next to each other. The paths of the two sets of waves interact. Where the crest of one wave meets the trough of another destructive interference occurs and the two waves at that point cancel each other out. Conversely, as a trough meets a trough or a crest meets a crest constructive interference occurs producing a wave, at that point, as large as the combination of the two individual waves.

Light can behave in the same manner. Now picture a wall with a single hole (or slit) in it and a second wall behind it. As light is shone upon the first wall the light emerges through the slit producing a bright spot on the wall. If the experiment is repeated with two slits in the wall the interference of wave occurs. What is produced on the second wall is what is called an interference pattern. This pattern is a series of alternating light and dark lines – areas where destructive (dark lines) and constructive (bright lines) interference occurs. It must be noted that this pattern is not what one would get if one

[19] This example is repeated in many of the texts that attempt to popularize modern science. My attempt to do the same is influenced greatly by the particularly clear example provided by John Gribbin (Gribbin, 3).

were to add the result of shining light through the left slit to that of shining light through the right slit which would be two single bright spots.

The peculiarities occur when one considers what happens when one fires a single photon, a single electron or even an atom at such a wall – for the case of the electron, one uses a phosphorescent screen that shows the impact of the electron at the second wall. In this case, we are dealing with distinct particles. However they are created and observed, they are done so as particles. When the electron is fired at the wall, with a double slit, it will pass through one of the slits or not at all. If it does pass through one of the slits, a mark will appear on the screen behind it where it impacted. As this is repeated over and over a pattern emerges on the screen which resembles an interference pattern. What this indicates is that as the electron passed through one of the two slits, it behaved as if it passed through both slits, interfered with itself as if it was a wave, and appeared on the screen where the interference of two waves would but as a particle. If one of the slits is covered up the interference pattern disappears and the electron acts like a particle. The image that forms on the screen is the same as that which would occur if one were to throw a bunch of rocks through a large hole in an actual brick wall (i.e. as a single bright spot). A further mystery is created when a device is set up so that one can observe which slit the electron passes through. What we see is that the electrons do pass through one slit or the other with a 50/50 distribution. However, the pattern that appears on the screen, now that the slits are being watched, is a pattern that resembles that of firing electrons through one slit then the other. In other words the electrons now behave exactly as particles. The pattern is the same as that which would appear behind a brick wall with two holes in it if one were to randomly throw rocks at it without aiming.

The simplest explanation for these phenomena is that once the electron is fired at the wall it becomes a probability wave. This wave describes an electron which has an equal chance of firing through either slit. The probability wave passes through the two slits and interferes with itself, as did the water waves as they passed through the two holes in the wall. The result of interference is the creation of a new wave with areas of high probability and areas of low or zero probability. When the wave hits the screen one of these probabilities occurs and the electron is observed as a particle at some point. The wave is said to have collapsed when it is observed. Consequently, when the slits are watched for an electron passing through it, the probability wave collapses at the first wall and the electron is seen to pass through one slit or the other. As the electron continues on to the screen it becomes a probability wave again which proceeds to collapse once more at the screen. However, because it had collapsed at the wall with the slits, appearing as a particle in one of its possible conditions, there is no second wave to create interference and, thus, a probability wave resembling an interference pattern.

This example, which has been carried out in reality, outlines the apparent paradoxes of the Quantum paradigm when viewed from a Newtonian frame of reference. It illustrates the importance of the role of the observer in an observation and how interactions are more important than things. It also illustrates the non-deterministic, statistical nature of observations and the abstract interpretation of quantum events. In the words of Neils Bohr:

> In the quantum formalism, the quantities by which the state of a physical system is ordinarily defined are replaced by symbolic operators subjected to a non-commutative algorism involving Plank's constant. This procedure prevents a fixation of such quantities to the extent to which would be required for the deterministic description of classical physics, but allows us to determine their spectral distribution as revealed by

> evidence about atomic processes. In conformity with the non-pictorial character of the formalism, its physical interpretation finds expression in laws, of an essentially statistical type, pertaining to observations obtained under given experimental conditions.[20]

So how, according to the Quantum paradigm, should we look at the world? First of all, it indicates that attempting to structure things so that they are predictable is futile. Even if we could measure the exact initial conditions of a system, which the Heisenberg uncertainty principle says we cannot, we can never predict the outcome of an event; we can only calculate the probability of an outcome.[21] The new paradigm also reveals that the slightest perturbation of the system sends it into wildly unpredictable directions, which are not only difficult but impossible to follow – the butterfly effect.[22] However, by observing the system from a distance, perturbations and all, an order begins to appear out of the chaos. Although we can never tell where a system will be at any given time, we can determine the boundaries of the system and determine towards where the system will tend. Moreover, we can still hope to understand the system even if we cannot predict it.

Along with this idea of viewing the bigger picture is the idea that we cannot break the system down into parts. What we find in this new paradigm is that things exist only in so far as they relate to the system. It is no longer useful to consider the activity of an electron apart from its environment (or apart from the equipment used to measure it); there is no longer any point in considering the parts separate from the whole.

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[20] Neils Bohr, "Causality and Complementarity," in *The World Treasury of Physics, Astronomy, and Mathematics*, ed. Timothy Ferris (Boston: Little, Brown and Company, 1991), 802-3.

[21] Heisenberg uncertainty principle: The theory that the uncertainty in the momentum of a particle multiplied by the uncertainty in the position of the same particle must be greater than a fixed constant.

[22] Butterfly effect: the theory that a butterfly flapping its wings in Tokyo can indirectly produce the necessary conditions for a tornado in Toledo.

Just as the Newtonian paradigm is not a monolithic set of beliefs, neither is the Quantum paradigm. In fact, this point is even more applicable to the Quantum paradigm in that it is more recent and has thus had less time to be debated. For example, there are competing interpretations of quantum mechanics, such as the many-worlds interpretation and the consciousness-created reality interpretation. The most popular is the Copenhagen interpretation. In describing the Quantum paradigm, this work attempts to bring together some of the underlying themes common to many of the interpretations of quantum mechanics, relativity and chaos theory, and focuses on those aspects of the competing interpretations that have had the greatest influence in shaping a world-view. To this end, six aspects of the Quantum paradigm are described in greater detail. These are the participatory or observer effect, the probabilistic nature of events and the concept of complementarity in quantum mechanics; the need for holism as suggested by chaos theory; and the idea of thinking in terms of interactions and emergent properties as described by field theory. These are not mutually exclusive ideas and the following attempt to discuss each one in turn reflects the need for clarity more than it does reality.

The participatory effect is explained as follows: 'the answer is dependent upon the question.' That is, what we look for will have a great impact upon what we find. It has already been demonstrated by the double slit experiment how important the role of the observer is to any event. In the Quantum paradigm things remain mere possibilities or probabilities until they are observed and the probability collapses into an event. Thus, how one goes about observing it will influence which of the possibilities will occur. In addition, as soon as we do observe the event then all the other possibilities disappear. As Fred Allen Wolf writes:

> If the world exists and is not objectively solid and preexisting before I come on the scene, then what is it? The best answer seems to be that the world is only a potential and not present without me or you to observe it. It is, in essence, a ghost world that pops into solid existence each time one of us observes it. All of the world's many events are potentially present, able to be but not actually seen or felt until one of us sees or feels.[23]

Understanding the world in terms of probability is also an important Quantum paradigm alternative to the Newtonian concept of prediction. Predicting an event at the quantum level is not possible. However, calculating the probability of any particular event is still valid. There are still events that have a zero percent chance of occurring – they are forbidden – and there are events that are highly likely to occur. For example, while it is possible for an electron that is part of a molecular bond to exist for a moment many miles away from the molecule, we can define a very small region outside of which it would be highly unlikely for the electron to be found. (It is these areas of probability that define molecular orbitals in quantum chemistry.) Furthermore by examining the probabilities and boundaries of events we can still gain great understanding even without the ability to predict.

Next we discuss complementarity – the idea that there are pairs of attributes that are intrinsically linked such that one cannot be measured or influenced without affecting the other. A common pair of conjugate variables is composed of momentum and position. In the quantum world, an object cannot at the same time have both an exact position and an exact momentum. Making a fine measurement of an object's momentum reduces the exactness of its position and vice versa. The phenomenon of complementarity is highly related to the participatory effect. Measuring the momentum provides one view of a

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[23] Fred Allen Wolf, quoted in Margaret J. Wheatley, *Leadership and the New Science* (San Francisco:

particle. Measuring the position will give another view. These views are both correct but they will not be consistent. How one looks at something influences what one sees, so in order to understand an object or event we must look at it in many different ways:

> ...evidence about atomic objects obtained by different experimental arrangements exhibits a novel kind of complementarity relationship. Indeed, it must be recognized that such evidence which appears contradictory when combination into a single picture is attempted, exhausts all conceivable knowledge about the object. Far from restricting our efforts to put questions to nature in the form of experiments, the notion of *complementarity* simply characterizes the answers we can receive by such inquiry, whenever the interaction between the measuring instruments and the objects forms an integral part of the phenomena.[24]

Another pair of conjugate variables is composed of time and energy. That is, the precise energy of a quantum object cannot be known at a given time – only over an infinite period of time. At a specific moment, the object's energy is unspecified. It is in this way that quantum systems 'borrow' energy in order to produce temporary particles out of nothing. As long as the energy of the system is constant when averaged over a period of time, no laws of physics are violated by this act.[25]

This brings us to holism. This concept is demonstrated nicely by chaos theory. The term chaos is actually used to describe a number of related phenomena and chaos theory is a blanket term that refers to the study of all or any of these. These phenomena range from those that are composed of complete randomness to those that contain very little (it is possible to model chaotic systems with zero randomness but it is debatable whether such systems exist in reality). Despite some differences, there are many commonalties in the studies of these phenomena. The first of these is that chaos theory is

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Berrett-Koehler Publishers, 1992), 58.

[24] Neils Bohr, 804-5.

[25] In fact energy only truly must be constant when averaged over an infinite period of time.

actually based on Newtonian mathematics. It is the branch of modern science that adheres most closely to Newtonian mechanics – it is a Newtonian mechanics that incorporates nonlinear dynamics. However, the interpretation of chaos theory does not belong to the same paradigm as Newtonian thought. Its interpretation is much closer to that of quantum mechanics in the Quantum paradigm. As has been noted, theories based on the Newtonian paradigm reduce systems into parts, interpret their past and present behavior and attempt to predict how specific actions will affect the system. Systems from the view of chaos theory are very resistant to being reduced down to a simpler level. The further one digs the more complicated the system gets. "A nonlinear equation cannot be broken down into bits and then reformulated to obtain a solution. Nonlinear differential equations, and the phenomena or problems they describe, must be seen as a totality, that is, as nondecomposable."[26]

Chaotic systems are usually deterministic and never predictable. They are deterministic in that for at least a period of time their behaviour can be described by an equation. It may be a non-linear equation but that does not stop it from being deterministic.

Chaotic systems are unpredictable for two reasons. First, while a non-linear system may be deterministic, in order to use this determinism to make a prediction, fine measurements of the system's state must be made. It is argued that such a measurement is

[26] Douglas Kiel and Euel Elliot, *Chaos Theory in the Social Sciences* (Ann Arbor: The University of Michigan Press, 1997), 4.

not only impossible but also forbidden by the laws of nature, such as the Heisenburg uncertainty principle.[27]

Second a non-linear system that is deterministic for a period of time will undergo a change called a bifurcation. This is a transition in which the system shifts from one deterministic state to a drastically different deterministic state. In order to predict what the new state will be, it is again necessary to have fine measurements. In addition to the possibility that such a measurement is forbidden, there is the idea that every system contains a little randomness. This randomness is enough to ensure that the bifurcation point is an unpredictable event with an unpredictable outcome. These characteristics of chaos make nonlinear systems so sensitive to initial conditions that it is impossible to predict the outcome of any perturbation of it.

While it may be impossible to make predictions about a chaotic system, there are states that it will never have and boundaries it will never cross. Furthermore, there are states that it will repeatedly return to and areas it will stay within. "Since chaotic regimes function within defined parameters, a stability exists in chaos ... chaotic behaviour is globally stable, but locally unstable."[28] Patterns within chaos can be determined by creating strange attractors. These are produced by plotting the state of a non-linear system, iterated repeatedly over time. Such system level plots reveal the order that exists within non-linear systems.

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[27] Regardless of the Heisenburg uncertainty principle, the number of measurements required to make predictions for a complex system would literally be infinite, not just a really large number – therefore it is impossible to obtain the required accuracy.

[28] Kiel and Elliot, 7.

Also of interest is that strange attractors, created in the way indicated above, form plots that fall into a category of objects called fractals. What fractals reveal is that as one focuses in on a non-linear system, the same patterns of order in chaos repeat themselves at smaller and smaller levels.

> Fractals suggest the futility of searching for ever finer measures of discrete parts of the system. There is never a satisfying end to this reductionist search, never an end point where we finally know everything about even one part of the system. When we study individual parts or try to understand the system through its *quantities*, we get lost in a world we can never fully measure nor appreciate.[29]

For these various reasons chaos theory, as an element of the Quantum paradigm, suggests a holistic view of things is necessary.

Moving on to the importance of interactions, if thinking in reductionist terms of one object having an effect upon another is an incorrect way to examine a system in the Quantum world, what is the correct way? The answer is unclear; however, field theory provides an important clue. From the viewpoint of field theory, the universe is filled with fields of forces. Events such as the existence of an electron are the consequence of the appropriate fields intersecting and interacting. In this way, what we call particles, such as the electron, are not particles as much as they are influences. The appropriate interaction of fields will produce an influence. We observe these influences as quantities which we call momentum, position and charge. Things that appear solid do so because of the interaction of these influences with ourselves. In order to understand the universe and in order to examine a system, from a Quantum paradigm, one must consider it from the perspective of a series of interactions. These define the elements of a system and therefore the system itself. Put another way, all aspects of a system emerge from

interactions. These aspects are called 'emergent properties.' That is, properties which are not the additive result of the system's parts but rather emerge out of the interactions between the system's parts.

In this work the term 'system' is used extensively. The reason for this is that it provides for an easy transition from the study of scientific theories and concepts to those within the social sciences. Defining a system, however, introduces another difference between a Newtonian and Quantum paradigm. The commonly held definition and the one used while discussing Newtonian concepts, is an interacting, independent group of bodies, under the influence of related forces, forming a unified whole.[30] Implicit to the idea of a system defined this way is the idea of a boundary to the system. The system could be the group of interacting molecules in a beaker or a room, or it could be the group of interacting individuals at a party, in a country or in the world.

In a Quantum paradigm the idea of a system becomes less clear. Although an isolated system with boundaries can be created hypothetically in order to carry out calculations, the reality of the situation is that such a system is impossible. First, particles can spontaneously appear in a system by 'borrowing' energy from the universe. Second, the Aspect experiment showed that any particles that have interacted always continue to do so.[31] Particles interact instantaneously across infinite distances. With all the particles in the universe continuously interacting with all other particles, the idea of an independent group of particles becomes difficult. Third, until the effect of a particle or a

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[29] Margaret J. Wheatley, 129.

[30] This definition cannot be attributed to any one or any few sources. It is the product of many years of reading science and social science literature. It contains the key elements that any science glossary or dictionary would contain.

group of particles has been felt in some way (i.e. observed) it cannot be said to have done anything. Thus, an object can only be said to exist in so far as it has an influence on those things around it. Fourth, even if there was an isolated system, there is no such thing as an independent observer of it. The fact that the person is observing it makes him/her part of the system. Consequently, all relevant systems are open, just as all "phenomena of interest to us are, in fact, *open* systems, exchanging energy or matter (and, one might add, information) with their environment."[32] The only possibly realistic closed system is the entire universe, which may itself be open.

Having described the scientific paradigms in detail, the remainder of Part I presents a general description of the Newtonian paradigm as a factor in political science, the potential impact of the Quantum paradigm and examples of the beginning of this impact.

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[31] Aspect experiment: a series of experiments carried out by Alain Aspect in the 1980s, see glossary.
[32] Alvin Toffler, xv.

3.0 General Description of the Newtonian Paradigm in Political Science

It is well admitted that the seventeenth century underwent, and accomplished, a very radical spiritual revolution of which modern science is at the same time the root and the fruit.

