universität wien

MASTERARBEIT | MASTER'S THESIS

Titel | Title

Neo-Conventionalism in Economics as an answer to epistemological demands

verfasst von | submitted by

Karen Spisso

angestrebter akademischer Grad | in partial fulfilment of the requirements for the degree of

Master of Arts (MA)

Wien | Vienna, 2024

Studienkennzahl lt. Studienblatt | Degree programme code as it appears on the student record sheet:	UA 066 642
Studienrichtung lt. Studienblatt | Degree programme as it appears on the student record sheet:	Masterstudium Philosophy and Economics
Betreut von | Supervisor:	ao. Univ.-Prof. i.R. Mag. Dr. Karl Milford

Table of Contents

1. Introduction

The present thesis aims at studying the development of formalism in economics in reference to the epistemological answers to the problem of induction. The latter triggered a philosophical problem that was attempted to be solved in different ways. One of these ways is the use of formalism in creating and building theories. Centrally, I analyse Paul Anthony Samuelson's book *Foundations of Economic Analysis* (1947) and his formalization of the theory of maximizing behavior. I inquire why some authors in economics took a formalist turn and I raise the hypothesis that formalism was developed as an answer to the demands for a theory that presents certain results. The relationship between formalism and [high partial] certainty will be further developed during this work, and the hypothesis regarding their connection defended. It should be clear that I do not intend to criticize or defend the use of formal methods in economics, but to study its progress in reference to epistemological demands raised in philosophy and philosophy of science.

In the first part of this work I start with a reconstruction of the problem of induction and verification in terms of a classification problem (Miller, 1994) and indicate the logic and epistemological reactions following from it, especially the thesis regarding a shift in scientific standards from theories proven true to theories classified as true with [high partial] certainty. Further on Section 1.3. I discuss one of the consequences to the problem of induction, that is, the methodological shifts to increase theory's valuation, indicating the formalist turn in the empirical sciences. I then follow to an outline of the solutions to the problem that are relevant to the development of microeconomic theory, in special the conventionalist and the pseudo-statement positions, and establishes a characterization of operationalism as a conventionalist position. Lastly, I raise the objections against the use of formal methods in economics commonly discussed in the story of economic ideas. (Bryant, 1985; Hausman, 1992; Schumpeter, 2006)

In Chapter 2. Economic texts, I begin with the work of Paul Anthony Samuelson (1947), whose writing raised problems in economic analysis discussed until the present day. I defend that Samuelson's notion of genuine scientific knowledge is based on the conventionalist position to scientific inquiry, in particular on operationalism and analytical truths. Following that, I discuss the possibilities of contrasting Samuelson's models with empirical observations and his own position in respect to theory testing. A similar understanding of Samuelson's

work was brought up by Alex Rosenberg (1976), whose texts I studied and inspired the literature chosen for my thesis. He returns to the common objection that the analysis of such texts is obsolete and no longer relevant in economics. Rosenberg claims that "This allegation fails for several reasons." He proceeds by emphasizing that the objections that epistemic issues regarding the forms of economic theories and models is irrelevant.

> ...grossly underestimate the similarities between classical microeconomics and recent work in, for example, general equilibrium theory. Arguments in this theory are generally carried out in topological or set-theoretical contexts, but even a cursory examination of the axioms in the deductive hierarchy of these theories shows that on their standard interpretation, these axioms are sometimes identical to and always maintain the same logical status as the axioms of classical presentations of microeconomics. (Rosenberg, 1976, p. 11)

This understanding can be seen by the following study of Becker and Stigler "De Gustibus Non Est Disputandum" (1977), a paper where the authors attempt to review Samuelson's modelling of preferences. The latter introduced elements to the Theory of Maximizing Behaviour that, instead of refuting its fundament, reinforced its epistemic basis while absorbing the critiques done throughout the years. This paper will be discussed in the last chapter.

1.1. Formalism in economics

Due to the general and frequently defended view that genuine scientific theories are proven true or highly probable theories, I will first analyse whether this particular view is also defended in economics. In philosophy, such view is defended by Bertrand Russel, who questions the possibility of achieving knowledge with such characteristics: "Is there any knowledge in the world which is so certain that no reasonable man could doubt it?" (Russell, 1912, Ch. "Appearance and Reality") Russel proceeds to explore the answer for this problem and to seek a theory that enables scientific theories to be proven true or to be highly probable. This view can be also found in economics by exploring the context of theory justification, that is, by a detailed reconstruction of the epistemic basis of the theories being analysed. According to this commonly defended view, if economics is a genuine scientific discipline, it

has to propose theories that are classified with absolute [high partial] certainty as true. Secondly, I want to explore whether this characterization of genuine scientific knowledge triggered and furthered the introduction and implementation of formal methods into economic theory as to establish proven true and reliable economic theories that form the basis for reliable predictions.[1] For that, I shall start with the philosophical concept of verification and the epistemic problems such a method has raised.

1.2. The problem of induction and verification

In the history of philosophical ideas, the so called problem of induction was formulated in 1739 when David Hume published his concerns in the book *A Treatise of Human Nature*. (1896)[2] There, he raises the problem regarding the validity of causal laws as well as the logical validity of content enlarging inferences based on past regularities, that is, inferences that the future will be like the past. In sum, he constructs a logical critique concerning content enlarging and truth preserving causation. However, the modern formulations of the problem

---

1 A prominent example of this position is the Lucas critique from 1976. (Lucas, 1976) Objecting to the lack of empirical content – in the form of extensive datasets – in the practice of econometric theory and quantitative policy evaluation, Lucas holds that economic theory must develop towards increasing accuracy in its parameters. As a consequence, one can establish reliable and precise predictions. That would reduce the arbitrariness of policy design and increase its scientific basis. In his words: "There seems to be no theoretical argument ruling out the possibility that [...] delegating economic decision-making authority to some individual or group might not lead to superior (by some criterion) economic performance than is attainable under some [...] rules […]. The point is rather that this possibility cannot *in principle* be substantiated empirically. The only *scientific* quantitative policy evaluations available to us are comparisons of the consequences of alternative policy rules." (1976, 41) The emphases are mine. With this, increasing empirical content combined with models of rational expectations form the basis of scientific policy evaluation. It's worth noting that the notion of science being defended by Lucas lies on instrumentalist grounds, such as those from the texts we will discuss later. That is, rules ought to be developed so one can predict future phenomena and act upon it to achieve desired normative results.

2 Such problem was already exposed by Sextus Empiricus (2 AD), whose scepticism rejected the existence of a truth criterion based on an ad infinitum regression. For him, the search of a certain fundament on which to base any form of knowledge leads to an ad infinitum regression in search of an unattainable truth criterion. That means that any forms of approving a truth criterion has, itself, to be approved, leading to an infinitely regressive reasoning. Differently than Hume, Sextus Empiricus argued for the suspension of any form of judgement, as a consequence, of the unattainability of truth.

(e.g. Miller, 1994; Popper, 2002) do not refer to his analysis of causation, and rather focus on its epistemological consequences. These consequences are the impossibility of inferring strictly universal and empirical statements from statements describing observations, for instance, inferring from the experience that every morning the sun rises, that the sun will always rise. Statements describing observations do not transcend experience and consequently cannot justify sentences that are strictly universal. With that, the problem of induction undermines two central characteristics of empirical science, that is, strict universality and empiricism. The former accounting for the possibility of the existence of satisfactory singular theoretical explanations and models, and the latter resulting from considerations regarding the basis of the truth decision of empirical statements as well as singular empirical observational statements.

By undermining these two characteristics, the problem of induction, in fact, raises a conflict between both. With the impossibility of strict universality, it is found to be illogical for a theory to claim universal validity if it ought to maintain the principle of empiricism. That means that scientific theories using inductive inferences to claim strictly universal statements ought to abandon the principle of empiricism, for it is not possible to verify a universal sentence based on empirical statements – either because universality has a larger domain than what observations can account for, or because verification itself is not logically possible, for it relies on inductive inferences from statements describing observations. On the other hand, theories maintaining the principle of empiricism, that is, theories maintaining that the truth decision of statements are based on observations, must accept that theories can only be a very large set of observational sentences. They can claim generality but never universality, for universal statements cannot inductively be inferred from sentences describing empirical observations.

