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The Significance of Economic Significance

Dakota M. Sneed Mr.
Oglethorpe University, dakmat@hotmail.com

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Cover Page Footnote

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Section I:

Introduction

Mathematical *and* statistical methods have been used by economists to build and to test theories and the models these theories entail. Despite the traditional use of both mathematical and statistical methods, there has recently been an increased emphasis on statistical methods to the detriment of any other metric. Statistical methods and equations are the vehicle used to determine statistical significance. Deirdre McCloskey argues that statistical significance alone is not always sufficient to make meaningful economic claims. "The problem, and our main point, is that a difference can be permanent without being 'significant' in other senses, such as for science or policy. And a difference can be significant for science or policy and yet be insignificant statistically, ignored by the less thoughtful researchers."[1] The reason for this, stated by Jerzy Neyman and Egon Pearson, is that statistical significance only contains the means to minimize statistical errors and does not contain enough information about the state of, and consequences actually present in the world.

"Is it more serious to convict an innocent man or to acquit a guilty one? That will depend on the consequences of the error; is the punishment death or fine; what is the danger to the community of released criminals; what are the current ethical views on punishment? From the point of view of mathematical theory all that we can do is to show how the risk of errors may be controlled and minimized. The use of these statistical tools in any given case, is determining just how the balance should be struck, *must be left to the investigator."*[2]

This quote explicitly gives examples of relevant measures that must be taken into account while making economic decisions that statistical significance cannot account for. Economic

[1] McCloskey, D., & Ziliak, S. (1996). The Standard Error of Regression. Journal of Economic Literature, 34(1), pg. 97
[2] Deirdre McCloskey, Standard Error of Regression, pg. 97

significance on the other hand can account for them. Something is 'economically significant' if it proves useful.[3] In regards to the quote from Neyman and Jerzy, knowing the potential risks to a community in the event a guilty man is set free would be useful.

The wider scope of economic significance allows it to account for factors that statistical significance cannot, while still including the factors that statistical significance includes. McCloskey however fails to provide a formal definition of economic significance. Although she calls for textbooks to explicitly distinguish statistical significance from economic significance, she never provides a definition of economic significance that would foster that distinction.[4]This paper is an attempt to flesh out what economic significance is and why there is a need to define it. This introduction will provide a brief summary of the components of my argument and will detail the reasons why clearly seaprating economic and statistical significance is necessary. I will then show that it is problematic to use statistical significance as an equivalent measure for economic significance. The use of these two terms interchangeably is ultimately the reason for the ambiguity in meaning. The problem has persisted for so long that it is no longer recognized as a problem or even as a term being misappropriated. The vagueness of the term economic significance--even as defined by McCloskey--does nothing to protect it from being equivocated with statistical significance. Through defining economic significance I hope to prevent the terms from being confused in the future.

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[3] This is never explicitly stated but is my interpretation based on McCloskeys use of the term in "Standard Error of Regression"

[4] Deirdre McCloskey, Standard Error of Regression

Since statistical methods are used to test potential hypotheses, to designate a variable as economically significant should stand as the highest classification that an independent variable could achieve in the context of testing theoretical relationships and attempting to explain how a dependent variable is determined. Analyzing and verifying economic significance would insure that when an economist makes a claim about a potential relationship it is not only mathematically founded, but the validity of the relationship is present in both a mathematical and applied real-world manner.

My argument starts with an outline of the general process and interpretation of econometric data. This will be followed by a section exemplifying the problems of a solely statistical interpretation. During this section, I will introduce the term "practical significance" functions as a vague term and is used solely for the purposes of highlighting and delineating the idea of statistical significance. I have intentionally left the term "practical significance" ambiguous in order to isolate the ideas that a purely statistical interpretation and reading cannot capture. More broadly, my outline of the general process and interpretation of econometric data will include an overview of econometrics, hypothesis testing, and how to read an econometric regression. Since statistical significance is determined by the t-test, I will spend more time examining the nature of a t-test and its relationship to statistical significance. My examination will outline what the t-test is used to test, how it is employed in econometrics, and what the results mean. Having outlined the general process and interpretation of econometric data and explained the t-test and its relationship to statistical significance, I will then compare the concepts of statistical significance and practical significance with the hope of showing that the two terms denote different concepts and that they are not equivocal terms.

Ultimately, this comparison shows that even if the scope of statistical significance is widened it cannot capture various ideas and does not account for those ideas captured by practical or economic significance.

After establishing the structure of statistical significance and what it is qualified to do, I then provide examples that are intended to illuminate the errors of limiting analysis to statistical interpretations. If a student of economics is not taught the problematic nature of using economic and statistical significance interchangeably then he or she will come to assume that they are equivalent concepts. McCloskey provides evidence that shows that 60% of economic articles in some journals use the terms synonymously and thus ambiguates the distinct concepts to which the terms refer.[5] In addition to that, she found that a large percentage of economic textbooks either inadequately explained the difference or did not mention it at all.[6] This section of my thesis ends with an explanation of why providing a clearer definition of economic significance than that offered by McCloskey will not only clarify the meaning of economic significance but will also clearly distinguish it from statistical significance.

Having described the need for economic significance in the presence of the limits of statistical analysis, a definition for economic significance is still required. In the next section I will propose a definition of economic significance. I will argue that for X to be considered economically significant, it must meet three conditions: it must be causal in the counter-factual sense, it must be mathematically sound, and it must be malleable. In the causal section I will explain what counter-factual causality is and why it should be essential to the concept of

[5] Deirdre McCloskey, Standard Error of Regressions, pg. 106
[6] Deirdre McCloskey, Standard Error of Regressions, pg. 100

economic significance. In the explanation of the second condition, my language shifts from statistical significance to mathematical significance to account for all of the potential errors that can occur[7]. Statistical significance is simply a measure of whether or not an event will occur by chance, while mathematical significance encompasses mathematical soundness in all aspects. Mathematical significance includes but is not limited to statistical significance. I end with an examination of the malleability condition. For X to be considered malleable in the sense necessary for economic significance, X must be actively manipulable.

After introducing, explaining, and justifying these conditions for economic significance, I will argue that it is possible for something to fail to meet the conditions of economic significance and yet remain important for statistical analysis. If it is true that something can be important for statistical analysis but does not meet the conditions of economic significance, then we need a new term that captures this importance—economic relevance. I will focus on explaining the nature of economic relevance and devote particular attention to two of its key factors, factors that include two of the conditions of economic significance. Economic relevance functions to allow a degree of vagueness so that economically relevant terms may not be discarded based on a fault in our knowledge of the factor itself. I will conclude this section with an examination of issues related to economic relevance and what research and/or expertise would have been helpful in defining economic significance and outlining problems with the statistical methods currently used.