Alexandre Koyre, *From the Closed World to the Infinite Universe*

The difference between Aristotelian and Newtonian political science is well summarised by Richard Bernstein. "The discipline of politics was once conceived of not as a theoretical study of how the political system works, but as a discipline that has as its *telos* a practical end: the leading of a good and just life in the polis."[33]

One of the clearest examples of the impact of the Newtonian paradigm on political science is found in the evolution of ideologies. Many present-day political ideologies are a consequence of the Newtonian paradigm and originated in the age of the Enlightenment. Before this time people, in general, accepted their lot in life. Knowledge came from above: from the monarch or the church. Leadership was essentially unquestioned by the masses and through adversity they looked to their masters for guidance. As people began to question the establishment, discoveries were made that produced changes during the Enlightenment. Attempts to explain the world, solve problems and improve conditions through science gradually increased in success, producing a revolution in thought. People no longer accepted their lot as fate and began to search for the secrets of the world. Newton's was very influential during this time. By using reason and mathematics he had produced a set of rules and equations to explain how the motion of bodies were governed. He was able to predict events and show cause

and effect. In the same way, at a later time, Darwin produced a theory to explain the evolution of man based on set rules of cause and effect.

With the advancement of science came technology and all the benefits and ills that accompany it. The result was mechanization of production, urbanization of society and severe social dislocation creating a crisis that was accompanied by unemployment, sickness, depression and inflation – the industrial revolution. These conditions, combined with the contemporary Newtonian paradigm and the belief that humans can take steps to improve their lives, led to the creation of political ideologies. These were systems of beliefs that interpreted what was wrong with the human condition and what could be done to improve it.

The term ideology was coined at the end of the eighteenth century by A.L.C. Destutt de Tracy. Tracy proposed a science of ideas and perception, a new science of thought, a Newtonian science that would replace Aristotelian metaphysics.[34] Tracy's ideology was materialistic, it did not concern itself with first causes and it was intended to provide an unprejudiced understanding of the universe. It was also very practical and closely linked to politics.

> "The aim of your work," he [Tracy] told the academicians, "is the knowledge of effects and their practical consequences." "Ideology" was genealogically the first science, since all science consisted of different combinations of ideas. But it was specifically the basis of grammar or the science of communicating ideas, logic, or the science of combining them and reaching new truths, education, or the science of forming men, morality, or the regulation of desires, and "*finally the greatest of the arts, for the success of which all the others must cooperate, that of regulating society*

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[33] Richard J. Bernstein, *The Restructuring of Social and Political Theory* (New York: Harcourt Brace Johanovich, 1976), xxii.

[34] Emmet Kennedy, *A Philosophe in the Age of Revolution: Destutt De Tracy and the Origins of "Ideology"* (Philadelphia: The American Philosophical Society, 1978), 45-46.

in such a way that man finds there the most help and the least possible annoyance from his own kind." [35]

It is the action-oriented, society-organizing aspect of Tracy's description of ideology that became accentuated over time as ideology came to be what it is today.

Modern political ideologies "provide an interpretation of the present and a view of a desired future. The anticipated future is invariably portrayed as materially better than the present and it is thought to be attainable within a single lifetime." [36] Furthermore, each ideology includes a list of specific steps that can be taken to accomplish goals.[37] These two aspects reveal the Newtonian origins of ideologies. They are based on the Newtonian concept that the past and present can be understood using reason and that once the appropriate rules are understood, the future can be predicted. It also incorporates the idea that once a system is understood we can establish the required conditions and causes to produce the desired and predictable effects. Thus, ideologies are a kind of 'recipe for success.' These aspects are also motivated by the idea of progress.

What the Newtonian worldview did was to provide a tool to break systems of government down into their basic building blocks (e.g. the individual) and to search for the fundamental laws that drive the system (e.g. the laws of human nature). In this way the political philosopher could then put the system back together, establish a set of initial conditions, whether or not they had ever occurred, and predict by a logical line of thought the outcome. It was no accident that liberalism with its emphasis on the individual was born in a period that was in love with the ideas of Newton.

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[35] Italics are Kennedy's but they are appropriately placed for my purposes. Emmet Kennedy, 47.
[36] Leon P. Baradat, *Political Ideologies* (New Jersey: Prentice Hall, 1994), 8.
[37] Leon Baradat, 1-8.

An excellent example of political theory written from a Newtonian paradigm is Hobbes' *Leviathan* (1651). Hobbes greatly admired Galileo and was fascinated by geometry and the proofs found therein. In his writings, Hobbes attempts to base his entire political thought on inductive reasoning from first principles with the individual as his unit of analysis. Hobbes first defines all his terms and starts with observations which he believes are obvious enough such that all can agree on their validity. From here he forms a mental construct of a state of nature, a state in which individuals exist without any form of government. He calls this state, 'the state of all against all.' The condition of man in this state of nature he describes as "solitary, poor, nasty, brutish and short."[38] From this and his observation of the primary motivation of man, that being self-preservation, Hobbes proposes the general reason government was created – that is, to improve man's conditions and improve the chances of self-preservation.[39]

In other words, Hobbes' mental exercise is as follows. He reduces society into its basic elements (the individual), observes them in isolation, creates rules based on observations of them in this state, and puts them back together in order to make generalizations on society and government. From this process, Hobbes is able to further induce the form this government must take, its powers and its relation to its subjects. Hobbes uses his specific observations on man in the mythical state of nature in order to produce general principles about the purpose and operation of government.

Laplace's work, like that of Galileo, also had a substantial impact on political theory and politics. As previously indicated, the Newtonian view of the world led

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[38] Thomas Hobbes, *Leviathan*, 107.

[39] The gendered term 'man' is used here to be consistent with the argumentation of Hobbes.

Laplace to claim that with enough facts at hand and the proper equations, all future and past states of the universe could be determined.

> And this image of a simple, uniform, mechanical universe not only shaped the development of science, it also spilled over into many other fields. It influenced the framers of the American Constitution to create a machine for governing, its checks and balances clicking like parts of a clock. Metternich, when he rode forth to create his balance of power in Europe, carried a copy of Laplace's writings in his baggage.[40]

A limitation of the Newtonian paradigm is that it requires a system that is predictable and logical and can be understood inductively. This can and does lead to the exclusion of data which doesn't nicely 'fit.' For example, in the introduction of William McNeill's study on the impact of major plagues on the outcome of history, *Plagues and Peoples*, it is explained how this important factor in understanding certain world events had been systematically ignored:

> Yet there remained the Black Death, together with a number of instances when a sudden outbreak of disease in an army abruptly altered military circumstances, and sometimes determined the outcome of a campaign. Such episodes could not be left out, but their unpredictability made historians uncomfortable. We all want human experience to make sense, and historians cater to this universal demand by emphasizing elements in the past that are calculable, definable, and, often controllable as well. Epidemic disease, when it did become decisive in peace or in war, ran counter to the efforts to make the past intelligible. Historians consequently played such episodes down.[41]

McNeill, in talking about those books which have addressed the issue, points out,

> Such books did not try to fit disease experience into a larger picture of human history. For them as for others, occasional disastrous outbreaks of infectious disease remained sudden and unpredictable interruptions of the norm, essentially beyond historical explanation and therefore of little interest to serious professional historians whose job it was to explain the past.[42]

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[40] Alvin Toffler, xiii.
[41] William McNeill, *Plagues and Peoples* (New York: Bantum Doubleday Dell Publishing Group, Inc., 1976), 4.
[42] William McNeill, 4-5.

This is an example of the way in which a paradigm influences not just what is considered research but also what is not.

It is useful to note that the impact of the Newtonian paradigm can be seen in rather different fields of study. In addition to science, political ideologies and history, the Newtonian paradigm is found in such contexts such as organizational process theory:

> Each of us lives and works in organizations designed from Newtonian images of the universe. We manage by separating things into parts; we believe that influence occurs as a direct result of force exerted from one person to another; we engage in complex planning for a world that we keep expecting to be predictable and we search continually for better methods of objectively perceiving the world. These assumptions ... come to us from seventeenth-century physics, from Newtonian mechanics. They are the base from which we design and manage organizations, and from which we do research in all the social sciences. Intentionally or not, we work from a world view that has been derived from the natural sciences.[43]

This has also, often, been how political theorists approach state systems, global systems and systems of all types. They continuously produce models based on 'newer and better' theories of cause and effect which take into account more and more variables. Despite this, the outcome of political systems has remained frustratingly elusive. Consequently, 'even newer and even better' theories are produced to explain this elusiveness but all the while remaining within a Newtonian concept of the world.

One last example of the Newtonian paradigm will be useful to make an important note. The concept of 'public opinion' emerged during the Enlightenment and was developed greatly by the liberal philosophers such as Locke, Mill, and Bentham.[44] Consequently, since this was a concept born in Newtonian times and influenced by Newtonian thinkers, the most popular conception of public opinion was clearly a

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[43] Wheatley, 6.
[44] Vincent Price, *Public Opinion* (America: Sage Publications, Inc., 1992), 5.

Newtonian one, as expressed by Vincent Price in his discussion of the history of public opinion:

> Society consists then of individuals seeking to maximize their own interests and utilities. A mechanism was needed for harmonizing these disparate interests. The answer to the problem of resolving separate and conflicting interests was rule by the majority, established by regular election and plebiscite. Public opinion, in this majoritarian view, was best expressed as the 'agglomerate interests of the men of the community.'[45]

This discussion is Newtonian in its conception of public opinion (the whole) simply as the sum of individual opinions (its parts).

At the time, however, there was a competing view of public opinion, best expressed by Rousseau. This view is that "public opinion transcends individual opinion and reflects an abstract, common good rather than a mere compromise of individual interests."[46] As it turned out, the introduction of the public survey and its growing popularity due to democratic, individualistic forces backed by a Newtonian concept of empirical evidence, favoured the former view over the latter.

Ironically, the recent impact of the Quantum paradigm has been to create a shift towards Rousseau's views on public opinion but not for the reasons he expressed. This particular case will be discussed further when the impact of the Quantum paradigm is examined. This example outlines two important points. First, not everyone is tied to the paradigm of his or her era. In fact, some may outright reject it as Rousseau did when he challenged Newton, Descartes and Bacon in his *First Discourse* on the contribution of their works to society:

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[45] Vincent Price, 13.
[46] Price, 11.

> Answer me then, illustrious philosophers – you who taught us in what proportions bodies attract each other in a vacuum; what are, in the orbits of planets, the ratio of areas covered in equal time intervals; what curves have conjugate points, points of inflexion, and cusps; how man sees everything in God; how soul and body could be in harmony, like two clocks, without communicating; which stars could be inhabited; what insects breed in an extraordinary manner – answer me, I say, you from whom we have received so much sublime knowledge: had you taught us none of these things, would we consequently be fewer in number, less well governed, less formidable, less flourishing or more perverse?[47]

Second, different paradigms can come to the same conclusions for different reasons. Before moving on to the impact of the Quantum paradigm on political science, the discussion turns to the potential of the Quantum paradigm. Moreover, a number of conceptual issues are cleared up.

[47] Jean-Jacques Rousseau, *The First and Second Discourses*, ed. Roger D. Masters, trans. Roger D. and Judith R. Masters (New York: St Martin's Press, 1964), 49-50.

4.0 Discussion of the Potential of the Quantum Paradigm to Impact Political Science

I
Kick at the rock, Sam Johnson, break your bones:
But cloudy, cloudy is the stuff of stones.
II
We milk the cow of the world, and as we do
We whisper in her ear, "You are not true."

Richard Wilbur, *Epistemology*

By the beginning of the twentieth century, enough evidence within the sciences had been gathered to seriously contest the Newtonian view of the world. Two new theories arose – the quantum theory (Planck, 1900) and the special theory of relativity (Einstein, 1905). The next quarter century witnessed the development of these and related theories. The Heisenberg uncertainty principle, Pauli's exclusion principle, the application of Schrodinger's wave equation, and the general theory of relativity all emerged during this period. By 1930, Niels Bohr had proposed the Copenhagen interpretation of quantum mechanics and the quantum world had been established.

During this same period chaos theory was emerging, although at a much slower pace. In 1903, Henri Poincaré noted that there are systems that are very sensitive to initial conditions making prediction essentially impossible.[48] It wasn't until 1961, when Edward Lorenz produced the first chaotic mathematical model for the purposes of examining atmospheric phenomenon, that chaos grabbed the attention of scientists.[49] The 1970s and 80s witnessed a great increase in the study of nonlinear systems within mathematics producing the common term 'chaos theory.'

[48] Alexander Hellemans and Bryan Bunch, 403.
[49] Hellemans and Bunch, 535.

While an anti-Newtonian, anti-positivist sentiment grew in the social sciences throughout the first half the 20th century, the quantum and chaos perspectives were not to make their entry until the 1960s. As Roland Omnes notes, following the rejection of the Newtonian paradigm but before the Quantum paradigm was felt outside the natural sciences there were many attempts to construct a new theory of knowledge. While these theories rejected the Newtonian paradigm, without full knowledge of the Quantum paradigm they were incomplete.

> We may mention those of Bertrand Russell (1872-1970), Alfred Whitehead (1861-1947), Ludwig Wittgenstein (1889-1951), and Edmund Husserl (1859-1938). All of them, in some sense, were born too late and too early: Too early to seize the full implications of recent scientific discoveries – in particular the laws of the quantum world – and too late to prevent the abrupt collision of their views with the new insights. It might well be, under such constraining historical circumstances, that the greatest philosopher of our age was Niels Bohr.[50]

In 1959, foreshadowing the impact of the quantum paradigm outside of the sciences, Arthur Koestler made the following observation:

> The two most important branches of modern physics, relativity and quantum mechanics, have not so far been integrated into a new universal synthesis; and the cosmological implications of Einstein's theory are still fluid and controversial. Until a new maestro emerges, or perhaps until space travel provides new observational data on our cosmic environment, the blueprint of the universe remains essentially the one that Newton drew for us, in spite of all disturbing rumours about the curvature of space, the relativity of time, and the runaway nebulae. [51]

It may be argued whether or not the maestro required to pull together the instruments of the Quantum paradigm ever did emerge or whom that individual may be. However, it is clear that all the elements have continued to play on and that they have had an impact on the world blueprint. As indicated by Bohr in 1958,

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[50] Roland Omnes, *Quantum Philosophy: Understanding and Interpreting Contemporary Science* (Princeton: Princeton University Press, 1999), 77.

> In general philosophical perspective, it is significant that, as regards analysis and synthesis in other fields of knowledge, we are confronted with situations reminding us of the situation in quantum physics. Thus, integrity of living organisms and the characteristics of conscious individuals and human cultures present features of wholeness, the account of which implies a typical complementary mode of description.[52]

In discussing the potential impact of the Newtonian-Quantum paradigm shift on theories and methods of political science, some clarifying comments must be made. Since the late nineteen-sixties/early seventies there has been much discussion of the rejection of the scientific method within political science. Periodically, this is linked to the return of something pre-positivist or pre-Newtonian.[53] From the perspective of the Newtonian-Quantum shift in the sciences, an alternate view is suggested. That view concedes the rejection of the approach commonly referred to as the scientific method, that is the methods of the Newtonian paradigm. However, rather than viewing this as a rejection of all scientific methods, the paradigm shift theory developed in this work offers that one scientific method is being replaced by another. The fact that this shift occurred in the first thirty years of this century within the sciences and in the second thirty within the social sciences is reasonable and to be expected. The confusion of viewing the new paradigm as a return to a pre-positivist or pre-Newtonian world is also not surprising. There are many similarities between the Quantum and Aristotelian world views, not the least important being that both are *not* Newtonian. However, there are important differences between these two world views, and if the tool constructed in this work is to be of value it will have to be shown that those that have rejected the Newtonian scientific

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[51] Arthur Koestler, *The Sleepwalkers* (London: Penguin Books, 1959), 504.
[52] Neils Bohr, 807.

method within the sciences have turned to something distinctly Quantum – not pre-Newtonian.

Another clarification is that the Quantum paradigm, as defined here, is not a philosophy of science, just as the Newtonian paradigm is not. That is not to say that the prevailing paradigm of a given time does not interact greatly with the philosophy of science – it does. Although the Newtonian paradigm is not equivalent to positivism, it has at times been closely linked to it. The challenge to the Newtonian paradigm at the beginning of the century also came as a challenge to positivism.[54] The rejection of the Newtonian paradigm coincided with the emergence of logical positivism.[55] And constructivism was only proposed once the Quantum paradigm was well established.[56] In addition, scholars within the philosophy of science often use quantum theory and relativity to argue their cases.

It must also be made clear that the following examination is not that of the impact of the Quantum paradigm on scientific philosophy. Nor is it a study of the impact of the philosophy of science on political theory. However, political theories are affected by

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[53] For example, Quentin Skinner, *The Return of Grand Theory in the Human Sciences* (Cambridge: Cambridge University Press, 1985).

[54] Positivism: the view that "positive facts" concerning observable phenomenon and their relations are all that can be known, and that inquiry into causes, origins, a purposes should be abandoned (R. Boyd, P. Gasper and J.D. Trout, 779).