As shortly aforementioned, the problem of induction rules out verification. That means, sentences describing observations that confirm a theory's results cannot be inferred to verify this theory because inductive inferences are not logically valid and do not preserve the truth of the initial statement. If the method of induction were valid, it would be possible to verify, or, in other words, it would be possible to prove theories true. Thus, without the logical possibility of verification, how can theories be justified as scientific?[3] Due to this question

[3] An important remark is that the idea of verification intertwines two different concepts: objective truth – that is, truth about sentences describing empirical reality – and certainty. It is by separating

and in order to find a satisfactory solution to the problem of induction, David Miller in his book *Critical Rationalism: a restatement and defence* (1994) reformulates the problem in terms of a problem of classification. In this sense, genuine science ought to classify statements as true, not to certify their truth values. In his words:

> What is not of immediate concern is whether we can know that it has been achieved; that is, whether empirical statements (observational and other) can be established with certainty, or endowed with conclusive and irrevocable empirical verification. The mission is to classify truths, not to certify them. (Miller, 1994, p. 1)

Consequently, Hume's argument logically sparks two possible consequences: either to reject the idea of objective truth and retain the idea of absolute certainty and partial certainty, or to reject absolute and partial certainty and retain objective truth. Confronted with those consequences, philosophical positions regarded the interpretation of scientific theories that are to be admitted in the body of science as a special form of justified true belief. These philosophical positions, however, reject the idea of a universal objective truth, accepting Hume's objection, and interpret verification in subjectivist terms, i.e., as confirmation and as justified belief.

Knowledge, then, becomes a belief that can be reasonably justified and it is believed to be true. Naturally, knowledge remains opposite to what is false, thus it takes more than just subjective belief to make a statement transformed into a scientific proposition. In addition, having good reasons to believe a sentence to be true is still not enough to make it part of the scientific body.[4] Thus the requirements for a belief to be genuine knowledge are that the

---

these two criteria that many positions will try to solve the problem of induction. This will be elaborated in the following paragraphs.

[4] The idea of good reasons is criticized by David Miller (1994) as unobtainable, unusable and unnecessary to form genuine scientific knowledge. Reasons, as in "having good reasons to believe in P", exist but rely on purely subjective grounds. First, good reasons are logically unobtainable. Having good reasons to believe in P can be understood as favourable reasons for the belief of the truth of P. A favourable reason, however, begs the question in the sense that, since reasons are not premisses, and having favourable reasons to believe in the premise, one have, at the same time, favourable reasons to believe in its conclusion C. The argument is a fallacy of *petitio principii*, although the inference is not. Good reasons can also mean that one has sufficient reasons to believe in something. But a conclusion reached thought sufficient reason can only be derived from the conjunction between sufficient premises and valid inferences. For the latter is logically true

subject has good reasons to believe in it, so that it is well justified, and that the truth values assigned to the theory are guaranteed. Alan Musgrave schematizes these conditions the following way:

(1) A believes that P

(2) P is true

(3) A can justify his belief that P.[5] (Miller, 1994, p. 3)

The question now is how a belief can be justified. For that, Musgrave adds to the scheme above a more strict third requirement which can be formulated as follows: (3b) A can justify his belief that P with certainty. These are the criteria that according to the author characterize genuine scientific knowledge according to subjectivist positions. The second criterion, however, should not be understood as truth verified by empirical statements, but as statements classified true with absolute [high partial] certainty. He then proceeds to raise possible objections to this characterization and explore their consequences, for instance, that for knowledge to be genuine it only has to be certain. His answer is that, even if an individual justifies his belief with [high partial] certainty, it does not follow that it must be true. Thus the truth requirement is maintained as to guarantee the classification of the propositions as genuine scientific knowledge. However, this requirement is based on a subjective

and unquestionable, but the former can be objected on the grounds of an infinite regress justification, or, once again, on grounds of the *petitio principii*. To conclude this first two arguments against the idea of good reasons, Miller writes: "...I cannot prove this thesis. But it is surely up to those who think that good reasons exist to explain what truth emerges from allowing any proposition to act as one of the judges in its own cause." (Miller, 1994, p. 63). The arguing of two other objections against good reasons follows from this last paragraph just quoted. If a statement that we believed in with good reasons is falsified, the author asks, what truth values could these good reasons provide against the falsification? Oppositely, if a statement is classified as truth, in what truth values the good reasons contributed to? In conclusion, good reasons do not play a role in classifying statements, thus they are unusable. Lastly, critical rationalism as a source for developing genuine science simply does not depend on reasons. We must raise hypotheses even when we do not have good reasons to believe in them, so we have an object of critique, furthering, this way, scientific development. The discussion on good reasons proposed by Miller is based on the rejection of the justificationist program. Good reasons, indeed, do not contribute and do not make sense in Popper's solution to the problem of induction and his falsificationism method. That indicates that Musgrave's scheme for knowledge as justified proven true belief, that will be studied next, is a different response and a different epistemology than that from Miller and Popper. It indicates as well that it abides to an opposite standard of genuine science.

[5] P is a singular statement describing observation.

understanding of verification. Instead of contrast with experience to classify theories as truth, one aims at achieving [high partial] certainty. The possible means for that are elaborated in the next section.

In sum, the problem of induction and the issues on theory justification pose the question of what are the characteristics of genuine scientific theories and how can they be achieved. If statements describing individual observations cannot base universal theories in terms of strictly universal propositions, how can genuine science regarding empirical phenomena be achieved? As a reaction, the history and the philosophy of science show a problem shift in epistemology. This problem shift consists in substituting objective truth to concepts of subjectivist truths, as Musgrave elucidated. This substitution permits to maintain the idea of [high partial] certainty. Consequently the shift consists in substituting objective truth with [high partial] certainty as the characterization of genuine scientific theories. Accordingly, this position defends that if absolute objective truth is not attainable because there exist no truth criteria, theories might still meet scientific standards by aiming at being classified as truth with [high partial] certainty, herein, being infallible.

As stated above, Hume's impossibility of verification and justification triggered two logical responses: the adoption of [high partial] certainty and rejection of objective truth, or the dismissal of [high partial] certainty and the conservation of objective truth. Justified proven true beliefs abide to certainty but not to objective truth as the scientific standard to be met. Positions defending subjectivist truth reject objective truth because the method used to guarantee the truth values of the statements – verification – is logically unable to do so, as the problem of induction shows. Regarding that, Miller (1994) summarizes the concerns of the epistemology of the empirical sciences by stating: "Universal hypotheses cannot be conclusively verified, even in a finite universe (if only because any claim to have inspected the whole universe is itself a statement of universal form..." and proceeds "Thus few, if any, interesting statements will be classified as true if they are required at the same time to be certified as true." (Miller, 1994, p. 1)

The second response triggered by the problem was the rejection of [high partial] certainty and reattainment of objective truth. This can be achieved by finding a different method to differentiate truth from falsehood and enabling the scientist to classify propositions. Thus it is not a rejection of certain knowledge per se, but an alternative proposition to obtain genuine

knowledge. The method developed in the history of philosophical ideas that refers to this response is the method of conjectures and refutations, in the Popperian meaning of the term.[6] Contrary to the justificationist approach to classifying statements as true through confirmation, the method of conjectures and refutations triggers falsificationism as a method to test hypotheses and to restore objectivity as the criteria for scientificity. If a conjecture passes the tests, it is provisionally classified as true – for ultimate falsification is not possible -, however it does not make any validity regarding its future predictions. That means that when testing a hypothesis, the scientist must try to falsify it, instead of verifying it. This way, one can avoid the issues raised by the problem of induction such as the logical impossibility of inductive inferences and verification.

For the falsificationist, there is an "open admission policy" (Miller, 1994, p. 7). For all hypotheses which ought to enter the body of scientific knowledge, the only requirement is their possible falsification.[7] In this sense, the method of science is to construct rigorous tests aiming at showing – not proving – the theories or sentences wrong. While a theory is not falsified – either by the lack of testing or by passing the tests it faced –, it is provisionally classified as true and maintained in the body of science. If a hypothesis fails a test, it is classified as false and removed from it for the time being. With this, experience is restored as the basis for the decision of truth or falsity, thus following the principle of empiricism I discussed in the beginning of this section. The same way, as mentioned, objective truth is retained and [high partial] certainty is rejected.

To test a hypothesis – independently of the methodological position taken – one must derive a singular prediction from the theory. This singular sentence describing a prediction – *explanandum* – is inferred from a set of premisses named *explanans*. They are composed of strictly universal and empirical statements, also called laws, and of basic statements describing the concrete historical situation, named initial conditions. After being inferred, the

---

6 Conjectures in terms of the Popperian philosophy have a special meaning in contrast to uncertain hypotheses. Conjecture is a hypothesis provisionally classified as true or false without making a prediction regarding its future validity. In contrast, uncertain hypotheses make a probabilistic prediction of its future performance.