[7] This is in response to possible issues that may arise from statistical analysis

The widespread dismissal of economic significance and/or the lack of distinction between economic and statistical significance can be viewed as the primary cause for many of the problems that arise in the interpretation phase of analysis. In some cases, the problem arises because statistical significance eclipses all other manners of analysis. For example, McCloskey cites an article from a leading economics journal in which ONLY statistical significance is used to analyze the variables and the nature of the variables within the economic structure being analyzed is completely ignored or dismissed.[8] Furthermore, in this article, the authors do not explicitly mention statistical significance. Instead, the authors speak only of “significance”, which sends the implicit signal that there is only one way to be significant. In referring only to “significance”, this article represents an unconscious collision of economic and statistical significance that confuses the two distinct concepts. McCloskey notes that two years later in the same journal, there is an article that uses the term “significance” to denote both statistically significant and economically significant factors. Although the author acknowledges the distinction between economic and statistical significance, he/she never explicitly distinguishes the two concepts, uses the terms as functional equivalents, and as a result, incorrectly attributes the same kind of significance to multiple variables.[9]

Although there is widespread conflation of statistical and economic significance in economics journals, McCloskey also provides examples of articles that express keen awareness of their distinction as well as acknowledgment that the answers they seek cannot be discovered

[8] It shows a serious lack of concern for anything outside of statistical significance. If statistical analysis is all that is used then it fails to strike the proper balance.

[9] McCloskey claims that this is the kind of practice that leads to the confusion of economic and statistical significance.

solely through the lens of statistical significance. In an article by Romer, Hamermesh, and Giliches, they claim: ""…Tests of significance are used here as a metric for discussing the relative fit of different versions of the model. In each case, the actual magnitude of the estimated coefficients is of more interest than their precise 'statistical significance.'"[10] This statement supports my thesis that to determine economic significance there is more to take into account than simple statistical significance. In other words, statistical significance is not an absolute objective measure for truth and relevancy and treating it as such is actively harmful to the economic community.

My argument for economic significance can be summarized graphically as follows: Economists have begun to think that statistical significance contains economic significance and is dominant (Figure A). I will show how statistical methods are insufficient for capturing the entirety of economic variables and I will propose, instead, that statistical significance is in fact a part of economic significance (Figure B). Furthermore I will make and support the argument that 'Economic Significance' is composed of not only 'mathematical significance[11]', but also 'causal dependency', and 'malleability'.

[10] American Economic Review,, Dec. 1984, pg. 912

[11] Underscoring this claim the is current debate as to how reliable current probability testing is with the American Statistical Association currently re-evaluating the reliability of p-values, mathematical significance is functionally just correct statistical analysis under what the ASA concludes.

Figure A:

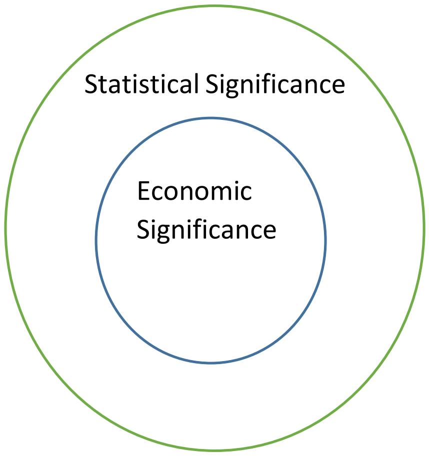


Figure B:

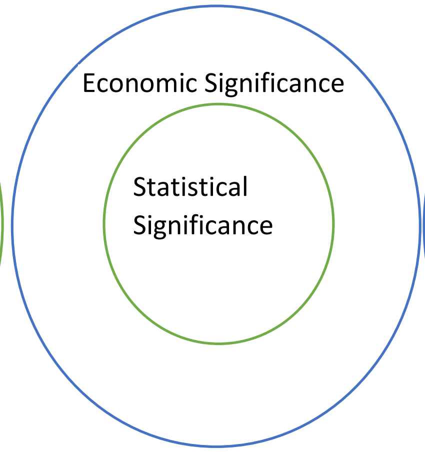
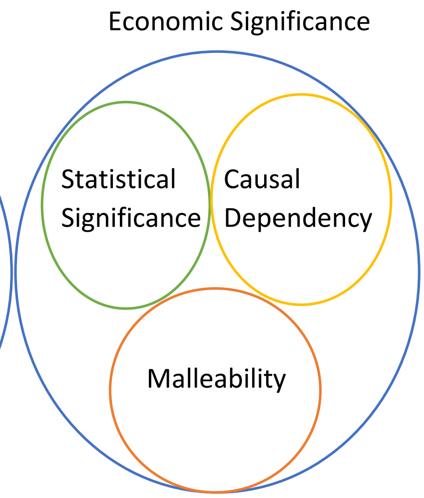


Figure C:



Section II:

Economic Theory and Statistical Methods

Before examining the components of econometric analysis, an overview of econometrics and its purpose as a whole is warranted. "Econometrics may be defined as the social science in which the tools of economic theory, mathematics, and statistical inference are applied to the analysis of economic phenomena".[12] This definition fails to capture the magic of the practice of econometrics. "Econometrics gives empirical content to economic theory…the econometrician also often needs special methods because of the unique nature of most economic data."[13] When an econometric model is created it is done to discover the true relationship between two entities. This process can be reduced down to three major steps. First, based on economic theory, a hypothesis must be formed, a mathematical model capturing the theory must be developed, and transformed into a statistical or regression equation. This statistical model is estimated and its results are subject to hypothesis testing.

In order to illustrate the last two steps of this process I will use David Romer's study, "Do Students Attend Class, ..., …?"[14] Romer theorized that student attendance directly influences learning in a university course. Romer does not develop an explicit theoretical

[12] Gujarati, Damodar N. Essentials of Econometrics. New York: McGraw-Hill, 1992. Print. (Page 1)
[13] Ibid, page 2
[14] Romer, David. "Do Students Go to Class? Should They?". The Journal of Economic Perspectives7.3 (1993): 167–174. Web...

model of student learning. Instead, Romer undertakes an empirical study to access the impact of attendance on course grades, his proxy for student learning. His regression model includes, in addition to class attendance, control variables that he believes influences grades. The linear regression model or statistical equation Romer employs is as follows,

(1) Grade = Constant + B_2(Fraction of Lectures Attended) + B_3(Problem Sets) + B_4(Prior GPA) + u_i[15]

There are two types of variables present in this mode: dependent and independent. The dependent variable in Romers theory is Class Grade. Class grade is dependent on the independent variables in the model. The independent variables are Fraction of Lectures Attended, Problem Sets, and Prior GPA. They are considered independent because they are free to move with no dependence on any other variable in the model. These independent variables represent the influence that they have with Class Grade. The coefficient or parameters attached to each independent variable (the B ‘s) represent the degree that the particular factor influences the Class Grade. Equation (1) is known as the population regression function (PRF). It is important to keep in mind that the PRF attempts to capture the true nature of an economic relationship, it is not an estimate, and it is THE value of a relationship of the ENTIRE population[16]. In other words, the “population” is the universe of all college students attending university at the time of the study. That is this model shows the true value of the relationship across all members of a population. The PRF however is more of a theoretical construct than

[15] David Romer, Journal of Economic Perspectives, pg.172; This is the first model that Romer developed to test his theory

[16] Population here referring to everyone that fits the category required. In the Romer example the population is all students.

one actually examined in econometrics. When an econometric model is estimated it is done from sample data from the population.[17] This new model introduces an error term which is intended to account for other factors that influence a grade and are unobserved or not explicitly controlled for in the model. Some examples are student will power, family tradition, social pressure, etc. In other words, the error term captures anything from the human element to acts of god.[18]