[55] Note that the term 'coincided' is used very purposefully. The relationship between the Quantum paradigm and logical positivism is not one of cause and effect. Rather, there was an interchange between those attempting to interpret developments in the sciences and those trying to meet the challenges to positivism. Logical positivism: a doctrine which primary attempts to interpret science and philosophy in terms of verificationism. That being the theory of meaning according to which all meaningful sentences are either analytic (true or false in virtue of the meanings of the terms involved) or empirically verifiable (R. Boyd, P. Gasper and J.D. Trout, 778-781).

[56] More will be said of these theories in Part II.

changes in scientific philosophy.[57] Thus, in examining the Quantum paradigm – political theory relationship, there is value in understanding the relationship between the Quantum paradigm and recent debates in the philosophy of science.

The Quantum paradigm gives credence to an instrumentalist approach. Instrumentalism is: "the view that a theory is merely a device or tool for producing accurate observational predictions; theories so constructed are not said to be true or false, but effective or ineffective."[58] The Quantum paradigm concept that there is no objectively correct way to examine something – just various ways to capture different aspects of it – provides some support for this idea. However, the element of the Quantum paradigm that assumes the existence in reality of entities and properties that cannot be precisely observed and measured rejects the position of the logical positivists that adhere to instrumentalism. Moreover, the Quantum view that unobserved entities do not exist in any definite, predetermined state, challenges the realist belief in a universe that exists independent of our knowledge of it. While there is room in the ongoing debate on quantum theory for the realist interpretation (Einstein was a proponent of such a view), it is not the common view and recent developments such as the Aspect experiments make the realist position harder to defend.[59] More importantly, the Quantum paradigm provides support for relativist theories – although not absolutely relativistic theories such as

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[57] For example see John G. Gunnell, "Realizing Theory: The Philosophy of Science Revisited," *The Journal of Politics* vol. 57, no. 4 (November 1995): 923-40.
[58] Richard Boyd, Philip Gasper and J.D. Trout, ed., *The Philosophy of Science* (Cambridge, Massachusetts: The MIT Press, 1997), 778.
[59] See glossary for a description of the Aspect experiements.

postmodernism. The more recent post-positivist philosophies such as constructivism are more consistent with the Quantum paradigm.[60]

We now return to the impact of the Quantum paradigm on political science. Ideologies have provided a useful example of the impact of the Newtonian paradigm on political science. They continue to prove useful as we consider the potential impact of the Quantum paradigm. To start, we consider the observer effect which illustrates an important lesson on how to interpret things. Political ideologies provide interpretations of the past and the present. These interpretations are always limited by how they approach the issue and the desire to identify the objective reality. In doing so they can overlook important possibilities. In a Quantum paradigm one would have to consider many possible interpretations and would have to resist choosing one as the best or ultimate truth. This complicates the search for specific steps to meet a desired end. In fact, it challenges the idea that there is an objective desired end. The rejection of a clear and ultimate end can be seen in changes to liberal democracy before and after the World Wars. While liberalism once offered that it could produce a utopian society, as did other ideologies, after World War II it suggested no such end point existed.[61] If it did exist, liberalism argued we could never be sure in which direction to head. Thus, how we went about doing things became more important than where we were going.

The theoretical discussions of Karl Marx and Max Weber also provide examples of scholarship that has been both very influential on ideologies and challenged for being too Newtonian. In particular, there has been a rejection of the deterministic character of

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[60] More will be said on constructivism in Part II, section 2.0.
[61] David M. Ricci, *The Tragedy of Political Science* (New Haven: Yale University Press, 1984), 99-132.

their assumptions.[62] While there are many differences between these two thinkers, both were influenced by the cause and effect thinking of their time. In Weber's case it is evident in his cultural determinism and in Marx, his material determinism. The writings of Marx and Weber remain influential to this day but have been reinterpreted to account for the rejection of cause and effect, and determinism.

Turning to interactions, it has been stated that they are more important than things. "Heisenberg describes the world of modern physics as one divided not into different groups of objects but into different groups of connections."[63] Traditionally, ideologies have attempted to interpret the past as the interaction of individuals or objects. They look at how one thing affects another and then try to determine how they can change things to their advantage. In order to think of one thing affecting another, it is necessary to divide everything into groups. It is said that Martin Luther and his followers separated from the Roman Catholic church. From a Quantum paradigm it is more valid to study the interactions that occurred. For example, the interactions between Martin Luther and the Catholic church contributed to a new world order. This may seem to be a simple argument over frames of reference but it is important to recognize that neither the Lutherans nor the Catholics would be what they are today if it were not for the other. In fact, no one would be what he or she is today if it were not for all the interactions that existed in the Universe at that time. Ideologies have always tried to establish a set of steps in order to effect the desired change. However, what happens instead is that an

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[62] More will be said of this rejection and the reinterpretation of Marx in Part II of this work, when the impact of the Newtonian-Quantum paradigm shift on the theories and methods of political economy is discussed.

[63] Wheatly, 72.

interaction occurs between the system and the individual or group attempting to affect it who are part of the system themselves. The end result is that both undergo a change. This change will depend upon all the factors acting in the universe at that time and will be anything but predictable. What is more important than studying what the various groups do is to examine how the various groups are connected to each other. This is called connectivism. If one wants to have an impact upon the system it is these connections that must be manipulated. In doing so, though, one cannot focus in on a narrow set of connections. Everything is connected to everything else in the Quantum world. Nothing happens without having an impact on the whole system. Thus, one must look at the bigger picture.

Chaos theory and concepts of holism have been applied to many fields. By studying the stock market over a period of time it has been discovered that its behavior begins to resemble a fractal.[64] Its fluctuations contain specific patterns on a daily and monthly basis. One cannot predict what the stock market will do at any one time but one does know where it will tend towards and what its boundaries are. It is in this way that ideologies within a Quantum paradigm must view political systems. According to this paradigm, systems of government, if examined over long periods of time, will follow the rules of non-linear systems, in which case one can give up trying to predict the state of the system of government at any specific time and concentrate on where it is tending and what its boundaries are. This suggests that the relevant point of entry into the study of government is at the level of understanding, instead of the traditional level of prediction.

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[64] Benoit Mandelbrot examined the price of cotton on the New York exchange. See: James Gleick, *Chaos: Making a New Science* (New York: Penguin Books, 1987), 83-86.

In considering field theory, Machievelli may have been on to something when he stressed the importance of *fortuna* on the outcome of events. He believed that if man could work with the ups and downs of *fortuna* that he would be infinitely successful.[65] Accepting uncertainty as integral to the universe and working with it as a principle is central to the Quantum paradigm. Thinking in terms of field theory, one may view fields from the perspective of the social sciences to be things such as cultural beliefs, the underlying world order and the prevalent paradigm itself. In a Quantum paradigm, one would consider events as the consequence of the interaction of such fields. By viewing the world in such a way, these events may still not be predictable but their probability of occurring may be determined, and by taking a holistic view, so too may the direction and boundaries of the system. This all suggests an understanding of the subject matter can be obtained without necessarily being able to make predictions.

[65] Niccolo Machiavelli, *The Prince,* trans., George Bull (London: Penguin Books, 1981), 131-133.

5.0 General Description of the Quantum Paradigm in Political Science

The philosophy of materialism, developed in antiquity by Leucippus and Democritus, has been the subject of many discussions since the rise of modern science in the seventeenth century and, in the form of dialectical materialism, has been one of the moving forces in the political changes of the nineteenth and twentieth centuries. If philosophical ideas about structures of matter have been able to play such a role in human life, if in European society they have operated almost like an explosive and may perhaps do so in other parts of the world, it is even more important to know what our present scientific knowledge has to say about this philosophy.

Werner Heisenberg, *The Debate between Plato and Democritus*

Having now discussed what effect the Quantum paradigm is likely to have on political science, some general examples of where the impact can be seen are given here. One of the many places that this shift has become very apparent in the social sciences as a whole is in the discussion of globalization. The trend towards thinking about things on a global level is partly due to the simple fact that technological advances in communication and transportation, along with an increased world population, have made it evident that nothing happens without having an effect on, or being affected by, the rest of the world. To state that this has been 'made evident' is to say that this was always the case; it does not state that this situation was recently created. The social sciences have just recently come to recognize it. In one book, a discussion of the factors of globalization in relation to politics includes the following:

> Climatologists even claim that the fluttering of butterfly wings in the tropical forests of Africa can affect rainfall in North America. Whether one likes it or not, the "ecological" planet is practically indivisible and we have to come to terms with planetary environmental interdependence...[66]

[66] Kimon Valaskakis and Angeline Fournier, *The Delusion of Sovereignty* (Toronto: Robert Davies Publishing, 1995), 19.

What is implicit in statements such as this reference to the butterfly effect is that our new interpretation of the world is less a consequence of any change in the world than just due to a change in the way we look at what always was.

Another example of the effects of the shift to a Quantum paradigm has been its challenge to liberalism. It has been argued that communitarianism is just a mild variation on liberalism without any new ideas of its own. It could be argued, however, that it is, in fact, a sign of the changes that have already been occurring in political science. The challenge to liberalism posed by the Quantum paradigm is this. Liberalism views humanity as composed of individuals capable of isolating themselves from their surroundings. As has been shown, in a Quantum paradigm every little perturbation has an effect on everything else. There is no such thing as an isolated system or individual. This is where communitarianism comes in. Communitarians agree with liberalism in that it stresses the happiness and livelihood of the individual as the ultimate goal. However, they argue that the happiness of one individual is tightly interwoven with the happiness of all others.[67] Civil society, thus, from this perspective, is a system of interdependent needs. This is much more in line with the Quantum paradigm.

The Newtonian framework of Hobbes' *Leviathan* has been described. The effect of the present shift has been to challenge Hobbes' first principles in the following manner. Hobbes started his induction in a very reductionist way. He puts man in a theoretical state of nature and determines the rules that govern his behavior. In this state man is independent and anti-social. As it does with liberalism, the Quantum paradigm

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[67] H.B. McCullough, ed., *Political Ideologies and Political Philosophers* (Toronto: Thompson Educational Publishing, Inc., 1995), 281.

challenges Hobbes' stress on the individual. In this paradigm, the idea of man as an anti-social, independent individual is not a good conceptual starting point. In addition, the Quantum paradigm challenges the idea that a system can be understood by breaking it down into a set of objects with set rules. According to it, the system as a whole is greater than the sum of its parts. A holistic view of humankind is required, not an atomistic one.

This brings us to the last example. As discussed earlier, the paradigm shift has had an impact on how public opinion is viewed. This is important in that it has the potential to have a great impact on the continuing debate over the ideal form of democracy. The idea that the interactions between things are more important than the individual objects themselves, illustrates that public opinion cannot be measured by simply adding up the opinions of each individual. This fact has been recognized in the social sciences. In discussing the various groups and individuals that play a role in forming public opinion G.E. Lang and K. Lang say, "It is in the *interaction* among these groups – as they form and change over time – that answers are likely to be found concerning the collective formation and impact of public opinion."[68] This idea has only begun to be put into practice due to the fact that the idea of one person, one vote is so strongly entrenched in western thinking, as well as the added feature that one person, one vote makes the process of calculating public opinion simple. However, as the concept of public opinion being more than the sum of individual opinions becomes more prevalent in areas such as qualitative research (e.g. focus groups), it will begin to affect how we think about determining the will of the people and the idea of one person, one vote in democracy.

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[68] Price, 43.

These have been only rough examples of the impact of the Newtonian-Quantum paradigm shift in the sciences on political science. Having come now to the end of the general discussion, we begin a more detailed analysis of specific examples. What follows is a survey of many of the major theories and methods in political science. Some theories extend back before Galileo and Newton and some originated at the beginning of the twentieth century. If the hypothesis that the scientific paradigm shift has an impact on political theories and methods is to hold true, then three trends must be evident.

1) Those theories and methods that were developed during the reign of the Newtonian paradigm will reflect that fact.
2) Theories and methods that were developed closer to the time of the paradigm shift will exhibit anti-Newtonian aspects, Quantum aspects, or both.
3) Recent developments in theories and methods, new and old, will reflect the newly established Quantum paradigm.

As a corollary to these points, it is expected that those theories and methods that have changed the most in the recent past, for whatever reasons, will more explicitly exhibit Quantum aspects. It is also expected that while some theories and methods will have made a more deliberate attempt to incorporate the new scientific paradigm than others, the predicted impact of the paradigm shift should not be limited to these cases.

The hypothesis of this work does not require, however, the paradigm shift to be the only explanation for changes in political theories and methods. More immediate reasons for the introduction of new approaches and revisions to old approaches are still valid. For example, the claim that the dissolution of the Soviet Union has had an impact on Marxist theory is not a competing theory to that argued here. Rather, it is predicted

that when a theory is challenged by world events, the reaction will be greatly influenced by the Quantum paradigm. In fact, as has been stated, theories which have been challenged the most are expected to show the greatest influence of the Quantum paradigm. The same is to be expected of new theories. They may have been developed for many different reasons but the more recent a theory is, the more evident the impact of the Quantum paradigm is expected to be.

The discussion of the theories and methods below is done in a manner that follows roughly the chronological order in which they were developed. Of course, the historical overlap of the theories and methods is great and the origins of most of them can be argued to have been existent in the time of the Newtonian paradigm. The three areas of political science discussed below are political economy, theories of methodology and feminist theory.

PART II: EXPLORATION OF THEORIES AND METHODS

1.0 Political Economy

Keynes was having dinner with Max Planck, the mathematical genius who was responsible for the development of quantum mechanics, one of the more bewildering achievements of the human mind. Planck turned to Keynes and told him that he had once considered going into economics himself. But he decided against it – it was too hard. Keynes repeated the story with relish to a friend back at Cambridge. "Why that is odd," said the friend. "Bertrand Russell was telling me just the other day that he'd also thought about going into economics. But he decided it was too easy"

Robert Heilbroner, *The Worldly Philosophers*

Following the design set out at the end of Part I, an examination is made here of the theories and methods of political economy. This seems an ideal place to begin an examination of political science. Viewing economics and political science as separate disciplines is a recent development. The great economists of the past were also the great political scientists. Until recently, few made the distinction. Even the separation between political philosophy and political economics was not so clear. This fact is made evident in the following discussion of the early (political) economists such as Adam Smith and Karl Marx.

Ronald Chilcote identifies nine phases of political economics.[69] The first two, petty commodityism and mercantilism, developed prior to the emergence of the Newtonian paradigm. Classical liberalism, utopian socialism, Marxism, and marginalism/ neoclassicalism all developed during the reign of the Newtonian paradigm. Thus a Newtonian orientation is expected amongst these theories. The development of

Keynesianism falls during the period when the Newtonian paradigm was under attack but the Quantum paradigm was not fully developed. Post-Keynesianism and Neo-Marxism were developed under the influence of the Quantum paradigm. It is amongst these last two and possibly the last three theories that the ascendancy of the Quantum paradigm should be evident.

The influence of Newtonian thought on classical liberals has already been mentioned.[70] The same influence on Adam Smith is also evident. After linking the practice of developing theories according to natural laws with the popularity of Newtonian physics, Daniel Fusfeld notes: "By the early years of the eighteenth century the political philosophers had developed a theory of liberal democracy based on natural-law precepts. An analysis of the economy in similar terms was next on the agenda."[71] It was Smith who took on this task, and *An Inquiry into the nature and causes of the wealth of nations* was the product. Smith's theory of economics emphasized the cumulative effects of individual actions through laws that explained, in mechanical terms, the deterministic equilibrium of a particular system[72] – in this instance, the capitalist system.

The political consequences of Smith's theory of economics are clear. The societal order and benefit produced by the freedom of the individual to pursue his/her own selfish ends provide a scientific argument for liberty. Economists, such as Jeremy Bentham, further extended the classical economic school, particularly with respect to politics.

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[69] Ronald Chilcote, *Theories of Comparative Politics: The Search for a Paradigm Reconsidered* (Boulder: Westview Press, 1994), 345-346.
[70] It will be discussed further with respect to Mill in the analysis of feminist theory within section 3 of this part.
[71] Daniel Fusfeld, *The Age of the Economist* (Illinois: Scott, Foresman and Company, 1986), 26-27.
[72] Robert Heilbroner, *The Worldly Philosophers: The Lives, Times, and Ideas of the Great Economic Thinkers* (New York: Simon and Schuster, 1980), 40-72.