7 One ought to differentiate falsifiability and falsification. Falsifiability implies the logical possibility of falsification, not necessarily de facto possibility. Falsification, on the other hand, requires that statements not only are synthetic, but there must be methodological rules enabling the falsification of the statements.

prediction is compared to basic statements describing observations. If the sentences deduced from the *explanans* contradict those describing the concrete phenomenon, one of the components of the *explanans* must be false. That is, either the laws governing the theory ought to be provisionally classified as false, or the initial conditions of it. In the first case, the entire theory is removed from the scientific body. In the later, the laws are maintained and the singular conditions for their applicability revised, removing those where the falsehood of the prediction lies on. With this, falsificationism maintains the idea of objective truth and empiricism as the requirements for the empirical science. It does that by proposing a methodology focused on testing statements in order to falsify them, instead of verifying.[8] Regarding this position, Miller concludes:

> We see therefore that science is a collection of statements, and that the business of science is the discovery, as far as is practicable, of the truth values […] of these statements. The whole business can be explained, quite satisfactorily, without any reference to certainty, probability, confirmation, support, reliability, confidence, justification, good reasons, or knowledge. Truth and falsehood suffice. (Miller, 1994, pp. 11–12)

1.3. From verification to alternative ways of justification

Due to Hume's objection, the aim of verification as well as probilification is not obtainable. To verify a theory – that is, to classify a theory true with absolute certainty – or infer a general statement from probability analysis – aiming at high partial certainty – implies inductive reasoning. Further than that, both imply inductively content enlarging and truth preserving inferences, which was already ruled out with the problem of induction. Together with falsifiability, the search for justifying theories became the core of the discussions in the philosophy of science.

In this section I examine the turns that epistemological standards took within these discussions, the new criteria raised by scientists and philosophers and how they reject (or

[8] Although falsification solves the methodological problem concerning objective truth, it does not solve the philosophical one of the correspondence between facts and sentences. The philosophical problem was elaborated and solved with Alfred Tarski (1944), where he elaborates a meta-semantic theory of truth.

reinforce) a certain concept of scientific research. By outlining this debate and already having presented the Humean problem, I intend defend that theories and methodologies shall have their epistemological status studied in respect to how they solve the problem of induction and demarcation.

Within the epistemic debate, issues of certainty and reliability entered the argumentation, and investigations aimed at introducing logical and pragmatic values as means to solve problems of theory justification. More than solving theory justification, the debate is centred in increasing justification. That means that new values – whether they are logical, pragmatic, cognitive or aesthetic – are adopted as to enhance scientific standards and ensure the quality of theories. For instance, theories must be based on reasoned argumentation. Statements must follow logically one from another, meaning that from premisses, a conclusion is deduced according to the rules of logic. In other words, theories must be internally consistent. Logical consistency is praised not only because it avoids the problem of induction by remaining on deductive grounds, but a lack of consistency within a system of statements means that a theory cannot be falsified once the contrast of the *explanandum* with experience cannot be preserved to the laws and initial conditions, thus resulting in arbitrary conflict. Consequently, any attempt to justify a theory must fail, as values and results are not linked to the premises.

A pragmatic evaluation of theories is, for example, decided on the basis of considerations of their usefulness. Regarding pragmatic values, for a theory to be useful it must present reliable predictions and results, thus being a valuable instrument. In the empirical sciences, two positions take place within an instrumentalist framework: pseudo-statement positions and conventionalism in terms of operationalism. For the pseudo-statement position, sentence functions forming a theory are inductively inferred from observation but do not claim to carry truth values at any time. In this sense, they are universal laws but are not understood as proper sentences, thus the prefix *pseudo*. The sentences (*explanandum*) inferred from the theories assuming the pseudo-statement position, however, can be contrasted with experience and their falsification affects the status of their conditions, although never falsifying the laws – as they are merely pragmatic constructs without truth values, that is, function sentences. Therefore, accepting that inductive inferences are not truth preserving nor content enlarging, the pseudo-statement position justifies its value by the usefulness of their constructs.

Conventionalism, on the other hand, first establishes an initial analytical sentence as an axiom and deductively infers theories and explanations from it. For the conventionalist, the initial sentence is conventionally chosen based on its usefulness and truth values are inferred from its analyticity. Because analyticity necessarily carries truth values, and deductive inferences are truth preserving, the statements of the conventionalist position can be regarded as proper statements, in comparison to the *pseudo* character present in the former position described. For the conventionalist, therefore, truth is retained as a convention, and deductive inferences carry this truth to the singular explanations derived. Pragmatic motives, in particular the idea of predictive power, play a role in both positions, what differs them is their logical development and the maintenance – or not – of truth values. In the second part of this work, the description made in this paragraph will be brought up again by a study of well known economic theories.

As a consequence to the aim of guaranteeing predicative power, therefore usefulness, the results derived from theories must be known with absolute [high partial] certainty. To guarantee the achievement of certainty and theory justification, the conventionalist framework introduced formalism in the empirical sciences.[9] The use of formalism, therefore of analytical constructs, improves theory justification in a framework where genuine scientific knowledge is knowledge classified as true with absolute [high partial] certainty. It does so because to axiomatize a theory by introducing formal and mathematical methods one aims to clarify the context and domain of the theory and to specify what the theory actually asserts by making it more precise. With that, the certainty of what is stated increases. In *The Logic of Scientific Discovery* (2002), Popper describes the problems a rigorous theoretical system avoids and how it improves the reliability of theories in terms of its contrast with experience. In his words:

> … a tentative system can usually be quite well surveyed as a whole, with all its important consequences. This is very necessary; for a severe test of a system presupposes that it is at the time sufficiently definite and final in form to make it impossible for new assumptions to be smuggled in.

[9] Certainty and formalism do not necessarily carry pragmatic values, but are used to attain pragmatic goals.

He then proceeds, “This, I believe, is the reason why the form of a rigorous system is aimed at.” (Popper, 2002, p. 50) But theoretical systems present other characteristics guaranteeing their epistemic value that go beyond the definiteness of their form and beyond the possibility of conclusively testing their hypotheses. A formal theoretical system, or an axiomatized theory, shows reliable results by deducing every conclusion from clearly stated premisses. Because of that, systems of axioms are internally consistent, independent in terms of their axioms not being deducible from any of the conclusions, sufficient so that the conclusions follow strictly from the premises, and necessary, as to avoid any redundant statement.[10]

By axiomatizing theories and introducing formal methods, it is possible to acquire a better understanding of what a theory is capable of explaining and of its logical consequences. Particularly in conventionalist positions, formalization by itself does not justify the preference of a theory in face of the existence of competing theories. The main standard for theories to aim at is that of simplicity.[11] That means, theoretical systems are preferred when they display a simpler explanation than others. Simplicity as a methodological choice, however, does not carry any epistemological gain. It is of a pragmatic and aesthetic character only.[12] Popper devotes a section of his book to the relation between simplicity and conventionalism. In his words:

> It is curious that conventionalists themselves have overlooked the conventional character of their own fundamental concept—that of simplicity. That they must have overlooked it is clear, for otherwise they would have noticed that their appeal to simplicity could never save them from arbitrariness… (2002, p. 131)

Although not recognized, in conventionalism, simplicity is an arbitrary standard as long as it is not combined with empirical content for it does not, alone, enhance explanatory power.

---

[10] It should be independent otherwise the system is led to the fallacy of *petitio principii* I mentioned in the previous section.

[11] Standards like precision, generality or simplicity, i.e., aesthetic standards, must be combined with concepts such as empirical content. Only this way, the use of formal methods guarantees the epistemic values of theories.

[12] For instance the common argument that formalism brings gains to the empirical sciences to help communicate ideas in a more straightforward and simpler way is of aesthetic preference. One might think it is simpler to read a prose instead of an equation, and both of them might contain the exact same content. The form in which theories appear is not an epistemic characteristic of them, only a pragmatic or aesthetic one.

In the contemporary literature of philosophy of economics, where axiomatized systems are extensively discussed, their scientific value seems to rely on aesthetic merits more than on epistemic ones. For instance, Dani Rodrik (2015) defends that theoretical systems such as models enhance our understanding of problems, show counter intuitive conclusions we would not find otherwise and enable the scientist to isolate variables and understand better the impact of different assumptions on the phenomena studied. That, according to him, is "...what makes models scientific." (Rodrik, 2015, p. 31) Additionally to the values characterizing science, Rodrik argues that it is in principle impossible to reject models based on empirical data, but he maintains the usefulness of them in the social sciences. While the first part of Rodrik's argument can be defended against the epistemological concerns I raised in this work so far, the impossibility of falsification cannot. By arguing that models cannot be rejected based on experience, Rodrik is renouncing that objectivity should be the source of truth-decision. By this argument, the use of models in the social sciences cannot be defended as furthering scientific knowledge as the search for truth.