The model is then developed to use the sample data and is known as the Sample Regression Function (SRF). Instead of getting parameter values like in the PRF, we get estimators of the PRF. In a regression, these values are “b” instead of “B”. “B” is the true value of a relationship, “b” is the estimator that we derive from sample data in a SRF. These estimators are generated using a statistical method, Ordinary Least Squares (OLS). The purpose of OLS is to minimize the difference (or error) between what our model predicts Class Grades will be for each student and what each student actually earned in the sample.[19]

Essentially, the data represents only a subset of the population. The econometrician is then faced with a problem: she is supposed to estimate the PRF with her sample data. “Our task here is to estimate the PRF on the basis of the sample information”.[20] By making sure that the model is created in line with Classic Linear Regression Model (CLRM)[21] assumptions, the OLS estimators (b’s) will be known as the Best Linear Unbiased Estimator (BLUE). Specifically, this

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[17] The sample is a sub-group of the population. For Romer his sample space was his class specifically, which is a subset of students.
[18] Essentials of Econometrics, pg. 27
[19] Essentials of Econometrics, pg. 34
[20] Essentials of Econometrics, pg. 28
[21] CLRM assumptions are statistical in nature and will not mean much to a reader outside of statistics

means that the estimator has the lowest variance possible, is linear and will eventually yield the parameter value that will on average be equal to the true but unknown population parameter value (B's).[22] BLUE-ness will provide the link between the SRF and the PRF. If the SRF adheres to BLUE, then eventually the estimators in the SRF will average out to be the parameter in the PRF. However, there are several errors that a model can fall prey to that will generally destroy its' BLUE-ness so that using the statistical analysis to test economic theories becomes problematic.

Assuming that a model follows the CLRM assumptions, and the estimators are BLUE, will allow an economist to do something called hypothesis testing.

> "In applied regression analysis a 'zero' null hypothesis, the so-called strawman hypothesis is deliberately chosen to find out whether Class Grade is related to Fraction of Lectures attended[23]. If there is no relationship between the two variables, then testing a hypothesis of any relationship value between the two is meaningless"[24]

While the book calls this method "straw-man" a philosopher will recognize it as a type of reductio argument. A straw man simply poses a weak argument that is only intended to act as an opponent to give the impression of a strong argument. A reduction however has the agent act as if the opposite of what they are proposing is absolutely true and then works to show a contradiction from there.

An economist hypothesizes that attendance influences class grade. The economist then assumes the opposite, that B_2 (the true value of the relationship between the two variables) is zero. This assumption is called the null hypothesis. Simply, this means that we are going to

[22] Essentials of Econometrics, pg. 60
[23] Paraphrased to reference the model I have been using for example purposes
[24] Essentials of Econometrics, pg. 64

make the assumption that attendance has no influence on Class Grade. If we can reject our null/reductio claim, then we know that the relationship between Fraction of Lectures Attended and Class Grade is not zero.

To determine whether or not we can reject the null, we need to use a method called the t-test. The t-test is a method based on the idea of a standard distribution.[25] The T-test is reliant on a special value called the T-Stat.

(2) t-stat = $(b_2 – B_2)/ Se(b_2)$,

Where B_2 is the value of the population parameter, the standard null hypothesis testing assumes that the value of B2 is zero. The symbol, b_2 is the numerical value that our model has estimated B_2 to be. Se (b_2) is the standard error of b_2 or square root of the variance, a measure of its dispersion around its mean (B). The resulting statistical value is then compared to values generated by the t-distribution that yields a critical value. The critical value will change based on what alpha-value is chosen. The alpha-value chosen is what percent chance there is that the economist will reject a true null. In other words, it quantifies what chance there is that we say B_2 is not equal to zero, when it actually is. It is most commonly set at the 0 5% level. If the value of the t-statistic, calculated in equation 2, is outside of the critical value, you can reject the null hypothesis that B_2 is unrelated to the dependent variable being tested.[26] If the null hypothesis is rejected then B_2 is considered statistically significant. If something is determined to be statistically significant it means that it is statistically supported that there is a relationship between the observed variables. If the t-statistic is not outside the critical values then the

[25] Also known as the bell curve
[26] Damodar Gujarati, Essentials of Econometrics, pg. 65

conclusion is that there is a greater than alpha-percent chance that the actual value of B2 is zero. If B2 is zero, then there is no relationship between the independent variable and the dependent variable.

In Romers analysis of attendance he found a final equation:

(3) Class Grade = -.78 + 1.38(Fraction of Lectures Attended + .86(Prior GPA)

Originally one of the problems that Romer had trouble accounting for was the theory that the more motivated a student, the more they would attend class and the better they would do. In an effort to control for the motivation variable he selected a sample from his class of just those students who completed all the problem sets. He basically uses the argument that he is going to use the problem sets as a proxy for motivation. "Doing the problem sets is arguably as good a proxy for motivation as attending the lectures for motivation".[27] He found that both Fraction of Lectures Attended and Prior GPA were statistically significant.[28] Since he concluded that those factors are statistically significant he came to the following conclusion: "The estimates imply that a student with the mean prior GPA earns on average a C+ if he or she only attends a quarter of the lectures, compared to a B+ if attendance is perfect".[29] Furthermore, he also concludes that "None of these ways of attempting to address the problem that attendance is not exogenous is definitive…simple ways of controlling for motivation and other omitted factors have only a moderate impact on the relationship between attendance and performance. Thus, although the possibility that the relationship reflects the impact of omitted factors rather than

[27] Romer, Attendance, pg. 172
[28] Romer, Attendance, pg. 173
[29] Ibid

a true effect cannot be ruled out, it seems likely that an important part of the relationship reflects a genuine effect of attendance."[30] Romer makes an appropriate conclusion that the statistical testing of his hypothesis has not yielded unquestionable results, but it does show some nature of a relationship. So, statistical significance has provided him with a basis for his claims about attendance and grades, but he does not use his statistical results as an absolute measure.

Now that a basic overview of econometrics has been established I will provide a more specific analysis of the statistical elements. The econometric process relies on the linear regressions of statistical equations as shown above. It has become evident, however, that there are some critical issues surrounding our ability to differentiate when something is statistically significant and when something is economically significant. If something merits statistical significance then there is an equal to or less than 5% chance that the true value of the estimator is not zero. It should be noted that, given this understanding of statistical significance, something's status as statistically significant is in no way based on or related to the nature of its existence within a given world context.

For the purposes of this section of the paper and before introducing my definition of economic significance, I am going to use the intermediary term "practical significance" to argue against purely statistical interpretations. Something is practically significant when it is relevant to the relationship being analyzed and is not equivocal to statistical significance. In other words, it is entirely possible for something to be practically significant and not statistically significant,

[30] Ibid

and vice versa. The confusion of economic and statistical significance is a mistake that some economists still make in their academic work. It is not their fault, it is simply something that is not taught in a standard textbook according to McCloskey.[31] There is also not an equation to determine whether or not something is practically significant. It seems like an obvious thing to keep in mind, but the repeated emphasis on statistical significance and distinct lack of attention towards practical significance means that the terms may become one in the same to many minds.[32]

Section III:

A Critique of Statistical Significance

According to McCloskey, in most economic works, the emphasis is almost exclusively on the statistical significance of individual coefficients.[33] The exclusive emphasis on statistical significance is a problem because it creates an environment where statistical significance is perceived as the most important criteria used to determine whether or not an independent variable is relevant in explaining the dependent variable being measured. McCloskey's data showed that 70% of empirical econometric articles in the American Economic Review used the terms statistically significant and economically significant interchangeably.[34]

[31] Deirdre McCloskey, Standard Error of Regression, pg. 89
[32] Deirdre McCloskey, Standard Error of Regression, pg. 98
[33] Deirdre McCloskey, Standard Error of Regression, pg. 106
[34] Deirdre McCloskey, Standard Error of Regression, pg. 106

The following discussion and example is taken from McCloskey and illustrates the problem with sole emphasis being put on statistical interpretations. The over emphasis on statistics can, in turn, lead to some critically flawed interpretations of results[35].This flaw is difficult to see in the more nuanced nature of economics, but easy to see in a simple framework. The following equation is the result of a simple regression of weight in pounds on height (X1) and hours of exercise (X2) performed by an individual. Preforming the standard t-test on the estimated values of each coefficient show that that both are statistically significant and that the model is correctly specified.