Using what he believed to be basic laws of human nature determined by empirical observation, Bentham argued for a utilitarian calculation of the moral course of action based on the greatest happiness of the greatest number. The further impact of these ideas is seen clearly through the work of John Stuart Mill who, through a restatement of utilitarianism and individualism, advocated democratic government and majority rule.[73]

One of the contemporary reactions to Smith's theory of economics was to accept his laws as valid for the capitalist system and point out how certain initial conditions – the distribution of income – could result in the collapse of the capitalist system. This criticism, fully developed by Marx, in no way refuted the Newtonian basis of Smith's economics. If anything it embraced it. The influence of the Newtonian paradigm is evident in the preface to Marx's *Capital,* in which he compares his methodology to that of the contemporary objective observers of physics.[74] Furthermore, his discussion of the fundamental influence of the economic foundation of society, in the preface to his *A Contribution to the Critique of Political Economy*, has been attacked for being deterministic.[75] Possibly even more than Marx himself, Marxist thinkers of the time relied on the contemporary scientific method. "Some of their [Marx and Engels] most influential interpreters – Bernstein, Kautsky, Plekhanov – relied heavily on natural science models and analogies to uphold the scientific character of Marxism, especially ones drawn from the Darwinian theory of evolution."[76]

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[73] John Stuart Mill, *Considerations on Representative Government* (New York: Prometheus Books, 1991).
[74] Karl Marx, "Capital: A Critique of Political Economy", in *Karl Mark, Frederick Engels Collected Works*, vol. 35 (New York: International Publishers, 1996), 7-11.
[75] Ronald Chilcote, 342.
[76] Thomas Bottomore, ed., *A Dictionary of Marxist Thought* (Massachusetts: Harvard University Press, 1983), 349-50.

Marxist thought applied the scientific method to political economy, thereby developing dialectical materialism. The materialist perspective is clearly Newtonian. "To be a materialist means to look for the actual, material conditions and causes of things in order that men by knowing the world around them can live better."[77] In discussing historical materialism Howard Selsam wrote: "Here is found for the first time a completely materialistic conception of history as a process having a direction which is determined by the forces which move it forward."[78]

One aspect of Marxist thought is not typically Newtonian and that is the Marxist focus on the whole, which stems from its use of dialectical logic. Others recognised the difficulty of examining the whole through its parts. However, Marx went one further in stating that the parts cannot be removed from the whole. While the use of dialectical logic in Marxist thinking originated with Hegel, the focus on the organic whole was likely strongly buttressed by the influence of the biological sciences, such as Darwinism, on Marx. The interplay of organic systems, biology, and the Quantum and Newtonian paradigms will be revisited in the discussion of neo-Marxist political economy. For now, it is sufficed to say that in later reincarnations of Marxist thought such as Marxist structuralism, this holistic aspect has been retained while the more deterministic aspects have been dropped.

The political economists of the period between 1870 to 1900 responded to the Marxist criticisms of classical economics, particularly through the development of the principle of marginal utility. The position of these neoclassical economists was not far

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[77] Howard Selsam, *What is Philosophy: A Marxist Introduction* (New York: International Publishers, 1938), 41.

removed from that of their forerunners. "The model was essentially the same as Adam Smith's, modernized to eliminate the labor theory of value and to bring it into conformity with the philosophy of individualism and newer ideas about scientific method."[79] The desire to emulate the methods of the sciences was developed even further during this period. These methods remained clearly Newtonian. Mathematical models, based on the premise of the rational actor, were heavily utilised and, keeping in step with developments in the scientific method, theories were postulated that could be falsified through empirical observation. As in classical economics, the system was a given and unchanging. Little mention was made of social institutions. They could all be lumped together as a constant. All that was required was to determine the appropriate laws. "Like Newtonian physics, it was a science of finite space in which inexorable natural forces worked out a stable equilibrium."[80]

For the most part, John Maynard Keynes did not reject classical economics either. While being flawed, the system from his perspective could be repaired. In this sense, Keynes does not reflect any drastic transition from those theories born from Newtonian roots. He argued that the world described in the theories of the classical economists was too far removed from the actual world, so he provided an alternative.[81] The flaw stemmed from the wrong mathematical model and the absence of important laws, not from the application of such models. Although revised, earlier political economic thought was upheld if not saved by Keynes. "The promise of Keynesian economics was that

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[78] Howard Selsam, 15.
[79] Daniel Fusfeld, 93.
[80] Fusfeld, 92

individual freedom and social order were consistent with each other within the framework of prosperity of all."[82]

It has been argued that all of the theories described so far, including Keynesianism, fall into one paradigm. In fact,

> ...the paradigm that provides the inner framework for economic thought has not changed since the seventeenth century; that neither the advent of marginalism that distinguishes classical from neoclassical economics, nor the admission of the possibility of involuntary unemployment, that distinguishes Keynesian from neoclassical economics were revolutions in the Kuhnian sense.[83]

Despite the lack of evidence of any influence of the Quantum paradigm so far, there were those during the period in which Keynesianism was at its peak that showed clear signs of having begun to reject the Newtonian paradigm. Friedrich Hayek, who was very much in opposition to Keynesiainsm, was one such individual. In his writings, Hayek notes the limitations of the Newtonian scientific method in studying complex phenomena. He uses the example of physics to describe the scientific method and explains why such a method cannot be applied to the social sciences, in particular economics. What he describes as the methodology of physics is clearly Newtonian, and his reasons for not applying it to the social sciences reflects the rejection of Newtonian thought that was prevalent at that time. It is not clear, however, that the Quantum paradigm had had any effect.

Hayek argues that social systems are too complex for researchers to produce simple predictive theories. While physical systems may be modeled by reducing them to

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[81] John Maynard Keynes, *General Theory of Employment, Interest, and Money,* ed. Elizabeth Johnson and Donald Moggridge (London: Macmillan, 1973), first and only paragraph of chapter one.
[82] Fusfeld, 126.

a few key variables, the complexity of social systems makes such models unrealistic. Given the number of factors a model of a social system would have to incorporate, it becomes impossible to provide the necessary information for all the elements of the model.[84] Thus, it would be unreasonable to expect to be able to create a law that predicts the exact occurrence of an event in a particular place at a particular time.

This limitation on studying social systems does not, according to Hayek, eliminate the possibility of producing testable theories. It simply means that the available theories will provide an understanding of relationships and structures. They will not provide any predictive power except to say that if A happens then B will not happen and either X, Y or Z will likely follow.[85] Consequently, theories in fields of study such as economics can best be used to provide an understanding of the types of events that can and cannot occur, under certain circumstances.[86] The idea that understanding rather than prediction ought to be the goal of study might appear to be based in the Quantum paradigm. However, Hayek reaches this conclusion through a belief that we can only obtain imperfect information due to human limitations, not from the Quantum paradigm concept that perfect information does not exist due to laws of nature. It is also due to the inability of man to obtain complete and perfect information that Hayek rejects the search for deterministic laws.[87] This is a rejection of the Newtonian method without showing

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[83] Guy Routh quoted in Gregory Daneke, "On Paradigmatic Progress in Public Policy and Administration," *Policy Studies Journal* 17, no. 2 (Winter 1988-89): 279.
[84] F.A. Hayek, "Degrees of Explanation," in *Studies in Philosophy, Politics, and Economics* (Chicago: The University of Chicago Press, 1967), 8-9.
[85] Hayek, 10-11.
[86] F.A. Hayek, "The Theory of Complex Phenomenon," in *Studies in Philosophy, Politics, and Economics* (Chicago: The University of Chicago Press, 1967), 35.
[87] Hayek, "The Theory of Complex Phenomenon," 37.

any signs of the Quantum paradigm. A rejection of determinism based in Quantum thinking would point to the non-determinism of nature itself.

In addition to the rejection of determinism and predictive laws, Hayek notes that the concept of a closed system (other than the universe) is a false one due to the infinite connections between every conceivable element.[88] Moreover, he notes that the numerous elements and their interconnections will produce properties in the whole that do not appear in the individual parts. These emergent properties are a function of the system and not of its parts.[89] In many ways the logic of Hayek's philosophy at the time was one step away from that of the Quantum paradigm. Unlike Newtonian based logic, there was nothing within it that would contradict a Quantum approach. It simply lacked a few key pieces of information that the natural sciences had only just discovered.

Developed in the late 70s, the philosophy of Roy Bhasker shares this characteristic of being ready to accept the Quantum paradigm.[90] Bhasker's ontology is an open and complex system that is composed of multiple layers, which are irreducible yet continuously interacting and evolving. It is indeterminate and defies prediction, yet follows rational rules that can be discovered and understood.[91] Michael Reed and David Harvey in "The New Science and the Old: Complexity and Realism in the Social Sciences," recently took on the task of combining Bhasker's philosophical ontology with a Quantum paradigm based scientific ontology.[92] The scientific ontology used is that of

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[88] Ibid., 34.
[89] Hayek, "Degrees of Explanation," 26.
[90] Roy Bhaskar, *A Realist theory of Science* (Sussex, England: The Harvester Press, 1978).
[91] Roy Bhasker, 45-62.
[92] Michael Reed and David Harvey, "The New Science and the Old: Complexity and Realism in the Social Sciences," *Journal for the Theory of Social Behaviour* 22, no.4 (1992): 353-380.

Nobel Laureate Ilya Prigogine. Prigogine's work is on dissipative systems, which is a subset of systems that fall under the more popular term chaos theory. In the next section, as part of a discussion on the explicit application of chaos theory to the social sciences, more will be said of the work of Prigogine. The point of interest for the present discussion of political economy is that the social ontology that is developed from the combination of Bhasker's and Prigogine's work is identified as a possible saviour for historical materialism by releasing it from its mechanistic determinism.[93] In other words, it is a way to save Marxism from its Newtonian failings. Before more is said of the attempt to revive Marxism, we return to Hayek.

Like the arguments of others of his time, Hayek's criticism of the appropriateness of applying the scientific methodology to the social sciences was actually at the same time being laid against the appropriateness of applying the Newtonian method to science itself. To some extent Hayek was aware of this, as he noted that physics was reaching a point where the complexity of its subject matter made the scientific method inapplicable.[94] However not having full knowledge of the evolving paradigm shift in the sciences, Hayek was not aware that he had only to wait to be presented with a methodology that would fit the requirements of his philosophy. Instead, Hayek looked to biology to find an alternative method of study to that of physics. While many biologists were as entrenched in the Newtonian paradigm as any scientist, the subject matter of biology itself made it more readily accepting of non-Newtonian ideas. It is likely for this reason that Hayek identified it as a potential field of study to model the study of social

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[93] Reed and Harvey, 366.
[94] Hayek, "Degrees of Explanation," 20.

systems. Once again, a discussion of organic systems, biology, and the Quantum and Newtonian paradigms will be provided in the following section on neo-Marxist political economy.

Overall, Hayek provides a useful example of the type of thinking that was produced by researchers that had come to accept the limitations of the Newtonian paradigm, without having the Quantum paradigm fully articulated and at their disposal. While such evidence of the rejection of the Newtonian paradigm is promising, there has thus far been little evidence of the impact of the Quantum paradigm. However, Elias Khalil notes both quantum mechanics and chaos theory have captured the attention of economists.[95] So we press on to examine two recent developments in political economy – neo-Marxism and post-Keynesianism – in order to verify this claim.

The variants of neo-Marxism are too broad to make many specific comments. However, as a set of theories that use Marxist thought as a starting point, there are generalizations and commonalties that are useful to note. As indicated previously, the aspects of Marxism that are abandoned by most neo-Marxists are those of reductionism and determinism. The tendency of Marxist thought to favour structural determinism is strongly resisted by neo-Marxism. This has meant a great deal of effort spent trying to answer the question of why the state serves the class system in non-structural terms.[96] In fact, the issue of class is downplayed in order to incorporate a range of social constructions. As described by George Taylor:

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[95] Elias Khalil, "Chaos Theory Versus Heisenburg's Uncertainty: Risk, Uncertainty and Economic Theory," *The American Economist* 41 no. 2 (Fall 1997): 28.
[96] Murray Knuttila, *State Theories: From Liberalism to the Challenge of Feminism* (Halifax: Fernwood Publishing, 1992), 149.

> This trend, which is now firmly entrenched, has occurred largely as a result of a systematic attempt to rid Marxism of essentialist or reductionist forms of explanation in favour of concepts which stress the partially contingent nature of social reality. This represents a crucial departure, since it also rejects the view that society inevitably follows a particular path...[97]

On the other hand, the Marxist focus on the whole, the view of society as organic, changing, dynamic and greater than the sum of its parts, and the focus on interconnections between parts is embraced fully. It was proposed earlier that this perspective was originally supported by the biological sciences of the time. Recently, this same perspective, or a similar one, is supported by the sciences of the Quantum paradigm.

This brings the discussion to the promised note on organic systems, biology and the Newtonian and Quantum paradigms. While biological science, during the reign of the Newtonian paradigm, was Newtonian in its approach, there remained something very non-Newtonian in its subject matter.[98] So much so that some, such as Thomas Landon Thorson, separated those influenced by Newton from those influenced by Darwin. He includes Hobbes, Locke, Harrington, Madison and David Easton in the first group, and Marx and Hegel in the second.[99] An interesting question to ask is: 'How would have the world been different if the Newtonian paradigm, based on physics, was replaced as the dominant paradigm by one based on theories from biology?' Biological systems are, of course, organic. This is very much at odds with Newton's mechanistic view of physical

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[97] George Taylor, "Marxism," in *Theory and Methods in Political Science*, ed. David Marsh and Gerry Stoker (New York: St. Martin's Press, 1995), 266.

[98] It is worth repeating that this is not to say that the biological sciences were any less Newtonian than the other sciences. Reductionism was just as much a part of its approach as anywhere else in the sciences. The difficulties of this approach were simply more evident in the study of biological systems.

[99] Thomas Landon Thorson in Chilcote, 139.

systems. If there is a science in which it is impossible to miss the importance of interconnections and the emergence of properties within systems that are greater than the sum of their parts, it would seem to be biology.

Biological studies in general and Darwinian thought in particular had an impact on those more familiar with it in a way that did not adhere strictly to a Newtonian paradigm. Thorson is right in identifying the presence of a Darwinian influence on Marx, which is not present in those such as Locke or Madison. Yet it would be overstating the point to argue that Darwinian thought represents a separate paradigm or claim that it was not in fact fundamentally Newtonian. Even ecology, the science that is upheld as the most holistic of them all, didn't produce claims of holism and emergentism until the 1950s.[100] In other words, ecology had to wait for the Quantum paradigm to take hold in order to take on its much-praised holistic orientation. Even now, it is argued by some that while a holistic ontology may exist within ecology, its methods remain primarily reductionist.[101] This is the strength of the hold of the Newtonian paradigm.

It is along these lines that the influence of biological systems on Marxist thought diverted Marxism from purely Newtonian principles, without posing any real threat to Marx's Newtonian methodology. The direction of this ontological diversion is furthered today. Not, however, from any particular influence from biology but rather from the impact of the Quantum paradigm. Within the Quantum paradigm, there is more than just a sense of the importance of dynamic, interconnected systems. The Quantum paradigm adds to this the pursuit of building theories rather than proposing law-like generalizations

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[100] Donato Bergandi and Patrick Blandin, "Holism vs. Reductionism: Do Ecosystem Ecology and Landscape Ecology Clarify the Debate?" *Acta Biotheoretica*, 46 (1998): 188.

and a resistance to determinism and reductionism. Appropriately, so do those theories that fall within the category of neo-Marxism.

Similar to many 'post'-theories, post-Keynesianism has many variations and often defines itself simply as in opposition to neo-classical economics. However, in *Post-Keynesianism: A New Approach to Economics*, Philip Arestis identifies key characteristics of those theories identified as post-Keynesian. To start, Arestis describes the post-Keynesian methodology as "a holistic rather than a reductionist or atomistic approach."[102] He also points out that its perspective emphasizes explanation over prediction.[103] This emphasis is seen in the post-Keynesian use of econometric models that are intended to increase understanding and are recognised to be dynamic and changeable and are not intended to produce predictions.[104] Arestis also points to the recognition of subjectivity in the handling of facts by post-Keynesianism,[105] as he does to the fact that it is explicitly not deterministic and it rejects the notion of the rational actor.[106] It adopts an uncertain, probabilistic view of the world.[107]

While the influence of the Newtonian-Quantum paradigm shift in the sciences on the methods of political economists is now clearly evident within neo-Marxism and post-Keynesianism, it is not limited to it. In a neo-conservative argument for a free-market economy, Don Lavoie identifies the standard criticisms of orthodox socialism, capitalism

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[101] Bergandi and Blandin, 190.
[102] Philip Arestis, "Post-Keynesianism: A New Approach to Economic," *Review of Social Economy* 48 (Fall 1990): 222-3.
[103] Philip Arestis, 225.
[104] Arestis, 229.
[105] Ibid., 225-6.
[106] Ibid., 226-7.
[107] Ibid., 227-8.

and Keynesianism as criticisms of Newtonian thinking.[108] As he states: "The older views of socialism ... have been subjected to criticisms along essentially the same lines as the older views of science have been."[109] He further argues that problems with socialism within this century stem from Newtonian elements that have been retained from nineteenth century thinking. "Socialist political economy was not just influenced by the 19th-century view of science, it was modeled on it. ... It would certainly be understandable if many aspects of the Marxian system of thought were tainted by the mechanistic model of the universe in which 19th-century culture was embedded."[110] Lavoie identifies chaos theory and quantum mechanics as part of a 'new science' that should be used to reconsider theories of political economy.[111] In doing so he advocates a theory of political economy that provides understanding rather than prediction. Moreover, he indicates that this new science is already being employed by the economic reformers of the Republic of China.[112]

One last study within political economy needs to be mentioned. That is the work of Elias Khalil. In "Chaos Theory Versus Heisenburg's Uncertainty: Risk, Uncertainty and Economic Theory," Khalil attributes a disagreement within political economy to a confusion between the chaos and quantum concepts of indeterminism.[113] Very conscious of the impact of recent developments in science on political economic theory, Khalil attempts to highlight the result of putting a greater emphasis on one aspect of the

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[108] Don Lavoie, "Economic Chaos or Spontaneous Order, Implications for Political Economy of the New View of Science," *Cato Journal* 8, no. 3 (Winter 1989): 615, 623, 628.
[109] Don Lavoie, 615.
[110] Lavoie, 613.
[111] Ibid., 618, 621.
[112] Ibid., 614, 619.
[113] Elias Khalil, 27-40.