Others, such as Nancy Cartwright (2007), supports models because of the simplicity in which they represent reality as analogue economies and the possibility of deriving tendency claims[13] that can be contrasted with experience.[14] According to her, tendency claims succeed by adopting the notion of models as thought experiments. By means of that, she aims to justify the extrapolation of the model world to the real world. Within this reasoning, a model plays the scientific role of experiments. A hypothesis is raised and an artificial world is created to test if this hypothesis would hold under certain conditions. Such as Galilean experiments, they focus on explaining one single mechanism or causal process (Cartwright, 2007), and the rest of the variables can be neglected.[15] In this sense, their results cannot be taken literally but its extrapolation from the analogous economy to the real world as tendencies would be justified.

---

[13] Tendency claims, however, are hypotheses regarding historical developments. As such, they cannot be falsified nor tested. Contrary to tendency claims, one ought to develop ideal or typical situations which can be substituted by different singular conditions and compared with empirical data, as mentioned in section 1.2. Singular hypotheses, in contrast with historical hypotheses, are the ones with explanatory power.

[14] For Robert Sudgen (2000) the link and the models fails the Popperian notion of scientificity once it does not propose a hypothesis that can be empirically tested and possibly falsified.

[15] Uskali Mäki raises a similar point regarding variable isolating and the epistemic value this practice adds to the models. For that, see Mäki, U. (1992) "On the Method of Isolation in Economics", *Pozna´n Studies in the Philosophy of the Sciences and the Humanities* 26: 316–351.

She argues, however, that this can only be taken into account in the case of Galilean idealizations.[16] Thus not every model can be a thought experiment.

To extrapolate the thought experiment, Cartwright defends the deduction of statements regarding the real world from the model world. For that, the model ought to be designed in a way that its results depend only on these Galilean idealizations, and not on background secondary assumptions. The issue for Cartwright is that most models, in fact, make use of too many assumptions in a way that the results derived in the analogue economy do not appear any more in the real one. In her words:

> For the validity of the conclusions appears now to depend on a large number of very special interconnected assumptions. If so, the validation of the results will depend then on the detailed arrangement of the structure of the model and is not, prima facie at least, available otherwise. (Cartwright, 2007, p. 18)

That means that one can no longer deduce from the conditions of the model world a statement regarding the real economy. While Cartwright concerns are legitimate given the development of modelling and ideal worlds in the social sciences, the proposed critique does not try to solve the problem of inductive inferences from the analogous economy. Because regardless of the type of assumptions used in the models, the extrapolation of tendencies from the analogous economy to the real economy does not preserve the epistemic gains from the analytical constructs.

Her argument, then, fails in its main conclusion. The distinction between Galilean idealizations and secondary assumptions is certainly valuable. By assuming only Galilean idealizations, one guarantees that a theoretical system can be examined as a whole based only on its necessary conditions, and those Galilean (and negligible) assumptions play only a supportive role in the model. With this, results do not rely on the negligence of otherwise central conditions. Yet, the type of assumptions playing a role in a theoretical system does not signify that its findings can be extrapolated in any form to empirical reality. That means that

---

[16] Cartwright defines Galilean idealizations as "[…] this kind of idealization, that eliminates all other possible causes to learn the effect of one operating on its own […]". (2007, p. 11) Later on we will discuss Alan Mugrave's paper on unreal assumptions in economics (Musgrave, 1981) where he distinguishes three types of unreal assumptions. Cartwright's Galilean assumptions correspond to what Musgrave will call "negligibility assumptions". (1981, p. 378)

the truth of the findings in the model do not – and logically cannot – imply real epistemic gain of objectivity, but analogy.

This discussion, therefore, misplaces the epistemological debate I have reconstructed so far. It does not enhance the possibilities of achieving true knowledge in the empirical sciences nor debates how that could be achieved. It maintains the discussion on justificationist grounds.

There exists many other justifications in the contemporary literature for the scientific validity of theoretical systems in economics and in the social sciences, for instance that models are mere conceptual exploration, (Sugden, 2000) where one can explore possible conceptual developments within pseudo-causal effects, or that they are a simpler language to communicate theories. Nonetheless, by simply being more general, a theory is not closer to solving the problem of induction than a less general theory. The aesthetic criteria aforementioned, and commonly agreed as relevant for the scientific inquiry, do not contribute to the furthered of what is frequently defended as genuine scientific theories, that is, theories that are proven true or highly probable theories. Precision, simplicity, generality, and hermeneutics do not truly justify nor deal with a theory's epistemological status. By themselves, these criteria do not contribute to an approximation to the truth or the classification of sentences as true. These debates, therefore, do not seem to dive into the source of epistemological conflicts, but remaining only on the methodological discussions permeating the social sciences.

If we then accept that the epistemological status of theories is regarded as a particular solution to the problem of induction and demarcation, or solutions to the conflict between strict universality and empiricism, one ought to maintain the study of methodologies in consideration to these different solutions. In this sense, to conserve the epistemological aspect of the discussion, I orient my study of operationalism in respect to one particular solution to the problem of induction: neo-conventionalism. This way, I am able to understand methodological decisions in respect to epistemological perspectives.

1.4. Solutions to the problem of induction

Solutions to the problem of induction can be distinguished in two broad classes in respect to their notions of genuine scientific statements: those that reject the idea of objective truth but

maintain the idea of absolute certainty and partial certainty, and those that reject certainty while withholding the idea of objective truth. These solutions are not particular to any scientific field and can be observed in all empirical sciences, both in the natural and in the social sciences.

In respect to their logical answers, the solutions to the problem of induction can be divided in two categories: those aiming at solving the problem by not rejecting inductive inferences and those that, alternatively, reject induction and implement only deductive inferences. For the first, genuine science can only be derived from singular statements regarding empirical observations. For the second, inferences from singular observations are impossible to guarantee the scientificity of the conclusions, thus the scientific method must implement the rules of deductive inferences. From the different solutions, it concerns to this thesis the study of conventionalism, a deductivist approach to the problem. That, I defend, embodies the notion that genuine scientific statements are statements that can be classified as true with absolute [high partial] certainty. (Miller, 1994)

From the possibilities of achieving certain results, conventionalism accepts the logical impossibility of induction and chooses a deductivist position for the attainment of genuine scientific theories. For the conventionalist, general statements are analytically true, certain and conventionally established. That means that they are stripped of their empirical content – in Popperian terms, the convention forbids almost nothing, thus it cannot be falsified except by a logical contradiction.[17] In addition, analytical statements are definitional sentences. As being unfalsifiable and empirically empty definitions, the conventionalist approach solves the problem of induction by remaining on the theoretical level where deductive logic prevails. (Miller, 1994, p. 103) Since deductive inferences preserve the truth of the principal statements – which are called axiomata or laws and are classified as true with absolute certainty -, the theories inferred from them are also true. Because experience is not the basis of the truth

[17] In *The Logic of Scientific Discovery* Popper makes an interesting characterization of empirical content. There, he states: "...the more a statement forbids, the more it says about the world of experience." (Popper, 2002, p. 103) Analytical statements are, therefore, those emptied from all empirical content per excellence, for their central characteristic is exactly to forbid almost nothing in the empirical and logical levels. Examples of analytical truths are the Euclidean geometry or classical mechanics, whose theoretical systems follow from an initial definitional sentence – named axiom – which cannot be falsified and are accepted as absolutely true with certainty. This definition will be brought again in Chapter 2, where I will explore the analytical statements in economic analysis and their epistemological status.

decision of analytical propositions, that is, the principle of empiricism is rejected, it is not possible to base the choice between competing axiomata on it. Consequently, the choice of axiomata has to be based on different standards, for instance standards as simplicity, which are conventionally determined.[18]

Considering that the principal propositions of a conventionalist theory are analytically true, conclusions deductively inferred are true as well, that is, classified as truth with absolute certainty. As experience is not the basis of truth decision, as just mentioned above, conventionalism shifts research emphasis from the scientific aim of objective truth in terms of the correspondence theory of truth, to certainty. With the principle of empiricism being rejected, conventionalism maintains that truth is unattainable and substituted for the idea of high and partial certainty. In order to achieve that, conventionalist theories are particularly interested in implementing formal methods, for they enhance the precision of the conclusions that can be classified as truth.