(4) $ExpectedWeight(lb) = 30X_1 + -.25X_2$

Note that the data applies only to men. The interpretation of the estimated values of the parameters are that for every foot a man grows he will gain an extra 30 pounds, and for every hour that a man exercises he will lose a quarter of a pound. A purely statistical reading of that statement is that greater emphasis needs to be put on X_1 since it is further from zero than X_2. Should someone come in for analysis of their weight and he were over-weight, a statistician doing the analysis would simply say he is too short for his weight.

Given the statistical interpretation, there are some immediately noticeable problems, namely that a statistician would recommend the over-weight man change his height before he exercise more. If, however, the example is removed from a situation seated so closely to common sense it is entirely possible to make interpretations of results just as absurd. Basically, when we examine an equation with something that everyone is familiar with, height and

[35] Deirdre McCloskey, Standard Error of Regression, pg. 104

weight, the problems of a statistical interpretation are obvious. If we create an equation with factors that are not as familiar, the same kind of error may not be as obvious. When the mechanics of the variables aren't as clear as weight, height, and exercise, the majority of economists fall back on the t-statistic to determine relevance. The t-statistic, however, is woefully devoid of any kind of situational relevance. When one uses only statistics to determine relevance, it is possible to create a variety of models that are as absurd as the one that determines that someone's height is too short for their weight.

Ultimately, the primary cause of the generation of such absurd models and interpretations is the astigmatic emphasis on the t-statistic. Furthermore, the reason that the t-statistic can generate such problematic models and interpretations is because it fails to account for the nature of the variable itself. In ignoring the nature of the variable, the t-statistic is limited to explaining only how likely something is to occur by chance or how unlikely a relationship between variables will occur by chance.[36] In the example of height-weight, we get the absurd result that we do because the t-statistic does not account for the nature of height; the t-statistic does not account for the fact that height is non-malleable. No one can change their height, and it seems intuitive that height is a greater indication of expected weight than hours exercised. The nature of the relationship between height and weight is simply absent from the analysis. The statistical significance also fails to capture the relationship of size between independent and dependent variables. Very rough knowledge of calories and the body reveals that 1 pound consists of approximately 3,000 calories, and a fairly rigorous workout

[36] Damodar Gujarati, Essentials of Econometrics, pg. 68

over the course of an hour will burn approximately 750 calories. Thus the statistic of .25 pounds lost per hour of exercise sounds roughly correct. The approximate accuracy of that coefficient doesn’t come from any statistical source. Rather, the accuracy comes from the background knowledge about how a body functions and how exercise mechanically relates to weight. In economics there are so many different scales of size and units of measurement that it can be difficult to tell if a certain coefficient makes sense without any aid outside the realm of statistical significance. To help bridge this gap, statistical significance and practical significance need to be established as distinct and separate concepts.

In addition to *distinguishing* statistical and practical significance, econometrics, which as demonstrated earlier, relies heavily on statistical analysis, also needs a means of determining whether or not the data *is* practically significant. A coefficient that is practically significant requires that it is large enough to be considered relevant to the dependent variable and should be examined in the big picture. To illustrate practical significance, consider the following example: Say that the number of labor hours contributed to output as measured by real Gross Domestic Product (GDP) has a coefficient of 0.5. That is to say, for every hour worked by any citizen, anywhere, GDP is increased by 0.5 units. Assume that the 0.5 coefficient is statistically significant. When an economic agent in charge of policy making is going to make a decision, whether or not to pay attention to labor hours contributed in the determination of GDP depends on contextual information. The 0.5 coefficient may be too small to even have a pragmatic effect on GDP. Number of hours labored may not be an independent variable that could be easily manipulated due to regulation, making it comparable to height in feet from the previous example. Most importantly, what this example reveals is that while the coefficient may have statistical significance it may not have any practical significance. Since only 30% of papers make the distinction between economic and statistical significance when drawing a conclusion,[37] not only is the value of non-statistical significance lost, the very nature of non-statistical significance is made elusive.

The lack of differentiation between terms creates a problem for the reader. The collision and equivocation of practical and statistical significance creates a scenario in which probability and pragmatics are wrongfully intertwined. Statistical significance is essentially a claim about probability that gets confused for a claim about pragmatism. Econometrics texts even admit that the statistical methods they rely on cannot be used to determine the causal relationship between variables without something else to put context on the findings.[38] This particular fact gets glossed over in the rush to find more supportive statistics. What they do not do, however, is explain what we should use to help establish a causal relationship between a coefficient and its dependent variable.

The simple solution is to remain grounded in reality. Instead of becoming lost solely in the statistical states of data it is important to remember the context in which they occur. All that the data represents cannot be contained in a t-stat analysis. Asking whether or not the coefficients are large enough to be meaningful and if the independent variable can be manipulated for pragmatic purposes is an entirely different question than whether or not that coefficient is unlikely to have happened by chance. The first question is a matter of economic significance, the second being a matter of statistical significance. The fact that 70% of

[37] Deirdre McCloskey, Standard Error of Regression, pg. 105
[38] Damodar Gujarati, Essentials of Econometrics, pg. 17

quantitative journal articles in the American Economic Review use the terms as though they're analogous points to a greater problem. In an effort to try and make economics more quantifiably sound the question of degree and relativism has been nearly ignored. Current textbooks give very little attention to the difference between economic and statistical significance according to McCloskey. She claims that they place such heavy emphasis on the statistical significance of variables that the term comes to represent any kind of significance.

The issues mentioned above are not issues that economists run into and scratch their head at in bewilderment. They needed to be shown to exemplify the fact that economists are not solely relying on statistical analysis despite the language they use in their analysis of results. Economists work around the problems and apply economic significance to determine the purpose and contextual value of the regression. However, it is important to note that up until this point I have not made any claims about what constitutes economic significance. I have intentionally used the term practical significance to show that economic significance is greater than the vague definition that McCloskey has given. It has an element of pragmatism, and also an element of statistical analysis. However, those two elements, even in combination, are insufficient in defining economic significance.