Quantum paradigm than on another aspect. He argues that if chaos theory is the primary influencing force, one might view the world as indeterminate due to the limitations of human knowledge. Alternately, quantum mechanics as a primary influence will result in an interpretation of indeterminism as a consequence of the uncertainty inherent in the world.

To incorporate Khalil's discussion into the theory being developed in this study, it must be noted that he confuses the use of the term determinacy in chaos theory. There is no actual claim to indeterminacy in chaos theory, only unpredictability. Systems are fully determinant but are unpredictable due to incomplete knowledge. Some argue, the cause of imperfect knowledge is an unanswered philosophical question and that it can be attributed to the limitations of humans, to the inherent nature of knowledge or to both. The Quantum paradigm as it has been defined in this study does not leave this question ambiguous. Indeterminacy is explained as follows. Systems are indeterminate because, for them to be otherwise, it would be necessary to collect exact measurements of all influencing variables. As it happens, systems have an infinite number of influencing variables and exact measurements are more than difficult to obtain – they are prohibited from existing. Even if it were possible to exactly determine the state of a system at a particular time, at some unpredictable future time the system would undergo a just as unpredictable change (a bifurcation), so that the new state could not have been predicted from its past. Furthermore, a system with any degree of complexity will have emergent properties that cannot be determined from its constituent parts or the interactions between its constituent parts. From this interpretation, the argument in economic theory that Khalil

has identified results from two theoretical camps that agree the world is unpredictable, but disagree over whether it is determinant.

In the discussion of Hayek, the attribution of unpredictability to the limitations of human knowledge was described as the consequence of rejecting the Newtonian paradigm without having the Quantum paradigm at hand. It is those such as Hayek that Khalil is really describing when he refers to those that have taken into account chaos rather than quantum mechanics. As we have seen this is a very narrow interpretation of chaos theory – one that is inconsistent with the Quantum paradigm as defined in this work. So we can now use our reinterpretation of Khalil to argue that the disagreement in political economics is actually between those that have rejected the Newtonian paradigm and those that have incorporated the Quantum paradigm.

From the perspective of political economy, there is evidence to support the hypothesis that the dominant scientific paradigm plays an important role in the development of theories and methods within political science. The discussion now turns to theories not too far removed from those discussed up to this point. They are theories with a methodological focus. Like theories of political economy many – but not all – of the following theories actively seek out a relationship with scientific methods.

2.0 Small "p", Small "t" – political theories

Methods from these "new sciences" are already being applied to various facets of social inquiry by some of the physical sciences and mathematicians who originated them. Moreover, the general societal impacts of these alternative worldviews have been discussed by physicists and engineers, turned social philosophers. Yet relatively few social scientists have appreciated the implications of these breakthroughs for their own paradigmatic miasma.

Gregory Daneke, *On Paradigmatic Progress in Public Policy and Administration*

The theories examined here are those that focus more on the methods of political inquiry than on any concern with explanation, philosophy or ideology. Behaviouralists Neil McDonald and James Rosenau distinguished such methodological political theories from the more traditional sort by referring to the latter as *Political Theories*, with capitals and the former at *political theories*.[114] Not all theories identified here as methodological are behaviouralist. In fact, this section begins with those theories developed before the rise of behaviouralism and extends into theories of post-behaviouralism. Moreover, the use of the distinction between the two types of political theories is used here for purposes of categorization and is not intended to imply, as many behaviouralists have, that Political Theories should be left to philosophers.

The many theories that fall into this category can for two reasons be viewed as a benchmark to test the paradigm shift. First, it is within these theories that one finds the greatest conscious attempt to incorporate scientific methods into the social sciences. Indeed, this fact essentially defines the work of individuals such as Marie Jean Antoine Nicolas Caritat, Marquis de Condorcet and theories such as behaviouralism. Second, these theories have traditionally been the most tied to the scientific methods of the

Newtonian paradigm. In other words, while the incorporation of the Quantum paradigm within political science may be the most explicit within these theories, it is also within these same theories that one would expect to find the most resistance; they have the greatest roots in Newtonian methods. These are in fact the trends that become apparent when these political theories are examined.

The application of the scientific method to the political sciences and the use of statistical methods in order to do so, made popular by the behaviouralists after the Second World War, have their roots in the 17th and 18th centuries. Condorcet was a French scientist and much more who took this task very seriously. For Condorcet, the methods and mathematics of physics could and should be fully applied to the political sciences.[115] "Why shouldn't politics grounded like all the other sciences on observation and reasoning, be perfected accordingly, as more subtlety and exactitude are brought to its observations, more precision, profundity and accuracy to its reasonings."[116] This is not to say that Condorcet was the first with this view – far from it. The foundations of much of what Condorcet advocated had been established by John Locke.

For political science, Condorcet advocated a rationally determined world order, examined by the tools of Newtonian physics. At the same time, he recognised that man can only have imperfect knowledge, even of a deterministic universe, explored with the tools of reduction, observation and induction; thus, his belief in the probable nature of

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[114] David M. Ricci, 147.
[115] Keith Baker, *Condorcet: From Natural Philosophy to Social Mathematics* (Chicago: University of Chicago Press, 1975), 85.
[116] Condorcet, in Baker, 197.

knowledge and his endorsement of statistical methods.[117] With regards to the former, Condorcet was greatly influenced by David Hume, and the latter, by Jacob Bernoulli.[118] Hume, too, was concerned with examining the implications of Newtonian science for the human sciences. Hume argued that humans are limited in their abilities to determine the truth. Even the most precise observations do not provide demonstrable knowledge of cause and effect. For example, Newton's laws of gravity based on precise observations allow for very exact predictions of the movement of objects. They do not, however, demonstrate the cause of gravity. Hume argued that man can only have probable knowledge, in that through observation he can note that certain events accompany or proceed others. Thus, man can expect a certain event to be followed by another and would be surprised if it did not. However, without the ability to understand cause and effect he cannot claim to know that the second event will follow the first – it is simply probable.[119]

This understanding of knowledge related nicely to the statistical methods being developed at the time and the two were brought together. "In effect, one of Hume's most important contributions to the logic of probable knowledge was to assimilate rational belief to the mathematical model of probability of chances."[120] Bernoulli is credited with having established much of the framework for the classical theory of probabilities applicable to the human sciences. "It was this Bernoullian vision of a mathematical

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[117] Baker, 105, 118.
[118] Ibid., 159-161.
[119] Ibid., 154-155.
[120] Ibid.

science of conduct, theoretically applicable to all the probabilities of life, that was to dominate Condorcet's conception of social science."[121]

The use of statistical methods in no way indicates that these thinkers rejected cause and effect or the existence of an objective, deterministic order to the world – quite the opposite. "Objectively, Hume insisted, there is no such thing as chance; there is only subjective ignorance into the ordered sequences we designate as cause and effect."[122] Bernoulli noted that the fall of the die is a determined event that could not be other than we observe and which we must treat as contingent only because of our ignorance of the causes of the outcome.[123]

This understanding of statistics is mirrored in the use of statistical mechanics to understand gases. The concept utilised in this instance is that the parts of the system operate according to deterministic Newtonian principles. However, the parts involved and the factors at work are numerous, so any one part may be acting in any one of many different ways at any given time. Thus, in order to produce laws for gases one must consider that the combined effects of the parts will follow the law of large numbers and produce, on average, a steady result (temperature and pressure in the case of the gas). Hence the use of statistics from a Newtonian perspective.

It is in this way that studies of democracy were carried out – in particular of electoral behaviour. Factors affecting voting behaviour were interpreted as essentially deterministic, although numerous and complicated. To overcome this complexity, it was assumed that many of the factors involved could be averaged out over a large segment of

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[121] Ibid., 158.
[122] Ibid., 155.

the population and/or over time. The law of large numbers promised that a steady equilibrium would emerge from the mass of individual actions.

This trend in social sciences continued and was the foundation for the behaviouralism of the twentieth century, popularised in the political sciences in the period following the Second World War.[124] Like their predecessors, behaviouralists are very much concerned with the application of the scientific method to political science – in this case, however, in the Popperian style.[125] The scientific method, thus defined, is very much but not completely Newtonian. The ideas borrowed from the sciences and subsequently refined are those from early twentieth century science. This was a period in which the Newtonian view of the world was greatly discredited; however, the forthcoming Quantum view had yet to be fully developed. Behavioralism is Newtonian in its nominalism and empiricism, and its rejection of normative theory. However, rather than advocating objectivity, behaviouralists argue for intersubjectivity. While individualistic, they reject the view of society as one simply composed of individual rational actors and puts an emphasis on the processes of institutions.[126] As Ricci wrote, "even [Joseph] Schumpter, who stripped his definition of democracy down to a Newtonian balance between competing elites, observed that democratic devices will function successfully only within a context of convictions and habits that lead to moderation and responsibility."[127] In other words, even the most Newtonian based research at the time could not avoid recognizing the importance of interactions and

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[123] Ibid., 157.
[124] David M. Ricci, 133-175.
[125] By Popperian style I mean Karl Popper's philosophy of science.
[126] Ricci, 140, 145, 157.

emergent properties such as civic culture. Furthermore, Popperism, upon which behaviouralism was built, rejected the Newtonian concept of induction in research.[128] Karl Popper himself attacked Marx's inductive reasoning and determinism.[129] Finally, in directly comparing themselves to the clearly Newtonian perspective of the classical liberals, behaviouralists recognised a complexity in political phenomenon not identified by traditional liberalism.[130]

It would be misleading to overstate the degree to which behaviouralist methods were at the time distinguished from those of the Newtonian paradigm. In the epilogue to *Essays on the Scientific Study of Politics*, Leo Strauss describes the rise of behavioralism within political science as the final catch-up to the sciences.[131] He argues that the natural sciences had undergone a revolution in the 17th century and that political science had ever since been slowing moving away from Aristotelian political science, in order to conform to the new science – that of Newton.[132] Strauss' view of behavioralism as the final step from Aristotelian to Newtonian political science was common and incorrect.

Strauss' view was incorrect because while it is true that behaviouralism called for an adherence to scientific methods, it wasn't to the methods of the 17th century. Rather it was the methods of the late nineteenth/early twentieth century that informed behaviourism. In hindsight, we can see that this was a transitional period in the scientific paradigm. As has been noted, this was a period in which the Newtonian paradigm was on

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[127] Ibid., 174.
[128] Ibid., 117.
[129] Ibid., 125
[130] Ibid., 160-62.
[131] Leo Strauss, "An Epilogue," in *Essays on the Scientific Study of Politics*, ed. by Herbert Storing (New York: Holt, Rinehart and Winston, Inc., 1962), 307-327.
[132] Leo Strauss, 309-311.

its way out, yet the Quantum paradigm was just being articulated. This was not so clear at the time of its occurrence. As a consequence, many political scientists that wished to be true to the sciences often found they were appealing to methods that contradicted themselves. They resembled 17th century science but were not. The desire to be true to the sciences meant that behaviouralists, at times, found themselves in opposition to the emerging Quantum paradigm of the sciences. At other times, they found themselves in opposition to the older Newtonian paradigm.

For example, written during the sixties, Alan Isaak's "Scope and Methods of Political Science" groups political science approaches into two – the traditional approaches and the behavioural approaches.[133] Isaak uses behaviouralism to examine methodological theories such as the individualistic-psychological approach, the rational approach and game theory, role theory, the group approach, systems theory and functional analysis, communication theory, and the power approach. While acknowledging the challenges of a more holistic approach, he defends the reductionist/individualistic position of behaviouralism.[134] Isaak defends the individualistic approach against the claim that it ignores emergent group properties by appealing to the methods of the sciences. However, the sciences themselves had by this time come to recognise the importance of emergent properties. So, Isaak was appealing to an aspect of the scientific method already abandoned by the sciences. Moreover as a logical positivist, as was the case with most behaviouralists, Isaak strayed from the Newtonian paradigm he appealed to for defense of his methodology. He advocated

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[133] Alan C. Isaak, *Scope and Methods of Political Science* (Homewood Illinois: The Dorsey Press, 1969).
[134] Alan Isaak, 27, 38.

intersubjectivity, rather than objectivity and rejected the positivist assertion that only observable phenomenon mattered. Given the great methodological turmoil at the time created by the Newtonian-Quantum paradigm shift, it is not surprising that a methodological theory which endeavored to model itself on the sciences found itself in such a position.

While particularly prevalent during the 1950s and 1960s, behavioralism came under heavy attack at the end of this period. Amongst those that adhered to the behavioural/empirical theory, it is well recognised that the late sixties transformed their practice. It was also noted that the concepts being challenged were those of an Enlightenment origin. In discussing the restructuring of political theory in the sixties Richard Bernstein notes:

> It is believed that solid empirical knowledge can help us not only to escape from superstition and prejudice, but also to achieve enlightened action. But many of these beliefs that led to such high hopes and expectations in Enlightenment thinkers have turned sour. There seems to be a natural progression from early Enlightenment ideals to contemporary positivist and empiricist modes of thought. What were once great liberating ideas have turned into suffocating strait jackets.[135]

In 1966, Gabriel Almond noted the development of a new paradigm in American political behaviouralism. In *Political Theory and Political Science*, he made three assertions.

> First, there was a coherent theoretical formulation in the American political theory of the eighteenth and nineteenth centuries. Second, the development of professional political science in the United States from the turn of the century until well into the 1950's was carried on largely in terms of this paradigm... Third, in the last decade or two the elements of a new, more surely scientific paradigm seem to be manifesting themselves rapidly.[136]

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[135] Richard J. Bernstein, *The Restructuring of Social and Political Theory* (New York: Harcourt Brace Johanovich, 1976), xxii to xxiii.
[136] Gabriel A. Almond, "Political Theory and Political Science," *The American Political Science Review* 60, no. 4 (December 1966): 869.

Agreement on what the new paradigm was is less evident in the literature that discusses this shift in political theory. For Almond's part, he advocated systems theory. Like many of the mainstream political methods of its time, systems theory demonstrated aspects of the Newtonian paradigm – such as determinism, while revealing the influences of the Quantum paradigm – such as a recognition of the importance of system level interactions and emergent properties.[137]

The reaction to behaviouralism and more generally positivism, has been extensive and varied. Some theories such as post-modernism outright reject the behaviouralist's desire to apply science to social science. Others simply suggest updating the notion of science applied by the behaviouralists. For example, those involved in statistical analysis continue the tradition of applying scientific methods to political science but with a more recent understanding of science.

Quantitative statistical analysis is an excellent example of a method which in practice has remained virtually the same under the influences of both the Newtonian and Quantum paradigm and yet has undergone great changes in meaning. As it has passed through the hands of those like Condorcet, on to the behaviouralists and beyond, many of the techniques have remained the same. However, important changes have taken place in the purpose, understanding and interpretation of the analysis performed. While the use of concepts such as cause and effect, and the desire to create predictive models, were originally taken for granted, there has been a move away from such ideas. Statistical analysts use terms such as cause and effect very carefully – although, not as carefully as many would like them to. Techniques that take into account reciprocal causation have

[137] Chilcote, 129-148.

gained popularity. Non-recursive models or simultaneous equation models recognise that some pairs of factors may not fit into a simple cause and effect relationship. One variable may be as much of a cause as an effect of another.