Because conventionalist positions regard theoretical systems as analytical truths, and the initial propositions in terms of the axiomata are classified with absolute certainty as true, experience in terms of empirical propositions does not cause scientists to consider theoretical systems as falsified or even to reject them. With that, the particular model used for analysing a phenomenon must be rigorously elaborated and serves as an instrument for the derivation of reliable predictions. However, if deductively inferred results continuously contradict statements regarding observations, the typical initial conditions of the model in question are amended or altered, but never the axiomata from where the results were obtained. This practice will be demonstrated with a reconstruct of a few microeconomic models in the next chapter.

Conventionalist theories were initially developed in the field of logic and mathematics. Historically, in part of the 20th century, they were axiomatized theoretical systems and displayed an operationalist character. These methodological choices towards the formalization of theories were carried out in order to increase the certainty with which these theories are

[18] This choice, specifically in the conventionalist approach to science, is imposed by a criterion of simplicity. As opposed to other responses to the problem of induction, where truth is the regulative idea for the scientific enterprise, here the axiom that generates the simplest theoretical system is the one that ought to be conventionally accepted. (Popper, 2002, p. 58) The consequences of this standard will be discussed in section 1.6.

classified. As Miller points out, certainty is a formal characteristic of a theory, thus formalization is an appropriate method for the achievement of increasing certainty.[19] As the concept of certainty evolved in the history of philosophy, it continues to rely, centrally, on the impossibility of inconsistency, which is guaranteed by the analyticity of the systems' axiom and its logical deductive development. Thus certainty and consistency are correlated scientific standards in the conventionalist theories.

The shift from theories aiming at objective truth to theories aiming at being classified as true with absolute [high partial] certainty produces a methodological consequence of increasing the use of formal methods in order to increase the certainty in which theories can be evaluated. As they were developed in the 20th century, formal methods were employed midst long discussions regarding a philosophical doctrine that was named operationalism. It is the link between conventionalism and operationalism that I will go into in the next section.

1.5. Conventionalism in terms of operationalism

The methodological debates in the social sciences during the 20th century were highly affected by the ideas of operationalism, often attributed to the American physicist Percy W. Bridgman. These ideas revolve around the notion that concepts ought to be operationally defined, instead of ontologically constituted. Categories are determined by the relations they maintain with other categories and the situations they are placed in, and they only have a meaning while inserted in these relations. Further, what is central for an operationalist analysis isn't the categories themselves, but the operations playing a role in them, either in their relation to other categories – for example the definition of space in relation to light speed or the conventional definition of space in meters – or their transformative potency in the environment. An example of the latter is given in the Stanford Encyclopedia by the following description: "For example, operational thinking has always been an important part of

[19] When making an analogy between formal and empirical sciences, Miller makes the following affirmation: "… discussions of human knowledge habitually and perversely confuse truth and certainty, a material property and a formal property." (Miller, 1994, p. 99) A few lines before that, he compares truth with consistency, the first being related to the Humean problem, and the second related to the mathematical paradox posited by Gödel in 1932. In this sense, Miller traces a lose relation between consistency of theoretical systems and certainty as an epistemic aim in the theoretical sciences. This, however, is a mere observation and Miller does not develop an argument properly connecting certainty and formalism.

chemistry, sometimes explicitly so, for example in Lavoisier's famous "operational" definition of a chemical element as a substance that has not yet been decomposed further." (Chang, 2021) Within Bridgman's framework, length measurements in micro and macro analysis must differ, thus space gains different operational definitions. That enables the scientist to deal with non-observable entities that have an empirical meaning, transforming them from metaphysical categories to empirical and measurable ones. Altogether, operationalism is concerned with building definitions for scientific concepts. As in most definitional pursuits, conventionally accorded sentences are in the core of operationalism. Whether length is a meter unit or a light speed one is conventionally determined by the needs of the specific scientific research. Thus operationalism is a forms of conventionalism.

In economics, operationalism appears more prominently in Henry Schultz and Paul Anthony Samuelson's early writings (Chang, 2021). Schultz was a professor in the University of Chicago between 1920s and 1930s, and one the founders of the Econometric Society.[20] He was one of the first econometricians and his most prominent book is titled *The Theory and Measurement of Demand* (1938). In a reconstruction of the history and development of operationalism, historian Albert E. Moyer cites a letter written by Schultz to Bridgman in which the first appraises the excellence of the latter's ideas and recently published book *Logic of Modern Physics* (1927). When referring to Samuelson, Moyer writes:

> Schultz's adoption of Bridgman's formulation established a unidirectional path of operational influence from Harvard to Chicago. In the mid 1930s, the path became a complete loop when a promising Chicago undergraduate (and future Nobel Laureate) went on to Harvard for graduate work in economics.

He then proceeds,

> Though Paul A. Samuelson's quantitative, econometric approach to issues is complex in origin, it reflected to some extent Bridgman's and Schultz's emphasis on precise meanings through unequivocal operations. Thus, Samuelson's first book, Foundations of Economic Analysis, originally carried the subtitle 'The Operational Significance of Economic Theory'... (Moyer, 1991)

[20] Schutz is referenced in the *Foundations of Economic Analysis* (1947) multiple times.

Just like the aim of operationalism in the natural sciences is to give empirical meaning to non-observable categories[21], Samuelson alters dramatically the meaning of utility analysis with the revealed preference theorem by enabling an account of individuals' choice without actually referring to their psychological dimension. With this, the explanation of a choice problem is formulated only through its observable relations. The author maintains that existing relations and how they affect economic analysis are conventionally determined. For instance, that individuals have transitive preferences, or that they have perfect knowledge, is a characteristic of their relation with their situation, which, in turn, is conventionally agreed on. This will be the subject of my second chapter.

As a consequence, the aim of an operationalist science is not to find the truth of particular mechanisms – in the sense of a correspondence theory -, but to construct a structure that can explain and predict phenomena. In respect to that, it is coherent that Samuelson aims at providing a structural *analysis* of economics, instead of developing a *theory* of it aiming at achieving truth.[22] The striking difference in constructing explanations on technical grounds, instead of theoretical, is that within technique, scientific progress is not evaluated in terms of explanatory power, but on instrumentalist grounds. Thus this focus on analytical technique, instead of explanatory power, solves the seemingly contrast between his main academic text, the *Foundations of Economic Analysis* (1947), permeated by logical deductivism and purely structural analysis, and his textbook *Economics*, where empirical analysis is prominent. At a first glance, one would oppose analytical structures to empirical analysis, however they are both employed based on an instrumentalist idea of science. This contrast will be brought up again once we account for Samuelson's theory of consumer behavior and the theory of the firm.

---

[21] These categories are later called "metaphysical categories" (Samuelson, 1938) and motivate Samuelson to actualize utility theory with the revealed preference theorem.

[22] Interestingly, one of Samuelson's most well known books that I will study in the next section is named *Foundations of economic* analysis, (the emphasis is mine) and his prominent textbook, as aforementioned, *Economics* has as a subtitle: *An introductory analysis*. That suggests technical and pragmatic values to his research, instead of the construction of a system aiming at the truth of the phenomena.

1.6. Arguments against formalism

The introduction of formal methods in economics animates a methodological and epistemological debate in the social sciences. Some of those who reject it claim that axiomatized theories do not belong to the empirical sciences. Others do so based on the ontological characteristics of the social world. To this latter argument, there are two critical levels: first, that the method from the social sciences must differ from the natural sciences, and secondly the consequences of formalizing social theories.

The philosophical dispute regarding the different methods for the natural and the social sciences has in its core the objection that the natural and the social spheres are ontologically distinct. Thus it is in the core of the first critical level of the objection just raised that ontological differences also imply method and epistemological divergences. When reconstructing this debate, Bryant (1985) writes the following regarding the nature of each world: "The natural world is, at least so far as science is concerned, a meaningless given. By contrast the human world is a meaningful construction: society and history are informed by, or obtain their form from, human ideas, values and purposes." (1985, p. 65)[23] Being a meaningful construction, the social sciences face an object that is composed of inherent ends filled with contingencies, where one is unable to find essential laws, unlike mechanics for instance.

The second critical level is directed towards the employment of formalism. For those refuting the possibility of all sciences to share one methodological and epistemological position, formalism is inadequate because there is something in the social ontologies that resists its formal apprehension. Being meaningfully constructed, the social world cannot be explained without a relation to ideas, values and purposes, thus, it cannot be a-historical, as formalism proposes. While the natural sciences face an object that can be instrumentalized and that lacks inherent ends, the social sciences encounter an object that is necessarily ethical, and whose ontologies resist an absolute operationalization and quantification. In sum, the core argument against the use of formalism in the social sciences is that formal methods leave out the social aspect of it, that essential component of the realm of values, that has inherent ends and cannot be reduced to an axiomatized system of definitions. From this perspective, some degree of

[23] In the context Bryant is referring to, meaningful constructs are thought in terms of hermeneutics, not as in positivism where sentences must be filled with empirical content to be meaningful.

realism is a better suited approach to the construction of theories. That means that theories in the social sciences must correspond to existing reality and shall aim to uncover its truth through the study of historical origins and developments.