Section IV:

Definition of Economic Significance and Economic Relevance

Now that I have shown sufficient evidence to prove that statistical significance alone is not sufficient to be used interchangeably with economic significance; economic significance needs to be clearly defined. For McCloskey, economic significance is some kind of vague practical attribute. It is vague in the sense that McCloskey never clearly defines the traits that constitute economic significance and readers are left to form a definition from her use. In order to determine what is economically significant there needs to be a formal definition of what economic significance is. This part will be devoted to formally defining economic significance in both a philosophically and economically sound manner. I am going to define economic significance as having three conditions that must be met. These conditions can be summarized as having a causal relationship, mathematical significance, and malleability. I will argue how these conditions are relevant and must be met for something to be considered economically significant. Although something can be relevant with these conditions partially met, they will not be economically significant. Furthermore, to account for variables that will partially meet the criterion that I have outlined I am going to introduce the concept of economic relevance. Economic relevance will consist of relationships that contain two of the three criteria required for economic significance since they will still play a relevant role in economic analysis. This is a category designed to house the factors that meet two or more of my qualifications and must be taken seriously but are not given the same consideration as something that is economically significant.

In econometrics, an econometrician should by all means admit that quantitative analysis does nothing but show correlation. "The collected data may be the result of several factors… and may be compatible with more than one theory."[39] If there is no way to establish anything beyond correlation with quantitative analysis, a different approach will have to be taken. Philosophy fortunately lends itself to answering these kinds of questions. The kind of causation proposed by David Hume is a popular concept and thus deserves explanation. Ultimately, however his type of causation will prove insufficient. There are cases where the Humean system would lead to the incorrect conclusion of a relationship between variables. Hume's analysis of causation takes, as its starting point, our customary conceptions of causation. Typically, when philosophers and non-philosophers claim that X causes Y they assume that X and Y are ***necessarily*** connected; if X causes Y this means that if X occurs then Y necessarily will occur. Hume is interested in the origin of this idea of causation, the idea of necessary connection, and the rest of his account of causation is an attempt to illuminate the source of our idea of causation and, ultimately, to show that when we claim that a causal relationship exists between two things, we are describing merely a ***constant association*** between two things and not a necessary connection between two things. "To me there appear only three factors connecting ideas with one another, namely, resemblance, contiguity, and cause or effect".[40] According to Hume all I mean when I say "X causes Y" is that (1) I have regularly experienced the constant conjunction of X and Y (2) I assume that nature is uniform and so, (3) When X occurs my mind immediately calls to mind Y. So according to Hume, because I have

[39] Damodar Gujarati, Essentials of Econometrics, pg.5
[40] David Hume, Enquiry Concerning Human Understanding, pg. 10

regularly experienced a constant conjunction of X and Y, because I assume, without reason, that nature is uniform, and because of the principles governing my mind, I come to think that X and Y are necessarily connected and I claim that X causes Y.

> "However hard we look at an isolated physical episode, it seems, we can never discover anything but one event following another; we never find any force or power by which the cause operates, or any connection between it and its supposed effect"[41]

Clearly, according to Hume, although I assume that X and Y are necessarily connected when I make causal predictions, if all "causation" "is" is my habitual experience of two things that have been constantly associated then the two terms of the causal relation are not ***necessarily*** related to each other in the way our mind assumes.

> "But what can a number of instances contain that is different from any single instance that is supposed to be exactly like them? Only that when the mind experiences many similar instances, it acquires a habit of expectation"[42]

Take for example butter on a table and the sun shining. Experience has taught us to expect the butter to melt in the sun. Our mind has often gotten the impression of idea A (sun shining on butter) to be followed by its usual companion impression B (butter melting). If we were to see the butter melt, as would often be the case, we would infer that the sun caused the butter to melt as our experience has led us to believe that this will be the case. We assert a causal relationship between the sun and butter melting because it is what experience tells us will happen. However, suppose the butter is left out on a table in the sun in Antarctica. Though the sun is present, the butter will instead be frozen. Our impressions of butter melting in conjunction with the idea of the sun has led us to actually hold the false belief that the sun's

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[41] David Hume, Enquiry Concerning Human Nature, Section 7, part 2, page 36
[42] David Hume, Enquiry Concerning Human Nature, Section 7, part 2, page 37

shining is ***necessarily*** connected to the butter melting. This example is to show how our perception of particular causal relationships change based on our sensory experiences, and not a system of necessary causation, and that our intuition can be fooled. One man might experience something so regularly he considers it a universal fact, while another man experiences the same two phenomena and the result is different. The Antarctica instance shows that there is no necessary connection between sunshine and butter melting and, moreover, according to Hume, we have no reason to think that necessary connections obtain between anything in the natural world; we have no reason to believe any of the laws of nature will hold in perpetuity. So, for Hume if causation ***is two things standing in a necessary relationship*** then there is no such thing as causation, per se.

> "Every idea is copied from a previous impression or feeling, and where we can't find any impression we may be certain that there is no idea. No isolated episode of mental or physical causation yields any impression of power or necessary connection."[43]

The point here is to say that there is not a sensory impression to which we can link any idea of necessary connection, i.e. to which we can link the idea of causation as necessary connection. And for Hume this is an important point because he believes that all our ideas result from sensory impressions. The first time we see two billiard balls hit each other and go flying we have no reason to suspect that the collision caused it. Only after repeated uniform events do we begin to assert a causal relationship. The necessary causality is never something we observe with any of our senses.[44]

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[43] David Hume, Enquiry Concerning Human Nature, Section 7, part 2, page 39
[44] Ibid

The problem with adopting this particular system can be highlighted in an example. An economist is doing research and finds that global warming and piracy are both increasing. The two increase simultaneously and continuously. Under the Humean definition of causality it is reasonable to conclude that the two variables occur together regularly in an identical way as it getting warmer and Coke sales increasing. However it seems that common sense would rule against that. It seems that there should be no causal relationship between global warming and piracy, but the correlation shown is enough to establish a relationship under Humean interpretation.

The opposite of this causal theory is that of necessitation[45]. Where Hume claims that all of our experiences of causal relationships is actually just correlation with a psychological quirk thrown in to gel the events together, necessitation is that for event X, Y must necessarily occur; there is no possible world or scenario in which event X is not followed by event Y. While this may initially seem acceptable for my purposes in this paper, the metaphysical burdens are simply too much. This elevates causal relationships to the same tier as logical truths, and makes claims that are stronger than what I need while simultaneously opening my theory up to unnecessary problems. For example, if I were to say that the sun causes butter to melt, this would be just as powerful as X is X. They would have the same strength claims. This causes a problem when we imagine a possible world in which the atoms of butter freeze in the presence of sunlight for whatever reason. While silly, it seems plausible that a world could exist with that particular set of properties. However, if I try to imagine a world in which butter (X) is not butter,

[45] Also known as causal determinism

that seems absurd. If something is not butter, it does not seem that it is both butter and not butter, rather that it is just not butter. The point being that the two claims assert two different claims with different strengths, and under the system of necessitation they are equally strong.