Ronald Inglehart is one of the more popular political scientists to rely heavily on quantitative analysis. In his more recent work, *Modernization and Postmodernization*, he provides an ideal example of the new language of statistical analysis. Inglehart shuns any and all deterministic interpretations and avoids making predictions. Alternatively, he discusses the probability or likelihood that societies will behave in a particular manner. "One cannot foretell the precise course of social change. Nevertheless, certain syndromes of economic, political, and cultural changes go together in coherent trajectories, with some trajectories being more probable than others."[138] This recent understanding of quantitative analysis is more in line with the Quantum paradigm. It downplays prediction, particularly at the individual level. It stresses understanding contributing factors at the systems level and it cautions against assuming simple cause and effect relationships.

In quantum mechanics, statistics are used to describe the probability of an electron existing within a specified space or the probability of finding an electron with a specified value for a property such as momentum. The statistics are given the interpretation that, until observed, the electron exists in a superposition of all possible states; e.g. it exists in all possible momentum states. Until observed, electrons are not considered to be in any one state. The act of observation is as important as the electron itself to specifying the state the electron is observed in. In contrast to the Newtonian

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[138] Ronald Inglehart, *Modernization and Postmodernization: Cultural, Economic, and Political Change in 43 Societies* (Princeton: Princeton University Press, 1997), 7.

concept of statistics, events do not have a determined outcome. In the Newtonian paradigm, statistics are used because we do not know the state of an object; however, we do know the statistical distribution of the states of a large number of objects. In the Quantum paradigm, *each* object has a probability distribution that describes the chances of all its possible outcomes. It is for this reason that statistics describe outcomes. Events are probabilistic in and of themselves, not just probabilistic in our knowledge of them.

Non-linear statistical techniques that work on the basis of probability have incorporated this Quantum paradigm understanding of statistics. They are employed in decision-making models that build off the assumptions of the classical rational theorists. Like the rational theorists it is assumed that the utility of an outcome for an individual can be described numerically in an equation. However, recently developed analysis, such as logistic regression, allows for non-linearity in these equations. Even more importantly, these techniques provide a probabilistic result where classic utilitarian theory produced a prediction. Instead of trying to predict the behaviour of an individual, logistic regression indicates the probability that an individual will behave in a certain manner. If an individual does not act in the manner the model indicated they were most likely to, the model has not failed; there was always the probability that they would act otherwise. This probability is not interpreted as a limitation of our knowledge but as the probabilistic nature of human behaviour. Also incorporated in the more recent forms of utilitarian theory are imperfect knowledge, subjective interpretation, uncertainty and unconscious utility.[139]

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[139] For an excellent collection of readings on the incorporation of these concepts into utility theory see: Peter Gardenfors and Nils-Eric Sahlin, ed., *Decision, Probability, and Utility* (New York: Cambridge

Even within a basic linear regression, the concept of perfect prediction has been lessened. The error or disturbance term in a regression equation has classically been interpreted as the result of measurement error or the effect of relevant variables left out of the model. While these interpretations remain, added to them is the idea that the error term also results from intrinsic randomness.[140] In accordance with these new interpretations of statistical methods, models of behaviour are seen to act in a manner similar to reality; they are not seen as a copy of reality and they are not intended to predict outcomes. As models designed to predict come to be seen as unrealistic, models designed to understand take their place.[141] The explicit use of chaos theory also displays a clear desire to apply a modern understanding of science to the social sciences.

Ilya Prigogine won the Nobel Prize in 1977 for his work on dissipative chemical systems. That is the behaviour of systems far from equilibrium. Through their work, Prigogine and Isabelle Stengers found that many of the Newtonian conceptions of the world were challenged by the nonlinear processes of nonequilibrium systems (chaos theory). This has had a substantial impact within science and the philosophy of science. The subsequent work of this team extends their analysis to include many other types of systems, including social systems. As Alvin Toffler notes in the introduction to *Order*

University Press, 1988). For an example of the use of utility theory in political science see: Henry Brady and Stephen Ansolabehere, "The Nature of Utility Functions in Mass Publics," *American Political Science Review* 83, no. 1 (March 1989): 143-163.

[140] Damodar N. Gujarati, *Basic Econometrics* (New York: McGraw-Hill Book Company, 1988), 34.

[141] The use of statistics by political scientists sometimes exhibits an interesting irony similar to that of behaviouralism. There are instances of great lamentations of the failure of political science to be able to incorporate the Newtonian/Popperian scientific method to its full extent. The need to view the world from a probabilistic viewpoint, instead of a deterministic one, along with the inability to reduce a system down into its parts within political science research, is seen as a failure. In these instances, the use of statistical methods is seen as a second best alternative to the scientific method. It is not recognised that the new science – that of the Quantum paradigm – calls for a probabilistic, statistical viewpoint.

Out of Chaos, "just as the Newtonian model gave rise to analogies in politics, diplomacy, and other spheres, seemingly remote from science, so too does the Prigoginian model lend itself to analogical extension."[142]

After exploring the applicability of chaos theory to the social sciences in *Chaos Theory and Its Implications for Social Science Research*, Gregersen and Sailer describe the important implications. The essential points made are that cross-sectional data collection and simple correlation analyses are unreliable and must give way to longitudinal measurements that can capture changes in dynamic systems over time. Simulations and other quantitative techniques are still useful tools but they must be used in order to understand rather than predict – prediction is a fruitless pursuit. To this end, there is an increased benefit in using qualitative techniques alongside quantitative methods.[143] Since the application of chaos theory is explicit, it is no surprise that these suggestions are based in the Quantum paradigm.

In "Nonlinear Politics," Thad Brown makes the argument that trying to understand electoral decisions at the level of the individual ignores the social dynamics at work in such cases.[144] While decisions are made by individuals, these decisions are the result of interactions. It is these interactions that are important in the understanding of large-scale collective behaviour as found in elections.[145] Accordingly, Brown advocates a holistic approach that focuses on interactions and uses nonlinear mathematics to produce

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[142] Alvin Toffler, xxiii.
[143] Hal Gregersen and Lee Sailer, "Chaos Theory and Its Implications for Social Science Research," *Human Relations* 46, no. 7 (1993): 792-798.
[144] Thad A. Brown "Nonlinear Politics," in *Chaos Theory in Political Science*, ed. L. Douglas Kiel and Euel Elliot (Ann Arbor: The University of Michigan Press, 1997), 119-137.
[145] Thad A. Brown, 121.

an iterative model of voting behaviour.[146] The consequence of such an approach is that the focus of the study is on understanding the dynamics of electoral decisions, not on the prediction of the outcome. The nonlinear nature of the forces at work in collective decision making makes prediction unfeasible but it does not eliminate the existence of patterns and well defined relations. Furthermore, while the state of a system may not be predictable at any moment, there are macroscopic variables that may be predictable over long periods of time.[147]

To end this section, the discussion turns to a recent development – social constructivism or interpretism. As a theory it fits somewhere between the outright rejection of the positivist notions of behaviouralism and a simple revision of behaviouralist methods. Constructivism is post-positivist in that it suggests major revisions but not anti-positivist as it does not simply reject positivism outright in the way post-modernism does.

> It rejects the "slash and burn" extremism of some post-modern thinkers who leave nothing behind them, nowhere to stand, nothing even for themselves to say. ... Indeed, constructivism maintains that the sociopolitical world is constructed by human practice, and seeks to explain how this construction takes place.[148]

However, this explanation of social construction is not a positivist exercise. "Standing back and observing this process is a useful activity, often to be undertaken with scientific

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[146] Ibid., 123.
[147] Ibid., 121.
[148] Vendulka Kubalkova, Nicholas Onuf and Paul Kowert, "Constructing Constructivism," in *International Relations in a Constructed World,* ed. Vendulka Kubalkova, Nicholas Onuf and Paul Kowert, (New York: M.E. Sharp, 1998), 20.

rigor, but not an activity that can produce the comprehensively true picture of the world to which positivists aspire."[149]

Like the other theories that fall into the small "p", small "t" category, it suggests a method and approach rather than an explanation. Constructivism crosses many disciplines and no consensus has developed on its application. However, there are distinct commonalities that clearly fit into a Quantum paradigm. For constructivists, truth is a social construction. In this way, an observer cannot be completely objective in his/her examination as there is not an objective truth to observe. The focus of constructivist research is not objects but rather processes, in particular processes of the social construction of rules and the development of institutions through the interactions between actors and these rules. The importance of interactions and the properties that emerge out of them is a fundamental aspect of both constructivism and the Quantum paradigm, as is the recognition of the impact of the observer on the system being observed.[150]

An excellent example of this connection is found in the application of social constructivism to international relations theory. In *International Relations in a Constructed World*, a chapter is dedicated to providing an outline of the similarities between the new science of quantum mechanics, chaos theory, and relativity and social constructivism. The argument is made that by following the ideas of the new science, international relations models can be produced from a social constructivist view-point. It is further argued that the weakness of these models in the past has been a methodological failing — the methods of the Newtonian paradigm:

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[149] Kubalkova, Onuf and Kowert, 17.

> The basic problem with international relations models derived from classical scientific methodology is, however, one that is generally unstated: most international relations models are based on the intellectual assumptions of Newtonian Physics: the clockwork, totally determined universe....it is not that science has failed but that we have emulated the wrong science, the science of the eighteenth and nineteenth centuries, rather than the science of the end of the twentieth century.[151]

Through a discussion of uncertainty, non-linearity, indeterminacy, probability, subjectivity, conditionality, complexity, chaos and properties that emerge out of interactions, Hamman identifies the similarities between recent developments in science (which he calls emergent science) and constructivist thought. As he argues "...the apparent goodness of fit between emergent science and constructivism is surely enough to suggest that it may be too soon for international relations theory to give up on the methods (and epistemology) of the sciences and mathematics."[152]

Having now covered a good number of theories in which the influence of scientific paradigms is expected to be explicit, the discussion turns to the opposite case. Much of feminist theory explicitly rejects the sciences as a guide to theories and methods. Thus, it makes an interesting example.

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[150] Nicholas Onuf, "Constructivism: A User's Manual," in *International Relations in a Constructed World*, ed. Vendulka Kubalkova, Nicholas Onuf and Paul Kowert (New York: M.E. Sharp, 1998), 58-69.
[151] Henery L. Hamman, "Remodeling International Relations: New Tools from New Science?" in *International Relations in a Constructed World*, ed. Vendulka Kubalkova, Nicholas Onuf and Paul Kowert (New York: M.E. Sharp, 1998), 179.
[152] Henery Hamman, 191.

3.0 Feminist Theories and Methods

Critics, feminists and other, have often portrayed empiricist methodology as derivative from the natural sciences. Empirical social scientists are seen as slavishly adopting the methods of another discipline to their subject.

Lynn McDonald, *The Women Founders of the Social Sciences*

The fact that the claims of the sort carried out in this work are subject to generalization is particularly apparent when examining feminist theory. A hint of why this is so is provided by Shulamit Reinharz: "Feminist research is amoeba-like; it goes everywhere, in every direction. It reaches into all disciplines and uses all the methods, sometimes singly and sometimes in combinations."[153] Within modern political science feminist theory, the diversity of methods used to explore the world is just about as great as within all academia itself. Reinharz argues that feminism is a perspective, not a methodology.[154] While some feminists may prefer a post-modernist approach, others clearly follow an updated version of empiricism. Much of feminist literature focuses on qualitative methods.[155] However, quantitative methods are employed regularly and the focus on other methods can be explained as a reaction to a perceived over-reliance of other members of the political science community on quantitative methods and the view of these methods as a means of defense for the status quo.

Thus, the examples provided here do not reflect all of feminist theory. However, it is not necessary that they do. The examples are intended to indicate common trends.

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[153] Shulamit Reinhartz, *Feminist Methods in Social Research* (New York: Oxford University Press, 1992), 243.
[154] Shulamit Reinhartz, 241.

Given this, feminist theory is an excellent example of the unconscious incorporation of the Quantum paradigm within theories that explicitly reject the scientific method. The following examination of feminist theory in political science will also make it clear that feminist thought had previously fallen neatly in line with the Newtonian paradigm and that the male centered thinking that modern feminism rejects is in fact closely related to this same Newtonian thought.

In discussing the evolution of feminist theory, the construct of a first, second and third wave of feminism is often used. Barbara Arneil in *Politics and Feminism* puts these three waves into an historical perspective. The first wave reaches as far back as John Stuart Mill and Mary Wollstonecraft in the eighteenth century; Simone de Beauvoir's 1949 publication, *The Second Sex*, marks the end of the first wave and the beginning of the second; and the start of the third wave is placed in the mid-to-late 1980s.[156] There is disagreement over the delineation of the three waves of feminism. In fact, some would debate whether there has even been a third wave. Acknowledging that there are no absolutely definable waves and that there is always a great diversity amongst feminist thought, it does seem fair to argue that feminism has evolved and that within the three time periods described above, much of feminism shared particular characteristics. It is these common characteristics that are the subject of focus here.

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[155] For a discussion of the use of these methods see Thelma McCormack, "Feminism and the New Crisis in Methodology," in *The Effects of Feminist Approaches on Research Methodologies*, ed. Winnie Tomm (Waterloo: Wilfrid Laurier University Press, 1989).

[156] Barbara Arneil, *Politics and Feminism* (Oxford: Blackwell Publishers Ltd, 1999), 156, 163 & 186.

Exemplified by Wollstonecraft's *A Vindication of the Rights of Women* and Mill's *The Subjection of Women*, the first wave of feminism was largely a liberal-feminism.[157] Appropriate to its time, it sought to determine objective, universal, rational rules for human behaviour. From the perspective of first wave feminists, humans are by nature all the same and there is only one perspective that needs to be considered – the human one. First wave feminists fought for greater freedoms for women. Some argued for the greater participation of women in government and the work force. Others argued that while men and women were objectively the same, for cultural reasons women were better suited to the private realm of the family. Either way, nearly all first wave feminists put equality, sameness and universality before difference.[158]

Arneil argues that second wave feminism showed a greater diversity than the first wave but that it was almost completely composed of hyphenated feminists, that is main stream theories such as existentialism, liberalism, Marxism, socialism, and others partnered with feminism. Often, the theoretical half of the partnership subordinated the feminist part.[159] In this way a study of these theories is largely a study of existentialism, liberalism, Marxism and so on. There are, however, distinct feminist elements in each of the second wave theories. These aspects are most apparent and in their purest form within second wave radical feminism.

As it turns out most second wave feminists, like first wavers, continued to look for universal laws.[160] The idea of the objective observer and only one perspective had

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[157] Rosemarie Tong, *Feminist Thought: A Comprehensive Introduction* (Boulder: Westiew Press, 1989), 2.
[158] Barbara Arneil152-163
[159] Arneil, 164.
[160] Ibid., 178.

begun to break down but only into a dualistic concept of observation. There was no longer one neutral, objective view. There were now two subjective views – the male view and the female view. While the objectivity of the male and female perspectives was in doubt, it was still believed that there existed a single, universal, female experience and female perspective. Some radical feminists endorsed the concept of biological determinism in order to explain the universal sameness between women and the universal difference from men.[161] That is an individual's biological make up is so important in defining who they are that on the whole all women are fundamentally the same, all men are fundamentally the same, and all men and women are fundamentally different.

The concept of objective observation was one of the first Newtonian concepts to come under attack. In the most advanced second wave radical feminist theory – lesbian feminism – a connection between the concepts of rationality, objectivity, the scientific method and maleness was made. As Arneil notes, "The scientific model of knowledge, which assumes a rational mind objectively dissecting the material world around 'him', has also been challenged by lesbian feminist writers. Mary Daly, for example, in her *Gyn/Ecology* argues that women must reinvent a whole new language and way of looking at the world in order to avoid the 'phallic culture' imbued by science."[162]

When feminist theory today rejects the scientific method, it is a 17th and 18th century notion of science that they have in mind. As Ann Oakley argues, the feminist critique of standard methods is set in opposition to a scientific model that is seen as male

[161] Ibid., 179.
[162] Ibid., 183.

at the same time as it is seen as Newtonian.[163] This model of inquiry has been depicted as the masculine attempt to control its subject matter, which is viewed as feminine. The masculine and the Newtonian method of the seventeenth century have been equated to such an extent that "an alternative name for 'Newton's mechanics' is 'Newton's rape manual' because understanding nature as a woman indifferent to or even welcoming rape was fundamental to these new conceptions of nature and inquiry."[164]

The fact that the brunt of the attack in much of feminist literature is focused on that which is interchangeably called male, Newtonian or Enlightenment thinking, is clear in Linda Nicholson's discussion of the feminist critique of the academy:

> In general, they have argued against the supposed neutrality and objectivity of the academy, asserting that claims put forth as universally applicable have invariably been valid only for men of a particular culture, class, and race. They have further alleged that even the ideals which have given backing to these claims, such as "objectivity" and "reason," have reflected the values of masculinity at a particular point in history. Feminists have criticized other Enlightenment ideals, such as the autonomous and self-legislating self, as reflective of masculinity in the modern West.[165]

Also, in T.R. Young's discussion of the application of the Newtonian science to the social sciences she explains:

> The idea of an objective science of human behavior complete with universal laws and deductive predictions which must be verified for the theory to be valid is a process which helps depoliticize the struggles of workers, colonial subjects, women, or students – anyone who challenges the putatively natural order of the social world given off by mechanistic models of society.[166]

It is the depoliticization of such struggles that much of feminist theory is in opposition to.