Formalism, however, does not claim to exhaust the entirety of the human sphere nor to aim at it. For the formalist position, the scientific standard entails that a theory is classified as true when its conclusions can be known with [high partial] certainty. That does not require any sort of realism and its epistemological position is independent from the special characteristics of the object of study. From that follows a different conclusion regarding the methodology applied in the social sciences. The problem of induction and demarcation cannot be solved by ontological arguments, since it lies on the logical and epistemic level. In other words, ontological arguments do not solve logical nor epistemological problems, thus a discussion of the methodology of the empirical sciences is still an epistemic discussion, instead of an ontological one. For instance, whether regularities in terms of universal natural laws exist or not does not make inductive inferences logically valid, and as a consequence, answering to this question does not solve the problem of how we can attain knowledge of them. In sum, the methodologies where historical developments are an essential part of the explanation fail a logical and epistemological evaluation as soon as they claim synthetic sentences in terms of universal statements. Within them, experience is no longer the criterion for truth-decision, for the verification of a universal statement is not possible.

These two positions – whether they adopt formalism for theory development or reject it – present distinct notions of scientific knowledge so that the only possible common ground to evaluate them is their explanatory power. If methodologies accounting for historical developments enable the construction of theories with higher explanatory power, then they ought to be the most appropriate approach to a theory of the social world. But the evaluation through explanatory power does not require one specific methodology to be elected the main one, it needs only that, after constructed, theories be tested and attempts to falsify them be employed. (Miller, 1994) Further, it also does not elect one position as the most appropriate one, but each theory must individually be tested. That means that historical methodologies might generate one better theory to explain institutions' formation and conventionalism produces a better one explaining institutions' functioning. In this sense, evaluating a theory

based on its realism or other criteria neglects the notion that science must aim at advancing our explanations of the world and reaching truth.

2. Economic texts

In this chapter I introduce Samuelson’s general approach to microeconomics and his explanation of market curves. The chapter begins by exploring the core economic problem – price formation – and its proposed solutions: market curves and the theory of maximizing behavior. Samuelson's approach is characterized by operational-conventionalism, which emphasizes the use of formal methods to derive reliable predictions. This formalist turn can be understood as a response to the need for [high partial] certainty and precision in economic theories, a shift triggered by different epistemological solutions to the problem of induction.

Following the introduction to Samuelson's general proposal to building economic theories, the chapter will examine the theory of consumer behavior, a cornerstone of microeconomic theory. The theory of the firm will also be studied, highlighting how firms decide on production quantity and prices as strategies to a choice problem. This section parallels the theory of consumer behavior, trying to point out to a consistent application of the rationality principle across different economic agents. Further, the chapter will address how the contrast between models and experience is dealt with by Samuelson and how that affects the epistemic value of both models and theories, as well as how it confirms the conventionalist characteristic of the author.

Additionally, the chapter will consider contributions from other economists, such as Gary Becker and George Stigler, who have expanded and reformulated Samuelson's initial models. Their work on demand curves tries to solve objections to the theory of maximizing behavior without challenging its assumptions, thus introducing new dimensions to the discussion of economic phenomena.

The chapter will conclude with reflections on the possibility of progress in economic theory, considering the implications of adopting formalist methodologies in terms of conventionalism to the further development of the empirical sciences.

2.1. The economic problem and its solution: market curves and the theory of maximizing behaviour

The theory of maximizing behavior is established as an attempt to provide a satisfactory explanation of market functioning that does not rely on psychological explanations. Paul Anthony Samuelson is interested in understanding how demand and supply are formed and proposing models able to predict consumption and production shifts. The goal is to weaken the assumptions from previous theories in order to increase the generality of the explanation and decrease the number of possible points of objection. In doing so, the author reduces the requirements for his theory to succeed, increases its domain and avoids establishing hypothesis for topics that are not in the interest of the explanation, for instance the psychological dimensions of choice making.[24] He does that by rejecting the notion of procedural rationality and adopting substantive rationality. (Simon, 1976) That means that the object of study is not *how* choices are made, but *what* choices are made, thus no psychological dimensions need to be accounted for, as only the outcome is what interests the economist, not how it came to be. Regarding that, Alexander Rosenberg points: "Revealed preference theory allows the economist to be almost entirely neutral on the psychological mechanism that leads to individual choice." (Rosenberg, 1992, p. 61)

The depsychologization of the explanation comes within a framework where the scientist aims at a certain and precision theory. In *The Price of Peace* (2020), biographer Zachary D. Carter unfolds the development of economic ideas at this time pointing that "Where *The General Theory* had proclaimed "uncertainty" to be the bedrock analytical concept for economic thinking, Samuelson and his protégés sought not only certainty but precision." (Carter, 2020, p. 438) In the historical context, a large segment of economists in the United States and in Europe turned to a methodology where predictions and measurements would be achieved by the use of large datasets, made then increasingly available and complete. Carter follows to defend that "Economists, awed by the tools now at their disposal, wholeheartedly pursued a methodology that emphasized precise measurement and prediction over conceptual or linguistic analysis." And he continues "...the rational, profit-maximizing behavior of human

[24] The depsychologization of the scientific problem appears not only with methodological individualism, as it is the case of Samuelson, but also in societal theories. Within the adoption of methodological individualism, the depsychologization is achieved by the stipulation of the rationality principle.

beings would allow statistics to reliably predict when and where economic forces would reach equilibrium—if the data were sufficiently accurate." (Carter, 2020, p. 438) Such as the conventionalist position I defended here, the sociological environment around Samuelson had turned towards an increasing effort of an economic science able to predict future phenomena, and used as means, the implementation and advance of formalism.

Within this background, I defend on the next pages that Samuelson adopted a conventionalist position where he aims at an absolutely certain theory whose results are reliable and can be used for future inferences.[25] To do that, he developed two core models: the theory of consumer behavior, explaining demand formation, and the theory of the firm, explaining the formation of the supply curve. In the first, the author reviews the development of utility concepts in previews economic theories (Samuelson, 1947, p. 93), how they were formalized, and establishes his theorem of revealed preference. In the second, he establishes firms production and cost functions and the formation of their supply quantities given the situational aim of profit maximization.

2.2. Samuelson's approach

Samuelson published in (1947) the book *Foundations of Economic Analysis* with the following opening paragraph:

> The existence of analogies between central features of various theories implies the existence of a general theory which underlies the particular theories and unifies them with respect to those central features. This fundamental principle of generalization by abstraction was enunciated by the eminent American mathematician E. H. Moore more than thirty years ago. It is the purpose of the pages that follow to work out its implications for theoretical and applied economics. (Samuelson, 1947, p. 3)

[25] This adoption also introduces a particular justificationist notion of rationality according to which theories justify pragmatic measures and actions by providing reliable predictions. This notion, not studied here, marks the development of philosophies defending the pragmatic problem of induction.

With this initial statement, Samuelson indicates his notion of genuine science as that related to mathematical reasoning, that is, logical deduction. He aims, however, at applying such a deductive method to the empirical sciences, and especially economics.

To begin with, we must understand what formal economics in this context is. It starts with the assumption that fundamental structures in economics are "operationally meaningful theorems" (Samuelson, 1947, p. 3) that can be systematically applied to multiple fields, that is, a fundamental and general form to be filled with singular content. These diverse areas of economics share common core elements that constantly appear in the formulation of their theorems. In all of them, *unknown variables* are specified, *relationships* between these variables and some *parameters* emerging from data analysis are stated, and a set of *conditions* under which these relations can take place are established. These unknown variables, their relationships and the conditions for these relations can be understood as the typical initial conditions of the theory. They are the physical objects playing a role in the phenomenon and the constraints the solution of the problem faces. The relationships take the form of functional equations, and are themselves conditions of quantitative or qualitative constraints. The mathematical appearance the structures display is not necessary, even though they can be entirely captured by it. Thus, we can talk about relations and interdependence, or we can talk about functional equations. It Should be clear that formalization is not necessarily mathematization, although in this context, the former can be translated to the latter without losing any meaning.[26]

For anything to follow from the construct of the model, a law animating the subject of the models is postulated. In the case of the theory of maximizing behavior, the universal law is, as Samuelson states, that individuals behave as they behave, or, they behave according to the logic of the situation – whatever the situation is. As already indicated in the previous section, Samuelson's theory is part of a process of depsychologization of theories explaining individual actions. Because of that, the nuances of the subject placed in the model is not the core of the scientific inquiry, but only their choices.[27] This principle is frequently named the

---

[26] The reason why I am raising this description is so I can later develop the second hypothesis I described in section 1.1 regarding formal methods and [high partial] certainty.