I am going to advocate a type of middle-ground causality. I need a causality with stronger claims that Humes theory[46] but not quite the strength of necessitation. This middle ground is the ideal position because it weeds out cases of confusing correlation with causation and avoids overly intense metaphysical claims. To solve this problem I am going to adopt the counterfactual classification of causality advocated by David Lewis. This system relies on a kind of many worlds framework but does not require any kind of claim about the actual existence of other worlds. When attempting to determine causality, imagine a world as similar to the one we inhabit, and is so similar that the only event being changed is the one we are going to try and change to determine causality, then pose a counter-factual for the event being examined. For the theory to work as intended the world must be as similar to this one as possible. According to David Lewis, “Whether e occurs or not depends on whether c occurs or not”[47] in this closest possible world. That is to say that if X occurs, Y occurs; and if X does not occur then Y does not occur. If Y still occurs in the absence of X or Y does not occur in the presence of X, then Y is not causally dependent on X. Essentially if we determine that Y will happen regardless of X in this possible world then it is wrong to claim a causal relationship between the two. However if I remove X, and Y does not happen, then the claim X causes Y is acceptable. While this may seem to be an exclusively philosophical mechanism, economists already essentially do

[46] Humes theory is also known as regularity theory when being referenced in more modern works
[47] David Lewis, Causation, Journal of Philosophy, pg. 563. To relate this example to my discussion directly, c =X and e =Y

this when they invoke the 'Ceteris Paribus'[48] clause. They are making an attempt at conjuring a world identical to ours in which everything is the same except the thing they are manipulating and analyzing whether or not the events are causally related. This method also allows for a chain of causal events and is not restricted to simple two part relations. To illustrate these two points, I will go back to the piracy and global warming problem. Under a counter-factual analysis, we would look at piracy rates without global warming, ceteris paribus. Evidence would indicate that piracy rates would rise in the absence of global warming, eliminating a claim of any kind of causal relationship. If however it could be shown that piracy would stop growing in the absence of global warming, the claim could be made that piracy is causally dependent on global warming. This method eliminates the kind of inconsistencies that would be present under the Humean system.

To show how this same principle is already used in an econometric sense, I will examine the regression created by David Romer in regard to attendance and students grades[49] (JES, 1993, pgs. 167 – 174). He created the model we examined before: Class Grade = -.78 + 1.38(Fraction of Lectures Attended) + .86(Prior GPA). To establish the causal dependency of Class Grade on the Fraction of Lectures Attended, we would have to observe that when the Fraction of Lectures Attended (FoLA) changed, Class Grade (CG) earned changed with it. Furthermore if FoLA did not change, then CG should not change either, ceteris paribus. Statistical analysis then steps in to tell us whether or not the effect represented is statistically

[48] Ceteris Paribus - with other conditions remaining the same. It is a term used in any introductory economic textbook

[49] This is the same regression from section 2, but now is Romers actual results and not just a theoretical construct for explanation purposes

different from zero. That is whether or not there is a substantial claim that FoLA influences CG at all. If it does not meet the conditions then it shows that the experimental regression may have other issues or that CG is not causally dependent on FoLA. If it does then the claim is essentially that, ceteris paribus, in the presence of a change in FoLA, CG will change. If FoLA does not then CG will not. If it can be shown that FoLA changes a statistically significant amount with no change in FoLA and the others being held constant we would not assume a causally dependent relationship. To summarize, econometricians utilize a similar qualification of causality as the counter-factual method without formally declaring that they are using it. Using the example above with X representing FoLA and Y representing CG, plugged into the counter-factual system accurately represents what a regression is trying to prove. Unfortunately the regression is limited to showing correlation but the philosophical method can be used to make more concrete claims about causality.

Using the counter-factual method also makes a good first move towards working through the problem of which factor is causally dependent on which that could have proven problematic under the Humean system. Take for example a disease, Ebola[50]. Before modern medicine it would have been impossible to determine whether or not the symptoms caused the disease or if the disease caused the symptoms. If I examine this issue with the counter-factual framework it highlights the causally dependent and independent factors, basically which causes which. Keeping in mind the basic test --if X does not occur, and Y does occur, then X and Y are not causally related—I will apply this to the example and show the singular direction of causal

[50] For the philosophically inclined, this problem is highlighted in the Aristotelian star problem. That is to say whether or not a stars twinkling is caused by distance from Earth or vice versa.

dependence. If the person is infected by Ebola (X), ceteris paribus, then the person will bleed to death (Y), and if the person does not have Ebola (-X) then the person will not bleed to death (-Y). This seems intuitive and allows us to make the claim that the disease (X) causes symptoms (Y) with Y being causally dependent on X. Now I will do the same thing in the opposite order to show that this is not an instance of mutual causation. Suppose the person is bleeding to death (Y), it does not necessarily require the person to be infected with Ebola (X). There are a host of reasons the person could be bleeding to death, and it does not require that the person have Ebola. If that were the case we would say that anyone bleeding to death would have Ebola, which is obviously not true. Thus we can conclude that the symptom of Ebola, bleeding to death (Y) is caused by the disease (X) and not the other way around.

One issue that is not entirely worked through is cases where the factors may be co-dependent. Continuing with the class grade example from Romer, one factor he attempted to include and later discarded was number of Problem Sets Completed. He was basically testing to see if homework completion influenced Class Grade. The issue was that it seemed intuitive that someone with a high grade would be more inclined to continue doing their homework versus someone who already had a poor grade. He suspected that there was some sort of dual dependency happening that complicated the measurement. He ultimately controlled for this variable in response to not being able to reasonably sort out whether Class Grade exclusively caused higher Problem Set Completion rates, higher Problem Set Completion rates exclusively caused a higher Class Grade, or if the two managed to cause each other. While this is a problem beyond the scope of this paper it is an important problem to recognize because it is not always clear as to which variables cause another, and in Romers case he controlled for it as best he could to avoid the issue. When building models determining which way the causality flows is important to discovering the relationships between variables.

Having clarified the kind of causality that must constitute the causal condition for economic significance, I will now to explain why a causal condition is necessary for economic significance. In the study of econometrics the purpose is to find the explanatory power in variables in regard to a dependent variable. This is reflected in the language of the study: explanatory and explained variables. Since the purpose is to find variables with explanatory power, the variables that would be valuable would be the ones with causal relationships to the dependent variable. If a variable lacks a causal relationship with the explained variable then it is not reliable in the determination of the explained variable. If for example personal disposable income (PDI) only occasionally influenced consumption (C) spending, PDI would not be viewed as an explanatory component of C. When an economic theory is correctly applied to the results of a regression it is essentially giving an argument for why this particular explanatory variable has a causal relationship with the explained variable. The only thing that a statistical analysis can provide is evidence of correlation. To bridge the gap between correlation and causation, economic theory is used to provide the explanation of a causal relationship. For example, statistically if the weather gets warmer, Coca Cola will sell more. The economic theory behind it is that in the face of higher temperatures, the utility derived from Coca-Cola increases, and those with higher reservation prices now finds that the benefit outweighs the cost where previously the cost had outweighed the benefit. This analysis does not serve to establish a causal relationship but explains more about the reasoning behind a relationship once established. Care must be taken to insure that the theories used describe causal relationships and not merely regular associations or constant conjunctions. If a causal explanatory variable changes then the consequence must be necessary. If this is not the case then the variable may be relevant but not causal.

The second condition that must be met is mathematical significance. I am using the phrase “mathematical” as opposed to “statistical” significance because I want to include the entirety of the statistical/mathematical process and not simply the T or F tests. There is currently some debate in the statistical community over the accuracy of current probability testing models[51]. This qualification includes statistical significance and testing but is not limited to it. Data needs to be examined for specification errors and other types of problems that can cause the results to be inaccurate. Earlier I gave examples as to how statistical analysis was not sufficient to define the entirety of economic significance. It does however serve an extremely important role in the meaning of statistical significance. If the condition of causality is met, the actual effects of the thing are lost without mathematical analysis. The empirical observation of the causal relationships would be unobtainable without this kind of analysis. Since economics is a study essentially based on the calculated cost and benefit of decisions, the validity and explanatory power of an empirical analysis is absolutely crucial.