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[163] Ann Oakley, "Gender and People's Way of Knowing: Some Problems with Feminism and the Paradigm Debate in Social Science," *Sociology* 32, no. 4 (November 1998): 718.
[164] Ann Oakley, 718-719.
[165] Linda Nicholson, introduction to *Feminism/Postmodernism*, ed. Linda Nicholson (New York: Routledge, 1990.), 5

It was this rejection of the Newtonian scientific method and its inherent maleness that third wave feminism in the 1980s took to an extreme.[167] Not limited to just methodology, this rejection included the common understanding of reason. In *The Man of Reason: Male and Female in Western Philosophy*, Genevieve Lloyd attacks the notion of an absolute, universal, neutral, objective truth. Lloyd contends that such a conception of reason, as it is understood in Western philosophy, is in fact a male construction.[168]

Moving past the idea of two perceptions of the world – male and female – and moving beyond the idea of one universal woman, third wave feminism endorsed subjectivity, relativity, the importance of the observer, and the importance of interactions.[169] It is at this point in time that the concepts that originated in the Newtonian paradigm were completely dismissed – most often as male. To support their attack on what they describe as phallocentric/Newtonian theorizing, concepts from the scientific Quantum paradigm are employed by feminists. In her examination of Mill's *The Subjection of Women*, Jennifer Ring makes a cogent argument that the feminist criticism of both liberalism and early feminism, for its reductionist examination of parts without consideration of the whole, can be understood as a criticism of those using the methods of yesterday, by those using the methods of today. This can be interpreted as the criticism of those within a Newtonian paradigm, by those within a Quantum paradigm.

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[166] T.R. Young, "Chaos and Social Change: Metaphysics of the Postmodern," *The Social Science Journal* 28, no. 3 (1991): 289-305.
[167] Arneil, 186.
[168] Genevieve Lloyd, *The Man of Reason: Male and Female in Western Philosophy* (Minneapolis: University of Minnesota Press, 1984).
[169] Arneil, 197, 219, 222, 231.

While Mill's work is heralded for being before its time by recognizing that women have been historically oppressed, it is criticized for falling short of the standards of modern feminism. Ring attributes this failure to Mill's methods which she describes as empirical induction, in which observations about the particular are used to make generalizations about the truth.[170] Although Ring does not identify it as such, this clearly falls into the camp of the Newtonian paradigm. It assumes the reductionist attitude that observations of a system's parts may be used to generalize about the whole. The logical consequence of this methodology is that it should be possible to scientifically determine whether women are equally capable as men through the simple replacement of men by women within existing institutions. This is not an experiment Mill actually proposed but rather a mental construct designed to approach the issue. However, beyond the lack of experiences that would allow a theorist to generalize the truth regarding the potential of women, this construct is flawed from the perspective of modern feminism and the Quantum paradigm. Simply replacing men with women does not consider the inherent bias of a system that is designed according to the value structures of men. A finding that women are not equally capable as men in such a situation is a construction of the system. As Moira Gatens explains:

> It is not so much that women are biologically unsuited to political participation, as political participation has been structured and defined in such a way that it excludes women's bodies. If this is so then fighting to have women included in the present body politic will be counterproductive unless it is accompanied by some analysis of

[170] Jennifer Ring, "Mill's *The Subjection of Women:* The Methodological Limits of Liberal Feminism," *The Review of Politics*, 47 (Jan 1985): 32 & 33.

> the exclusions of women's corporeality that still define that body politic and a working framework from which to think and live other ways of being.[171]

That Mill did not incorporate such a consideration is not surprising given that he could not. Such a possibility requires a move away from the inductive process of viewing the whole through its parts. It requires a view of the part as being defined by its relation to the whole. In other words it requires thinking much more akin to the Quantum paradigm.

The flaw in Mill's work, as defined by modern feminist theory, is also identifiable in early feminism which has been described as 'add women and stir.' In *The Women Founders of the Social Sciences,* Lynn McDonald examines the work of women in the social sciences from the Enlightenment up to the end of the nineteenth century. She suggests that the modern feminist criticism of empiricist methodology as being male is a misconception. McDonald demonstrates that the methodology of feminists during this time was the same as all others in the social sciences – a methodology of the Enlightenment. She makes these comments with regard to the collection of women social scientists highlighted in her monograph.

> Any feminist who wishes to argue that the empirical social sciences imply a "male method," that objectivity is a trap, that recourse to the established methods of gathering data limits one to supporting the status quo, will find no help from the women discussed here. Rather these methodologists contributed to the very framework of empiricism from its terms and underlying assumptions to advice on the practicalities of how to do research.[172]

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[171] Moira Gatens, "Towards a Feminist Philosophy of the Body," in *Crossing Boundaries: Feminism and the Critique of Knowledge*, ed. B. Caine, E.A. Grosz, M. de Lepervanch (Sydney: Allen and Unwin, 1988), 60.

[172] Lynn McDonald, *The Women Founders of the Social Sciences* (Ottawa: Carleton University Press, 1994), 16-17.

In short, the modern feminist view of empiricism as having failed is argued to be not because it is male but rather because it is Newtonian. This is similar to Ring's critique of the methodology of Mill.

In addition to the practice of using concepts of a Quantum paradigm origin to reject what is clearly Newtonian, recent developments within feminist theory correlate highly with many aspects of the Quantum paradigm on their own terms. That modern feminist theory represents a substantial theoretical shift is recognised. "The new feminist methodology was not, then, a refinement of an older tradition of social research, it was a quantum leap, a Kuhn-ian passage from one paradigm to another."[173]

In addition to the previously discussed focus on interactions and the whole, a common aspect of recent developments in feminist theory is the participatory effect or the role of the observer. Reinharz identifies three features of feminist research which touch on this issue. These are the incorporation of the views and experiences of the researcher into the research, the interaction between that which is studied and the researcher, and the presentation of the research findings.[174]

The certain view that a particular observer brings to research is not seen as an introduction of bias but rather a valuable asset. This greatly reduces the need for the observer to remain disconnected from that which is being studied. An interaction between the researcher and the subject is encouraged, not avoided. Consequently, the need to

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[173] Thelma McCormack, "Feminism and the New Crisis in Methodology," *The Effects of Feminist Approaches on Research Methodologies,* ed. Winnie Tomm (Waterloo: Wilfrid Laurier University Press, 1989), 15. The use of the term "quantum leap" is obviously not an attempt to incorporate the Quantum paradigm. It is simply a scientific term that has gained popular usage. However, it does highlight the fact that the concept of a paradigm shift can itself be considered a product of the Quantum paradigm. This can lead to a very difficult circular argument.

[174] Reinharz, 258-268.

present the experiences, views and interactions of the researcher requires somewhat different methods of presentation of the research findings. Just as the observer is no longer detached, the reader of the findings must be brought in, in order to experience the research as the researcher did. In essence, the concept of the objective observer is rejected. These ideas are also found in the feminist concept of embodiment that stresses the importance of the time, place and observer to any given observation. As Arneil describes:

> Women and men are thus situated in a particular place and time, demarcated by their bodies. This cannot simply be eschewed, as is done in political theory from Thomas Hobbes's state of nature to John Rawls's original position. [Elizabeth] Grosz comments: 'This idealized space, the prerequisite for the knowing, objective, rational subject, is the space based on the male disavowal of his body and his sex, and the assumption that he occupies a neutral position. Feminist theory on the other hand readily accepts the complicity of subject and object in knowledge production.'[175]

These developments have opened the door for an increased focus on normative theory in research, which is certainly not limited to but is an important aspect of feminist theory.[176]

Normative theory itself is not a Quantum occurrence. However, the rejection of the objective observer is and the consequences of this rejection fit nicely into the Quantum paradigm. The interaction between observer and observed is taken as a given. As stated by Bohr, "while, within the scope of classical physics, the interaction between object and apparatus can be neglected or, if necessary, compensated for, in quantum physics this interaction thus forms an inseparable part of the phenomenon."[177] And, as in

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[175] Arneil, 198.
[176] Normative theory in political science is defined as "the discovery, or application, of moral notions in the sphere of political relations." Isaiah Berlin quoted in Daryl Glaser, "Normative Theory," in *Theory and Methods in Political Science*, ed. David Marsh and Gerry Stoker (London: MacMillan Press, 1995). Such research implies the rejection of the objective observer.
[177] Bohr, 804.

feminist theory, this fact has important consequences for the reporting of research results. "Accordingly, the unambiguous account of proper quantum phenomena must, in principle, include a description of all relevant features of the experimental arrangements."[178] The feminist criticism of the idea of an objective observer has been identified as similar to the tenets of other theories developed in the twenties through to the sixties. These theories include poststructuralism, ethnomethodology, phenomenology, postmodernism and hermeneutics.[179]

In addition to a focus on interactions and the whole, and the rejection of the objective observer is the principle of complementarity. This principle states that there are pairs of properties that cannot both have precise values at the same time. As noted in part I, a consequence of this principle is that data collected in different manners will have different values. However, this does not imply a limitation. It suggests a need to view the same object through different means. That this approach is reflected in feminist theory is clear in a statement of Marilyn Strathern:

> Much feminist discourse is constructed in a plural way. Arguments are juxtaposed, many voices solicited, in the way that feminists speak about their own scholarship. There are no central texts, no definitive techniques; the deliberate transdisciplinary enterprise plays with context. Perspectives from different disciplines are held to illuminate one another; historical or literary or anthropological insights are juxtaposed by writers at once conscious of the different contexts of these disciplines and refusing to take any single context as an organizing frame.[180]

The validity of many different perspectives and relational thinking is also found in the feminist discussion of identity. "Within a relational frame work, identities shift with a changing context dependent always upon the point of reference. Not essences or

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[178] Ibid.
[179] Oakley, 715.

absolutes, identities are fluid sites that can be understood differently depending on the vantage point of their formation and function."[181]

Another aspect of third wave feminism is the rejection of universal definitions. This is a natural consequence of the acknowledgment that observations are probabilistic and depend upon the observer. If observations depend upon circumstances then so do definitions. Facts must be stated relative to their setting. This does not suggest that there are no facts – just that they are conditional. Postmodernism, a very important aspect of third wave feminism, sometimes takes the concept of relative knowledge to an extreme. That is, nothing can be stated as true and everything is a construction of the observer. This is not completely compliant with the Quantum paradigm which stresses the importance of the circumstances of observations but does not reject that there is some sort of reality – the circumstances must simply be considered. The Quantum paradigm also allows for the idea that some things are simply not true, which postmodernism does not. Inglehart suggests the postmodern idea of absolute subjectivity is defended through a misreading of modern, scientific concepts. He notes that some interpret the Quantum concept that the world is probabilistic to mean that there is no reality.[182]

It could be argued that some postmodern feminists are so eager to reject the phallic/Newtonian world that they apply concepts that refute it further than those which acknowledge that there is still some value to the Newtonian perspective. Inglehart, for example, acknowledges the shift in the sciences away from Newtonian thought and the

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[180] Marilyn Strathern, quoted in Reinharz, 245-6.
[181] Susan Friedman, "Beyond White and Other: Relationality and Narratives of Race in Feminist Discourse," *Signs* 21, no 1 (Autumn 1995): 17.
[182] Ronald Inglehart, 13.

implications for social science research, yet notes that we can still reach the moon using Newtonian concepts.[183] Amongst feminists there are those that warn against the extremes of postmodernism:

> The dangers of postmodernism as seen by some feminists are those of both relativism and the abandonment of theory. While many reject the modernist "view from nowhere," they question whether postmodernism would not lead us to the equally problematic "view from everywhere." Are coherent theory and politics possible within a postmodern position?[184]

It also could and has been argued that the more radical postmodernists, viewing Newtonian thinking as the enemy, have employed the language of modern science with the vague sense that it supports their attack. However, without a real knowledge of the scientific terms that they use, the work of these writers is nonsensical from the perspective of either the Newtonian or Quantum paradigm. This is seen more amongst postmodern philosophers than postmodernists working within political sciences.[185] It has been mentioned in Part I that an individual does not need to understand the scientific theories of the Quantum paradigm in order to be influenced by it. This holds true for radical postmodernists and they have been influenced by the Quantum paradigm but in a way that is unlike other theorists mentioned thus far. Extreme postmodernism jumps at 'anti-Newtonian' aspects of the Quantum paradigm but then interprets them in ways that make them unrecognizable to someone who understood the original scientific theories. This is only very weakly (and maybe not at all) representative of the impact of the scientific paradigm shift on the social sciences that has been considered so far.

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[183] Inglehart, 21.
[184] Linda Nicholson, 9.
[185] Two examples of postmodern philosophers that have greatly distorted scientific terminology and concepts are Jacques Lacan and Julia Kristeva.

It should be made clear that this ambiguous use of Quantum paradigm language has not been true of all those that name themselves postmodernists and again it is less evident amongst those that operate within political science than those in philosophy. This may be the case because while philosophy can end with the rejection of something (such as the Newtonian paradigm), political scientists must find a new mode of operation so that they may continue their studies. In doing so, political science postmodern feminists reveal the true influence of the Quantum paradigm on their thinking.

One final link between recent changes in feminist thinking and the Newtonian-Quantum paradigm shift is worth noting in order to show the influence of the Quantum paradigm on political science feminism. A fundamental aspect of feminist theory over time has always been a prescription for change. However, the conceptualization of the nature of the society and power structures that need to be changed has undergone an important shift. In the past, these structures were viewed as tending towards a natural equilibrium. First wave feminism tended to accept this equilibrium as natural and primarily challenged the perceived importance of women within it. Second wave feminists struggled to change the equilibrium – some as a rejection of nature, others as a rejection of the equilibrium as natural.[186] Either way, there was always a view of society as tending towards some steady state. This focus on equilibrium is central to Newtonian thought. In part due to computational limitations and in part due to philosophical leanings, scientists within the Newtonian paradigm modeled systems using linear equations with solutions that suggested a natural equilibrium.

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[186] Tong, 3.

The focus on linearity and equilibrium continued until the much-discussed advancements in non-linear mathematics and studies of systems far from equilibrium. These Quantum paradigm advancements are reflected in the third wave feminist rejection of the concept of equilibrium. This rejection is evident in the postmodern feminist critiques of 'Western metanarratives,' such as those of Marxism, liberalism and science.[187] Postmodern feminism rejects the concept of a natural equilibrium produced by the interaction of classes, as proposed by Marxism; the interaction of rational individuals, as proposed by liberalism; and the interaction of worldly bodies, as proposed by the sciences. While many second wave feminists attempted to create their own metanarratives such as Marxist feminism, suggesting an alternate equilibrium more favourable to women, third wave feminists have rejected any such idea.[188] According to postmodern feminism, any equilibrium is artificially created. If it appears natural, that is simply part of its construction.

Of the theories and methods included in the analysis presented here, feminist theory more than any other has striven to separate itself from the sciences. Its language is the most removed and direct references are usually only made in the context of rejecting Enlightenment/Newtonian thought. However, the fact that much of the feminist critique of this Newtonian thought resembles the Quantum critique of the Newtonian paradigm is revealing. Furthermore, the Quantum paradigm is strongly felt in the alternatives suggested by political feminist theory.

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[187] Chris Weedon, "Postmodernism," in *A Companion to Feminist Philosophy*, ed. Alison M. Jaggar and Iris M. Young (Malden, Mass.: Blackwell, 1998), 76.
[188] Ibid.

The parallels between feminist theory in political science and the Quantum paradigm are not exact. However, for a theory that starts from the position of rejecting the sciences, the connections are striking. The implication is that the influence of the Quantum paradigm does not require a conscious attempt to incorporate scientific methods. It is a more systemic occurrence than that.

PART III: FINAL THOUGHTS AND CONCLUSIONS

1.0 Methodological Limitations

During the conception stage, the method is free to consider all hypotheses, even the most far-fetched, in order to mimic Reality. Everything can be tried, a bold abstraction of something that has succeeded elsewhere, the exploration of the faintest clue, or a leap through empty space. The mountain peak where it lands has experience as its only sanction and consistency its only ethic.