[27] It is important that there is some sort of subject acting in his environment in the centre of the model as it is characteristic of the social sciences to try to understand human agency. As Karl Popper puts in *The Myth of the Framework* (Popper, 1994, p. 128), "The problem of the

"rationality principle", and it is defined by the author as a very simple theorem expressing that people behave as they behave, "...nothing more is stated than the conclusion that people behave as they behave, a theorem which has no empirical implications, since it contains no hypothesis and is consistent with all conceivable behavior, while refuted by none." (Samuelson, 1947, p. 92) Samuelson proceeds a few pages later: "This does not require (a) that the individual behave rationally in any other sense, (b) that he be deliberate and self-conscious in his purchasing, (c) that there exists any intensive magnitude which he feels or consults." (Samuelson, 1947, p. 98) According to the author, the rationality principle is not an empirical hypothesis, that is, it is not open to falsification nor verification. It is an analytically true sentence instead of a statement regarding an empirical phenomenon. Thus, it is classified as true with absolute certainty because of its analytical character. In Section 1.4. I mentioned Popper's description of the conventionalist sentences as stripped of all empirical content, and I remarked that, as a consequence, their sentences forbid almost nothing in the empirical universe, being purely definitional statements that cannot be falsified. If these arguments are accepted, one can read Samuelson's words aforecited as a conventionalist approach to the solution of the problem of induction. It solves it by applying truth preserving inferences which, as a consequence, conserve the truth values of the initial statement, the rationality principle.

A second argument concerning the epistemological status of the rationality principle are the comments Samuelson does regarding its testability. In the conventionalist position, as earlier reconstructed, the fundamental theory is not testable, or its testability is irrelevant to the truth of the theory. I will raise these arguments in section 2.6., where I study the contrast between microeconomic theories and experience.

Before all else, I must clarify that there are two levels in the construct of Samuelson's explanation of markets, the context of theory creation and the context of theory evaluation – sometimes also referred as context of theory justification. The first considers the sociological and psychological emergence of the theory. In this case, Samuelson defends that his theory of maximizing behaviour is inferred from different historical cases, such as the history of economics accessed through textbooks and economic texts, and observing entrepreneurial behaviour. (Samuelson, 1947, p. 21) In this context, the author establishes general laws on the

unintended consequences of our actions, consequences which are not only unintended but often very difficult to foresee, is the fundamental problem the social scientist."

basis of observations of individual theories. Since Samuelson makes use of inferences by analogy, the context of theory creation, logically, is in an inductivist framework. But the context of theory creation cannot be identified with its evaluation, once we have seen in the history of philosophical ideas, that it is not possible to justify scientific theories with inductivist inferences. In addition to that, one could raise an objection arguing that there must exist some pre-conception of models in the scientist for him to evaluate the different theories he studies. Thus, the analysis of individual theories is not the actual starting point of one's argument and does not serve as epistemological justification.

With these criticisms, the logical and epistemological status of Samuelson's context of justification must lie somewhere differently than his context of discovery. That means, inductive inferences are not valid to justify a theory's logical or epistemological status, thus their justification must be on different logical grounds. I defend now that the context of theory evaluation is based on deductive reasoning and his theory is justified with the conventionalist conceptions of analytical truth and certainty. To do that, I will reconstruct the logical steps the author presents us in the first 5 chapters of his book.

For my reconstruction, I am making use of Popper's idea of situational analysis, presented in a lecture in the Department of Economics of the Harvard University in 1993 and later published under the title "Models, instruments and truth: The status of the rationality principle in the social sciences", and Musgrave's different types of assumptions. The idea of situational analysis is part of Popper's answer to the problem of classifying theories as true and the problem of methodology in the social sciences that we discussed in the first part of this work. According to him, to develop an appropriate method of social analysis, we must understand theories "...*as an attempt to solve a certain problem*." (Popper, 1994, p. 157)[28] In this sense, economic theories can also be studied considering the problem they try to solve. It is this the approach I will employ to reconstruct Samuelson's theories. To grasp a theory, Popper argues, one must first distinguish what kind of problem it aims at explaining: predicting singular events or predicting a certain kind of events. To solve the latter, as it is Samuelson's intention, one might construct a model. Models, similarly, to how Samuelson characterized operationally meaningful theorems, are typical situations representing how different relations take place, how different elements act upon each other – for instance how a shift in prices

[28] The emphasis is from the author.

affects demand -, and aiming at predicting kinds of events – demand and supply curves, in our case. According to him, the models in the social sciences that assume the rationality principle have three main features: a situational aim, typical initial conditions and an animating law. From these, results are deduced, and the theory's explanatory power can be tested. For the theories of rational choice, the animating law is the rationality principle. It is what animates the model in the sense that it makes the agent and the objects interact with each other. The situational aim is nothing more than what the choice maker aims at. It could be profit maximization, but it could also be to cross a street, as Popper describes in this lecture. The typical initial conditions are the knowledge shared by those facing the choice problem, the physical objects in it, and the social institutions, that is, all the rules that constrains the choice problem.

These conditions encompass all those features that specify the situation in which the model must work and from where the results will be deduced. But they are not all the same. Musgrave discuss different types of assumptions in economics in the paper "'Unreal Assumptions"' in Economic Theory: The F-Twist Untwisted (1981)[29]. According to him, three types of assumptions play a role in economic modelling. Negligibility assumptions (also denoted in more recent literature as "Galilean assumptions" [Cartwright, 2007]) assume that one element in the phenomenon has irrelevant impact on the explanation we are aiming at. It is not, in any case, a hypothesis regarding the inexistence of the element or regarding one of its special features. A second type of assumption commonly used are domain assumptions. This is a supposition restricting the domain on which a theory or a model claim to have explanatory power. For example, a model that assumes a balanced budget can be understood as a model that only presents reliable results if applied to a situation that has, initially, a balanced budget. Lastly there are those assumptions that Musgrave calls heuristic assumptions. These are part of the development of a theory. They are also not hypotheses regarding an element of the model, and its falsehood is usually clearly known, but the assumption is made in order to allow one step of the theory to be taken, or to generate a counterfactual scenario that enables the scientist to compare results with and without it.

[29] The term "F-twist" refers to Milton Friedman's paper "The Methodology of Positive Economics" (Friedman, 1966), in which Friedman discusses the use of unreal assumptions in the discipline, disregarding the epistemic differences of each assumptions playing a role in each explanation.

These first two assumptions can be related with the extension of empirical content they concede to a theory. Negligibility assumptions, for instance, increase the empirical content by decreasing the restrictions of a theory's application. If full employment is a negligible assumption within an economic theory, that means whether there is full employment or not does not affect the validity of the hypothesis raised. Thus the explanation must work independently of the degree of employment in that economy. As a consequence, the employment status of an economy cannot be used to falsify a model's prediction and the theory applies to a larger set of situations. Domain assumptions, on the other hand, can be understood as those decreasing the empirical content of theories – the same way because it restricts their applicability. A theory with a smaller domain means a theory with a more specified set of relations and conditions therefore being harder to falsify. Empirical content plays an important role on the evaluation of a theory's epistemic status, and as we have seen, it is central for assessing the rationality principle and its consequences in the construct and test of models.

2.3. Theory of consumer behavior

The model Samuelson develops for his theory of consumer behavior is an attempt to explain demand curves independently from the concept of utility (Samuelson, 1938, p. 71). The economic problem he is interested in is the decreasing demand as a result of increasing prices, thus, a certain type or kind of events, as Popper mentioned in his lecture. Samuelson starts from the postulate that individuals are rational in the sense that they aim at maximizing their utility. Utility maximization, therefore, is the situational aim posited in the model. The author then stipulates a few conditions for the model, for example that individuals know the prices – which they cannot affect -, the commodities available, their income, and their preference scale. They have perfect knowledge of all these elements. The role of this latter assumption is debatable. One can understand it as a domain assumption, meaning that the model cannot be applied to situations in which knowledge is incomplete[30], or as a heuristic one, where the

[30] See for instance Akerlof's model for the market of lemons (Akerlof, 1970), where assuming imperfect information in a basic microeconomic model leads to the collapse of this market economy. The primary idea of this paper is to highlight how information imbalances between buyers and sellers in a market can lead to adverse selection and market failure. The paper explores situations where sellers have better information about the quality of their products than buyers do.

simplicity of the conditions is only a heuristic device for further theory development or testing. Additionally, there is only one type of physical object in the model, the commodities to be purchased. There are, however, no constraints in supply, and the limiting determination of the problem is given by the individuals' budget and their marginal rate of substitution – that is, their willingness to switch one commodity by another.