Suppose there is a variable that is casually linked to the dependent variable, and included in an econometric regression, but is statistically or mathematically unsound. Take the example of Coca-Cola again. If we manage to prove that sales are causally dependent on the weather, but get faulty measurements as to what degree the relationship holds, the knowledge

[51] This debate includes but is not limited to P-values and their accuracy.

of a causal relationship is not economically valuable. To know that a causal relationship is present is not in and of itself useful. If an economist were armed with only a causal relationship he or she would have no idea whether the weather is a strong enough variable to merit accounting for: the economist would know only that there is some kind of relationship. A worse scenario would be a false analysis of the quantitative nature of the relationship and to invest resources into accounting for it on false pretenses. The inclusion of this variable would be irrelevant at best and actively harmful at worst since the measurement would be unknown or inaccurate. Some kind of consequence could be supported through the causal relationship, it may even be determinably positive or negative. However, the invalidity of the statistical analysis keeps us from knowing any more than that there is a relationship. It would be difficult to find someone willing to attribute economic significance to a statistically or mathematically insignificant variable regardless of causal relationship.

Statistical analysis, beyond being essential, allows economic agents to make important decisions. It allows them to anticipate change, to gauge marginal benefit and cost, to determine which variables to focus on, and to delineate which variables effect the right amount of change or are the most efficient variables. This type of analysis allows us to determine whether or not trying to influence a particular variable has greater benefit than cost. If the money and effort economic agents put into manipulating a variable do not potentially yield a net benefit, they will not invest the time and money. Continuing with the Coke example, suppose that we now have a sound case for sales being causally dependent on the weather, and we know exactly how much of an impact the weather will have on sales. As the company, we can anticipate the change in sales that will accompany a particular shift in the weather, allowing us to change production, arrange storage, etc. In addition to reducing costs, they can also use the same methodology to make efficient growth choices. If Coke is faced with investing in advertising in social media or traditional methods, they would be able to determine the best means for increasing their revenue. If Coke were to get this wrong there could be host of negative consequences. They could over/under produce, invest heavily in inefficient marketing techniques, all of which could spell the end of Coke. While the example uses a private company, the costs reduction/revenue increase can be extrapolated to the government. The idea is that with the knowledge provided by quantitative analysis economic agents can make more efficient decisions regardless of size or level. These kinds of projections are only possible due to the kind of empirical analysis that mathematics allows us. All of the potential costs and benefits are important factors when an economic agent is in a position to make a decision to reduce inefficiencies and optimize resource utilization. The significance of statistical analysis and all of its requirements and metrics such as the significance of variables through t-statistics and the BLUE-ness serve an important role in determining the accuracy of the data that is used to make such a decision. This data is the work horse at the core of economic significance. As I previously argued, statistical significance is insufficient to warrant economic significance alone. It is however the lynchpin of pragmatic use and the metric used to determine the best course of action that should be taken. Causality provides a standard for us to determine whether or not the variable is rightfully linked as a cause to some effect. Econometrics through the use of statistical analysis provides a quantifiable consequence to the manipulation of causal variables.

The third and final piece of economic significance is malleability. Non-malleability here being used to refer to a thing that is totally self-legislating. Essentially non-malleability means that by some circumstance, its' nature, our current understanding, our current tools, the market that it is present in, any property that yields the attribute non-malleability, the manipulation of said thing is beyond our control. There is nothing we can do that will intentionally manipulate its' value in accord with our will. This condition is essentially to account for the difference between the variables that an economist would need to take into account and those that an economist could view as a potential tool. An example of a non-malleable variable would be the weather. At this current point in time there is no way for us to directly influence the weather. The weather however can affect economic decision, IE: buy more coke when it is hot. The weather would not be an economic factor that could be influenced and as such not as important from the perspective of an economically minded decision maker who cares about economic significance. When an economist is making a decision to invest limited resources, those resources should not be invested into nonmalleable variables such as weather, and should instead be used to manipulate malleable factors such as the amount of advertising.

Suppose an economist runs a regression and discovers a particular variable. This variable is discovered to be causally related and is also mathematically significant. Now further suppose that this variable does not meet the final condition of malleability. I.e. the variable is non-malleable and will legislate itself. It is important to keep in mind that the non-malleability does not mean "static". A non-malleable variable may shift dramatically, but this shift does not result from our actions. It is also important to note that the property of malleability may change and is not absolute. Take, for example, the case of foreign trade with a foreign country (China) that has a fixed foreign exchange rates. In that example the foreign currency exchange rate is considered non-malleable to U.S. analysts. In other words, the foreign exchange rate may change, but not as the result of any action an American economic agent takes. Instead, any potential change would be rooted in movements from within China itself. It seems intuitive that malleability would be a relativistic measure; the concept of non-malleability is dependent just as much on the subjects' abilities as the nature of the thing being manipulated. The concept of manipulability is dependent on the subject being examined and their abilities. A Chinese analyst charged with reviewing the impacts of the fixed exchange rate may consider it malleable since he is being asked to review it's efficacy and can potentially influence it to change. From the US analyst perspective the exchange rate would be non-malleable due to it's fixed nature. A short and simple way to think of it is that if something can be reasonably considered manipulable from a relativistic stance, it is malleable. If it is not reasonably manipulable, then it is non-malleable. Furthermore, a non-malleable variable is not necessarily going to stay non-malleable indefinitely. If the Chinese minister of economics were to come out and declare a floating exchange rate, then it would be considered malleable to both the US and China. It is reasonable to assume that the US could introduce a quantity or quality of goods that would influence the value of Chinese currency. The importance behind malleability is separating economic entities that can be controlled, versus those that must simply be accounted for.

However, reverting Chinas hypothetical foreign exchange back to a fixed value does not indicate that we should ignore it. Just because the variable is non-malleable does not mean that it is irrelevant or useless. It is still very relevant to the amount of foreign trade that China participates in. In the case of a regression related to the Chinese foreign trade, the fixed value is relevant. It seems likely that excluding the value of Chinese currency could result in a misspecification error of omitted variables. This means that not including the non-malleable variables could have a quantifiable impact on the validity of the mathematical analysis. For the purpose of the example, also assume that the relationship between foreign exchange rates and foreign trade is such that it satisfies the causal condition. This example creates a scenario where Chinas exchange rate must necessarily be considered, but does not fulfill the qualifications for economic significance by definition. Although it is non-malleable, it is mathematically and causally important. This leads to my next move. It is foolish to claim that economic significance is the only measure of utility or that if something does not meet the conditions of economic significance then they are not worth consideration.