Roland Omnes, *Quantum Philosophy*

When examining the epistemologies, ontologies and methodologies of social scientists, it is sometimes necessary to take the explicit descriptions of their work at face value. While one can often examine the work of researchers to test their methodological claims, it is not always possible. That is, if a researcher claims to believe in a holistic approach, it is not always clear whether their work reflects this. For example, within the field of ecology some argue that many researchers who claim to have a holistic epistemology clearly have a reductionist methodology.[189] So it may be asked what limitations, if any, does this place on the evidence provided in this study?

The answer is that the possibility of a researcher's epistemological claims not being reflected in his or her methodology leaves the nature of the Quantum paradigm impact somewhat ambiguous. It does not, however, have any effect on the evidence of the existence of such an impact. The mere fact that the Quantum paradigm in the sciences has led political scientists to make claims of holism or try to appear to take the subjectivity of observation into account is enough to argue that there has been an impact. This study has shown that these claims have certainly been made. Once such claims are

[189] Bergandi and Blandin, 190.

made it is hard to imagine that the influence would not sink even deeper and it has also been shown that in some instances, the effects of the Quantum paradigm do go further than simple claims. It is even evident amongst those that make no such claims – e.g., feminist theorists.

While this work has argued that the construction of the Newtonian-Quantum paradigm shift is a productive tool in understanding political science theories and methods, it has been descriptive, rather than prescriptive. Although it undoubtedly reflects a particular set of beliefs and values, it is not intended to suggest what political science should do. The purpose of this work is neither to provide a prescription for change nor to make any judgement of the value of the impact of the Newtonian-Quantum paradigm shift. Others have called for a revolution in their field in order to match the sciences. The behaviouralists of political science attempted it in the 50s and 60s, trying to produce a political science paradigm based on Popperism. Margaret Wheatly has done the same for business management today. In *Leadership and the New Science*, Wheatly describes how to look at business management from the perspective of a Quantum paradigm. At the end of the book she claims that the social sciences have only just caught up to the sciences of the seventeenth-century and calls for a quick catch up to twentieth-century science. While this work examines these explicit attempts to apply natural scientific concepts, it does not try to add to them. It has not been clear that such efforts have been very fruitful. In any case, it is a task that has been left to others.

In addition to avoiding any arguments as to the proper direction for political science methods and theories, this work has done little to provide an exact mechanism by which the prominent paradigm in the sciences influences political science. In some

instances the path of influence may be through observant philosophers of science, which catch the imagination of political scientists, as Karl Popper did the behaviouralists. There is also a general dissemination of modern scientific concepts by popular science writers, such as John Gribbin and Stephen Hawking, and there are instances in which scientists discuss the philosophical ramifications of the most recent advancements in the natural sciences. Such writers are often even more in step with the scientific paradigm than are the philosophers of science. The philosophical writings of Niels Bohr have already been mentioned. Roland Omnes, a professor of physics at the University of Paris XI, is a modern example of such a scientist.[190] From a less academic source come popular books that try to apply concepts from quantum mechanics and chaos theory to other disciplines and to society in general. Wheatley's *Leadership and the New Science* is one such book. *The Quantum Society*, by Danah Zohar and Ian Marshall, and *Quantum Jump* by W.R. Clement are other examples.

The grounding of these writings in actual scientific concepts varies greatly, as do the credentials of the authors. Regardless, it is clear that there are many works out there that can be identified as potential conduits of knowledge from the natural sciences to the social sciences. However, it may not even be wise to try to identify a direct path of influence from the sciences to political science. As it has already been suggested, the underlying concepts of a paradigm may originate in everyday society just as much as they do in the sciences. Just as a liberal society may have been a major contributor to the Newtonian scientific paradigm, an increasing sense of globalization may influence how chaos theory is interpreted. It may take a discipline structured as the sciences are for

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[190] In particular: Roland Omnes, *Quantum Philosophy* (Princeton: Princeton University Press, 1999).

epistemological and ontological undercurrents to form into a paradigm, but if these undercurrents already exist in other disciplines and society at large, the influence of the sciences is less a matter of instruction and more one of articulation. Whatever the truth may be, evidence of the influence has been convincing without an explicit articulation of the mechanism, which will have to remain a mystery till another day.

Having covered some limitations and unanswered questions of this work, we turn to a defense of a methodological choice. This study is true to the Kuhnian concept of the paradigm except that it proposes the existence of only two paradigms in the sciences – the Newtonian and Quantum. Kuhn discusses many more paradigms existing all at once in various disciplines of the sciences. He also identifies many more paradigm shifts over time. It is certainly true that methodological variations do occur across the sciences. It has already been noted that the subject matter of the biological sciences leads the researcher to have a different perspective from those in physics. It is also true that the scientific method did not remain stagnant throughout the period of the Newtonian paradigm. Variations do occur over three hundred years. Given this, it could be asked if trying to fit scientific methodology into two neat packages is an over simplification. If this were so then trying to understand the methods and theories of the social sciences through these oversimplified constructions may not be the helpful exercise one may want it to be.

In response, it has been argued throughout this study that while variations may occur across the sciences and the social sciences, there are always common underlying assumptions and these assumptions have only changed substantially once since the seventeenth century. Therefore while the methods of the biological sciences may differ somewhat from those of physics, Newtonian biology and Newtonian physics share much

more in common with each other than they do with any of the sciences in the Quantum paradigm. Furthermore, the physics of the nineteenth century shares more in common with that of the seventeenth century than it does with that of the twentieth century. In essence the disagreement between Kuhn's multiple coexisting paradigms and the two exclusive paradigms of this work is due to a difference in level of analysis. The level of analysis required to examine the impact of scientific paradigms on the social sciences is at the level of fundamental assumptions. It is at this level that the Newtonian-Quantum paradigm construction operates.

There is, however, a point to be made about generalizing paradigms. Since the rise and decline of the Newtonian paradigm is in the past, it is relatively safe to highlight the aspects of the paradigm that persisted throughout its reign. These aspects may be used to make generalizations about it. This is an exercise that is somewhat more precarious when applied to the Quantum paradigm. The key theories that led to this paradigm are relatively young – about a hundred years old. Furthermore, consensus regarding the meaning of these theories is still very tentative. While the Copenhagen model has dominated interpretations of quantum mechanics, it certainly has its critics. This raises the question of what the impact will be of the competing interpretations of quantum mechanics and of systems represented by non-linear equations? Will the Quantum paradigm look different to historians a century from now than it does to us today? It would be surprising if it did not, so how might it look different?

While there is no clear answer, there are hints of what is to come. There have always been those uncomfortable with the relativism of the popular interpretation of quantum mechanics. While it is not as absolutely relativistic as the postmodernists would

like, it certainly does not suggest the objective world that nineteenth century positivists expected. Despite his role in the development of the Quantum paradigm, Einstein remained a realist to the end. Today still, there are those that would suggest that quantum mechanics and relativity theory can be understood without resorting to the relativism of the Copenhagen model. One such physicist and popular science writer is John Gribbin.[191]

In chaos theory as well, the exact interpretation of the point at which a non-linear system spins off into an unpredictable direction is open for debate. From the perspective of the Quantum paradigm, as it has been defined here, there is an inherent randomness in a system that ensures that the bifurcation point of a system is unpredictable. In contrast to this, there are those that would insist that all systems, including those of the non-linear sort, are fully deterministic and predictable – or at least they would be if we could ever make an exact measurement of the system, which we can't. They would claim there is no absolute reason why one has to accept a system has any randomness in it at all.

What these counter-interpretations of quantum mechanics and chaos theory suggest is that there is still plenty of room in science for realists and that they might eventually pull those social scientists back that have overzealously applied the lesson of relativism. Ultimately, this is only the beginning; the consequences of the Quantum paradigm shift are extensive and only partly realized. The full impact won't be known until the shift has completed. At which point, the sciences will continue onto a new paradigm.

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[191] In particular: John Gribbin, *Schrodinger's Kittens and the Search for Reality* (New York: Little, Brown and Company, 1995).

2.0 Warnings

Why did the Chicken cross the road?

Aristotle: It is the nature of chickens to cross the road
Newton: Who could have predicted the chicken would cross the road?
Einstein: Did the chicken really cross the road or did the road move beneath the chicken?

Anon

While the common interpretation of quantum mechanics is more relativistic than science necessitates, it does not go as far in rejecting reality as have some philosophers and political scientists. Is it possible that philosophers of knowledge have taken some of the messages from the Quantum paradigm too far? Newtonian mechanics is still appropriate at some levels of analysis. It is just not universally applicable. Could methods informed by the Newtonian paradigm still be valid at some level within political science? The answer to both questions is 'probably.'

In the natural sciences many of the systems scientists work with are on such a scale that quantum effects can be ignored. Although many of the basic assumptions of the Newtonian paradigm are misleading, the conclusions that one comes to with such a paradigm are, in many circumstances, accurate enough for all intents and purposes. Although, theoretically, it is more accurate to calculate the path of a baseball thrown into the air from a Quantum perspective, the answer will differ so little from that calculated using Newtonian mechanics that it couldn't actually be measured. The key is to be aware when the Newtonian paradigm fails to provide the correct interpretation and when it will suffice. The same applies when we consider the effects of a paradigm shift in the social sciences. The concept of cause and effect is a strong force in our thinking and in many

instances such reasoning appears to be substantiated, which, again, for all intents and purposes it is. Thus, it may be going too far to completely discredit the concept.

This fact should act as a warning to those within the sciences, the humanities or the social sciences, who see quantum mechanics and relativity theory as reasons to abandon all forms of objectivity and accept a completely relativistic view of their discipline. This warning has been touched upon more than once but is worth repeating. Furthermore, it is not a conservative warning. In fact, the sort of subjectivity suggested by the Quantum paradigm is far more radical than the abolition of reality suggested by some postmodernists and others.

As a final reflection, a second cautioning is warranted. The presently held idea of a paradigm is itself a product of the Quantum paradigm. Khalil discusses the Copenhagen model of quantum mechanics and its impact on epistemology. He notes "that the epistemological road leads us to the much discussed new theory of knowledge, spearheaded by Thomas Kuhn."[192] Consequently this study has undertaken a description of a paradigm shift in terms of that shift. This may be a dangerous error in logic but it is one that cannot be avoided; at least not if one accepts the present paradigm!

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[192] Khalil, 28.

3.0 Conclusion

At the entrance to science, however, the same requirement must be put as at the entrance to hell:

Qui si convien lasciare ogne sospetto;
ogne viltà convien che qui sia morta.[193]

Karl Marx, *A Contribution to the Critique of Political Economy*

Suggesting that political scientists may learn a great deal about their discipline by examining how it has been influenced by the paradigms of the natural sciences is a risky business. Some may assume that such an exercise is a behavioural suggestion that political science should be more like the natural sciences. Others may feel that such a comparison is designed to find fault with political science theories and methods. Others still could argue that such an analysis has an overly narrow focus. By this point, it is hopefully clear that these criticisms do not hold.

Part I developed a tool by which to understand changes in political science theories and methods over the past three hundred and some years. In doing so, it described what one would expect to observe when examining these changes. Part II applied this tool to three areas of political science – political economy, methodological theories, and feminist theories and methods. Evidence was provided in all three cases of the impact of the Newtonian-Quantum paradigm shift. Put differently, Part II demonstrated how these three cases appear when viewed from the perspective of the Quantum-Newtonian paradigm shift in the sciences. Whether political science has

[193] The translation of this quote from Dante Alighieri's *La Divina Commedia I Inferno*, is: "Here all suspicion must be left behind. Here every kind of cowardice must die." Translated by Louis Biancolli (New York: Washington Square Press, 1966).

become any closer to the natural sciences or if this is even desirable is not considered. It is not germane to the process of examining the ability of the Newtonian-Quantum paradigm shift to provide greater understanding. That this perspective does provide greater understanding has been made evident. It has been seen that feminism, which most often explicitly rejects the sciences, appears subject to the same influences as the methodological theories that consciously incorporate scientific methods. It has also been seen that those methods most wedded to the Newtonian concepts of prediction, cause and effect have incorporated the Quantum concepts and language of probability and randomness. Most importantly, it has become evident that the list and range of political scholars that have been impacted by the Newtonian-Quantum paradigm shift is an extensive one. Clearly the tool developed by this work – using the Newtonian-Quantum paradigm shift in the sciences to examine changes in political science theories and methods – has much to offer.

GLOSSARY OF TERMS

The following is a list of terms that are used in this work that may have alternate meanings depending on the discipline in which they are used. Given the interdisciplinary nature of the discussion presented here, an indication of the way in which the terms are being used becomes necessary. Other terms that are not interdisciplinary, but may have been used without the provision of an explicit definition, are included in this glossary. It is recognised that these are not the only possible definitions for the terms. When a definition originates from a particular source, that source is indicated in parentheses.

Aspect Experiments: a series of experiments, carried out in Paris in the early 1980s by Alain Aspect and his colleagues, which established that what Albert Einstein called 'spooky action at a distance' really does operate in the quantum world (Gribbin, *Q is for Quantum: Particle Physics from A to Z*, 22).

Behaviouralism: within political science, an approach to research that seeks to apply the concepts, methods of the sciences – most often the scientific philosophy of logical positivism.

Bifurcation: an abrupt change in the long-term behaviour of a system (Lorenz, 206).

Communitarianism: political philosophy which emphasizes the role of community and tradition in defining the interests and rights of persons (McCullough, 306).

Complementarity: the quantum nature of certain pairs of variables which prevents both of them having precise values at the same time. (Gribbin, *Q is for Quantum: Particle Physics from A to Z*, 85)

Constructivism: Constructivism is a radical kind of subjectivism (and derivative of Kantianism) which posits that reality does not exist outside our conceptions of reality, and that through conceptualizing we "construct" reality (The ISM Book Online, www.monadnock.net/ismbook).

Deduction: a method of reasoning by which one infers a conclusion from a set of known generalities.

Determinism: determinism is the belief that all physical events and human actions are determined or settled by external forces before they happen. In other words, determinists deny the existence of freely chosen human activity, and the more consistent determinists

even deny any personal responsibility for human actions. Determinists are usually, in fact almost exclusively, adherents of materialism (e.g. many, many scientists today are materialists and determinists) – though there are social or economic determinists also, especially those influenced by Marxism. Determinism means pretty much the same thing in practice as it does in philosophical theory, except that popularly it has connotations of fatalism (The Ism Book Online, www.monadnock.net/ismbook).

Epistomology: The study of the nature, origins, objects, and limitations of knowledge (Boyd et al., 777).

Fractal: a set of points whose dimension is not a whole number. Also, a set of similar structure whose dimension "happens to be" a whole number (Lorenz, 208).

Induction: the process of discovering a general principle from a set of facts (Cambridge International Dictionaries, online).

Intersubjectivity: the knowledge of ideas that are patently true and therefore acceptable to everyone regardless of particular prejudices (adapted from Ricci, 145).

Logical Positivism: A doctrine which primary attempts to interpret science and philosophy in terms of verificationism. That being the theory of meaning according to which all meaningful sentences are either analytic (true or false in virtue of the meanings of the terms involved) or empirically verifiable (Boyd et al., 778).

Materialism: the ontological doctrine that states that everything that exists is, or depends on, matter (Boyds et al., 778).

Nonlinear system: a system in which alterations in an initial state need not produce proportional alterations in subsequent states; one that is not linear (Lorenz, 210).

Normative Political Theory: the discovery, or application, of moral notions in the sphere of political relations (Isaiah Berlin quoted in Marsh and Stoker, 21).

Objectivism: the term 'objectivism' refers to the idea that reality exists outside of the mind and that existents retain their identity no matter what human beings or other conscious creatures think or feel about it (The Ism Book Online, www.monadnock.net/ismbook).

Ontology: the entities postulated by a particular theory (Boyd et al., 779).

Positivism: the view that "positive facts" concerning observable phenomenon and their relations are all that can be known, and that inquiry into causes, origins, a purposes should be abandoned (Boyd et al., 779).

Realism (Scientific): The belief that an objective reality exists independent of observation.

Reductionism: the idea that nature can be understood by dissection. In other words, knowing the lowest-level details of how things work (at, say, the level of subatomic physics) reveals how higher-level phenomena come about. This is a bottom-up way of looking at the universe, and is the exact opposite of holism (The Computational Beauty of Nature Glossary Online).

Relativism: in epistemology, the view that the acceptability or unacceptability of knowledge claims is relative to a particular group or community, and that there are no objective epistemological standards (Boyd et al., 780).

Subjectivism: the term subjectivism (contrast with objectivism) refers to any doctrine in a tradition, stretching all the way back to the Sophists of ancient Greece, which denies that knowledge and values are in any way based on reality, and which thus holds that knowledge and values are relative (The Ism Book Online, www.monadnock.net/ismbook).

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