To capture the economic factors that that fall short of economic significance, but are still highly relevant to an agents decisions making process, I will introduce the term “economic relevance”. Economic relevance is closer to what I believe McCloskey had originally intended when she wrote about something having economic significance. Rather than proposing a new list of conditions something must meet to be deemed economically relevant, something will be economically relevant based on the degree to which it falls short in regard to the criteria for economic significance. A particular variable that meets two of the conditions for economic significance is economically relevant. For example, if a variable is both causal and mathematically sound, then all that can be said about the variable is that we cannot control it. Despite its failure to meet the malleability condition, the variable should be taken into consideration precisely because the variable stands in a causal relationship with the dependent variable, and because we can also mathematically determine the degree to which it affects it. To omit the variable ONLY because it fails the malleable condition would be to leave a crucial piece of an economic puzzle out. Suppose instead that an analyst has stumbled upon a variable that is both causally related and malleable. This would simply be a case of needed mathematical refinement. Somehow he has obtained the knowledge that this independent variable is causally related to the dependent variable and that it is reasonably within the realm of control. Dismissing this variable would be a critical mistake, although it does not qualify for economic significance. It could later become qualified after fleshing out its quantifiable details more thoroughly. The final permutation would be if something were to be malleable and mathematically sound but not causally related. Suppose this particular variable works in a specific way in this market that does not align with its' behavior in other markets. The variable should still be considered since it shows a mathematically supported effect on the dependent variable and is also within our ability to control. It should be noted, however, that if a policy is implemented utilizing this variable that it depends on a special circumstance in the market and the solution in this instance may not be a solution that could be applied elsewhere.

When all three conditions are met, it qualifies for economic significance. If two conditions are met then the variable is considered economically relevant. The final case that could arise is the case in which a variable met only one of the conditions. There are so many different variations on the nature of the things that could meet a condition. So in this case, the burden is on the economist to determine if the variable is relevant to the dependent variable. Due to the wide range of things that could qualify for one variable, instead of looking for a class of things, or type of things, rationality will just need to be applied and potentially relevant variables will need further analysis while irrelevant ones will be discarded.

With both economic significance and relevance defined, something needs to be said about their proper use. To say that something in isolation is economically significant is an incorrect use of the term. A variable is economically significant ONLY in the context of its' relationship with something else. For example, when I tell my friend that worker productivity is economically significant to GDP, I am asserting that (1) worker productivity universally influences GDP, (2) I have knowledge of the approximate degree that worker productivity influences GDP, and (3) that worker productivity is a variable that is reasonably manipulable. Economic relevance is also a relational term and indicates the nature of the relationship between two things in a given context. Suppose I say that worker productivity is economically relevant to GDP. In this instance, I am asserting that worker productivity is important to GDP, but is less significant than in the original utterance. Economic significance and economic relevance can be obtained or lost as a result of a change in context. For example, worker productivity may not be economically significant to GDP in country X, but is in country Y. What is important is that economic significance is not a property of a particular variable; worker productivity itself does not contain economic significance, but rather it is something that is derived from the properties of the relationship between two things such as worker productivity and GDP. Economic significance is a trait of a particular relationship and is not inherently present in any economic factor. Rather economic significance is something we can say about the relationship between two things.

I have attempted to define economic significance through the use of philosophic discourse. This definition is far more useful than some vague kind of pragmatic principle. Furthermore it opens the definition up to debate. It is far easier to refine an idea with a concrete starting point as to what something is, that I hope I have provided, than a vague notion of what it should be. My goal is to create a definition of economic significance that both philosophers and economists can agree is at the least, a good starting reference point.

Section V:

Continuation

Hopefully I've given a satisfactory account of the meaning of economic significance, economic relevance, and statistical significance. There are, however, some areas where I feel my definition could have benefitted from additional expertise. First, the "statistical significance" condition for economic significance could have been strengthened if I had a more thorough understanding of the statistics behind econometric analysis. I have intentionally kept my criticism of the mathematics in the realm of interpretation and use in order to avoid overstepping the boundaries of this work and making my definition vulnerable to criticism that a more mathematically inclined individual could easily account for.

Nonetheless, a greater understanding of the mathematical principles governing the t-stat could only lend credibility to my argument that statistical significance is insufficient in a vacuum. I am operating off of the assumption that the t-statistic and test is totally structurally sound. I previously mentioned the authors McCloskey and Ziliak having written a book "The Cult of Statistical Significance" on the topic of the validity of the t-stat. They claim to have an argument against the t-statistic. The mathematically inclined would be able to analyze their argument from a technical point of view and either validate or condemn it. This would contribute a more technically proficient element to my argument rather than a strictly theoretical one.

A specialist in metaphysics would also be able to greatly contribute to my work here. While I focused on which form of causal theory serves my definition best from a pragmatic point of view, adopting a stance also carries the weight of metaphysical claims. Since my thesis relies heavily on counter-factual causality, any viable criticism leveled at counter-factual causality serves as a strong criticism of my definition of economic significance. My thesis, therefore, would benefit greatly from a defense against common counter-factual criticisms. A specialist in the philosophies of David Lewis would also be able to point out the nuances of his argument in greater detail. My thesis here just outlines the pragmatic function of his causal theory. A more detailed interpretation of his work may reveal a nuance about the causal element of my definition that either supports it or weakens. This being the case, I could develop a more specific model drawing from his work or work to amend possible problems myself.

Section VI:

Conclusion

My thesis aimed to infuse a vaguely understood economics term, economic significance, with a philosophically sound definition by way of distinguishing it from statistical significance. The need for such a definition points to a larger issue within the practice of economics. Economics started originally as a philosophical pursuit[52]. Over time the practice has shifted steadily in favor of mathematics over philosophical discourse. While mathematics are important, the very nature of the world dictates that mathematical analysis alone cannot bridge the gap between the real world and the interpretation of the data. My examples for the insufficiency of statistical significance highlight some cases of this occurring. The more that mathematics is seen as dominant, I fear the more often there will be confusions of this sort. Mathematical myopia is a problem. The evidence being the statistics that McCloskey found.

Economics and philosophy both benefit from the combination of the two. Economics serves to make the philosophy behind it applicable. It is well and good to know the theories and proofs of why things happen, but economics is done in the balancing of cost and benefit. If those figures are entirely unknown then the application of the underlying theory is sketchy at best and will almost certainly lead to inefficiencies in the application. Economic analysis on the

[52] The first economists were essentially philosophers that dealt with a quantifiable topic; IE: David Hume

other hand needs philosophy to keep it grounded. The most accurate data that has ever been gathered still needs to be interpreted in the light of the underlying philosophical theories.

In conclusion, I hope my definition of economic significance will help distinguish it from statistical significance. I have endeavored to show that statistical significance is not sufficient to account for economic significance. In order to more clearly divide the two I have provided a definition for economic significance. Economic significance requires a variable to meet three conditions: universally causal relationship, mathematical soundness, and malleability. This status is the highest status that an economic variable can hope to achieve. To allow for variables to develop over time I introduced economic relevance. This allows for variables in development or with relative value to be examined and not be stuck in a bi-modal system where they are irrelevant or economically significant. I realize that there are probably few variables that will achieve the status of being economically significant given my definition. This is why economic relevance is just as important. The majority of variables will fall into this category. In the larger picture I hope this move assists in reinforcing the importance of philosophy in economics. The definition of economic relevance is less definite and requires critical thinking skills and analysis, which are the hallmarks of philosophy. The disciplines of philosophy and economics benefit each other, and they are not mutually exclusive disciplines. In fact, the two disciplines work best when coupled with each other. However this goes against the current trend of emphasizing the mathematical element. This trend is dangerous. It undermines the founding discipline of economics. Economics was originally an exercise in philosophy and only later came to be a quantifiably supported. In philosophy there are certain things that cannot be quantified. Over emphasis on mathematics cannot ever bridge that gap.

Hopefully I have not only prevented the confusion of a statistical and economic term but have also set a good example for how interdisciplinary work can solve a problem better than either discipline working individually.

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I pledge that I have acted honorably. –Dakota Sneed