In the case of what Samuelson calls "single economic units" (Samuelson, 1947, p. 5), the problem can usually be reduced to a maximum/minimum solution. That is, the equilibrium solution lies in the extremum value and is called a "static equilibrium". (Samuelson, 1947, p. 313) In this case the final solution is fixed in time and does not evolve any more. That is the case of the theory of revealed preference we are treating here and of the theory of the firm, which I study next. Otherwise, when plural systems spreading across time interact, an equilibrium position must have its characteristics defined and the solution of the interacting systems will be the necessary values our unknowns must have to reach the stable position. The latter will be called a "stationary equilibrium" (Frisch, 1936, p. 101), and is usually understood as a constant rate of change through time that maintains the system without great variations. (Samuelson, 1947, p. 313) In the defence of equilibrium or stability states, Samuelson conjectures the existence of a statistic expressing that, even though unstable positions exist, some situations are more frequent than others, thus being called equilibrium position. Therefore, for convenience, the economist assumes the existence of stable positions in his system and regards other situations as mere transitions. (Samuelson, 1947) The model can, then, be presented as in Table 1.

The author uses the example of used cars, where some cars are *lemons* (low quality) and others are *peaches* (high quality). When buyers cannot distinguish between lemons and peaches before making a purchase, they may be unwilling to pay a high price for high-quality goods, as they fear they might end up with a lemon. This information asymmetry results in a market where high-quality goods are under-represented because sellers of good-quality products can't command higher prices due to buyers' scepticism. Consequently, only low-quality goods dominate the market over time, which further erodes buyers' trust and willingness to pay. This leads to a vicious cycle where the market for high-quality goods gradually deteriorates. This paper was considered groundbreaking and introduced in economics a new concept, that of "asymmetry of information", now widely used. With this in mind, Samuelson's theory of consumer behavior can be understood as the most fundamental and simplistic model and most of its assumptions mere heuristic ones, to be changed in a later stage of theory development to explore different consequences and be applied to more realistic situations.

Individuals choose the bundle that provides the highest utility for them given that they are constrained by their income and they cannot affect prices. The problem, therefore, is a maximum one with a set of constraints. These constraints can be on the subjective realm, that is, part of the characterization of the subjects‘ preferences in the problem, or objective, that is, related to the information given to all the individuals inserted in the problem. These conditions are sufficient for the deduction of stable demand curves, which maximize individuals' utility. The latter is a direct consequence of the situational aim and the universal law of the model posited by the author.

Table 1

The theory of consumer behavior reconstructed using situational analysis

Law: “People behave as they behave”, that is, accordingly to their situational aim.[31]	
Situational aim: Individuals choose as to maximize their utility within an ordinal preference scale.	
Typical initial conditions:	
Subjective knowledge	Individuals have perfect knowledge.
	Each individual has a marginal rate of substitution.
Objective knowledge	They are bounded by their income (I).
	Prices (p_i), commodities available (x_i), and income (I) are given.

2.4. Theory of the firm

The theory of the firm is structurally very similar to the theory of consumer behavior. Both fall under the epistemological umbrella of the maximizing behavior theory and share a common universal law, the rationality principle. Instead of explaining the formation and behavior of the demand function, in this theorem Samuelson aims at constructing a model that explains changes in supply. Differently than the consumer theory, where individual have explicit utility functions, firms’ profit is a residual value deduced from the supply amount of

[31] 1947, p.92.

x_i, the output. The construct of the argument can be divided in two steps, each one being one auxiliary model. The first model aims at finding firms' best production combination and it can be described as presented in Table 2:

Table 2

The theory of the firm reconstructed using situational analysis, first step

Law: Firms "behave as they behave", that is, accordingly to the situational aim.[32]	
Situational aim: Individual firms choose their input as to minimize their cost of production.	
Typical initial conditions:	
Subjective knowledge	Firms have perfect knowledge of the market; they know the prices of output and of the productive factors.
	Every firm knows their marginal physical degree of productivity.
	Every individual firm has a cost structure.
Objective knowledge	They are bounded by their income (I).
	Prices (w_i) of inputs (v_i) are given.

In this first step, individual firms must find the production combination that minimizes the cost of the production of a given constant output (x_i). Now revenue is ignored, and the cost function of the individual firm is deduced. This cost curve is a function of the firm's cost structure, that is, the prices of input, the quantities required, the additional costs the production may have (A), such as taxes, and their marginal productivity. In the second stage, the cost function deduced from the first stage becomes one of its conditions. In addition, this second stage introduces a market situation in which firms must maximize their profits and are in monopolistic competition with each other. It can be reconstructed the as shown in Table 3 below.

[32] 1947, p. 92.

Table 3

The theory of the firm reconstructed using situational analysis, second step

Law: Firms "behave as they behave", that is, accordingly to the situational aim.[33]	
Situational aim: Individual firms choose their output as to maximize their profit.	
Typical initial conditions:	
Subjective knowledge	Firms have perfect knowledge of the market; they know the prices of output and of the productive factors.
	Every individual firm knows the cost function that minimizes the cost of production.
Objective knowledge	Prices (w_i) of inputs (v_i) are given.
	Price (p_i) of output (x_i) is given.

From these conditions, one must deduce the quantity of output x_i that maximize profits. With constant prices of output, and knowing their marginal cost curve, firms deduce their marginal revenue curve and find its intersection with the demand curve. That is when the marginal cost equals marginal revenue. Since demand is horizontal – that is, absolutely inelastic -, and at a determinate level of quantity x of good i the cost for the next unit gets higher than their marginal revenue, moving forward in the quantity axis could only decrease profits. Thus, the optimal supply position is when marginal cost equals marginal revenue and demand.

As in the theory of consumer behavior, Samuelson makes assumptions of different kinds. In the first step, output is assumed constant and given, thus playing the role of a heuristic assumption – since the entire model is constructed to explain changes in supply. The assertion of synthetic statements as typical initial conditions such as given income imply that there are negligibility assumptions regarding situations' causes playing a role in the explanation. For instance, the initial condition that firms are bounded by their income implies that the income distribution is irrelevant to the solution of the problem. It also implies that the relationship

[33] 1947, p. 92.

between some variables within the same model does not exist, without, however, explaining or treating this proposition any further.

In the second step, the author aims at deriving a general supply function that determines the optimal level of output, that is, the one that fulfils the situational aim: profit maximization. To do that, he must change the assumption that output is given and transform it in the unknown variable. Another assumption in the model is the market form as atomistic competition, which plays a role of a negligibility assumption. In this sense, the model structure could be maintained if the market was a monopolistic one or any other. The values would change, as prices and marginal revenue increase, but supply would always equate to marginal revenue, marginal cost and demand. This would be different, for instance, if demand was assumed elastic, which is not the case. The demand assumption can be understood as a heuristic assumption given that it is knowingly unrealistic but functions as to work out the internal logic of the model. That is the same for the conditions in which prices are all given and the amount of input available is infinite.

In such fundamental models as the theory of the firm and the consumer behavior theory, a large part of the unrealistic assumptions is a heuristic device. That is clear by the initial intention Samuelson described in his book. These models aim to be *operationally meaningful*, that means that their internal logic captures something that we can be certain about and that can be applied for economic analysis. For Popper, this type of model is "...a *typical situational model*, capable of 'explaining in principle' (to use Hayek`s term) a vast class of structurally similar events." (Popper, 1994, p. 168)

In this analytical level, it is the internal logic of the models and their ideal conditions that are being worked on. They provide a basic operational structure that can be developed for further ideal situations, for instance the example already presented of Akerlof's paper on the market for lemons, or the changes in demand elasticity in Becker and Stigler's model of preferences that will be presented later. Either way, Samuelson's theory of maximizing behavior provides a logical operational structure that can be adapted for the explanation of different situations with the change of one or a few typical initial conditions – establishing these as heuristic devices.

The different assumptions in the model are also affected by its testing. A fundamental operation as that presented in the theory of maximizing behavior is hardly realistic, and its

domain is so vast that it can easily be falsified. Thus its typical conditions, when substituted by singular conditions, do not yield certain predictions. For that, the assumptions and the internal logic of the models are to be changed, and a new prediction to be made. This new prediction, shall be an appropriate hypothesis to explain the singular phenomenon being studied. In this sense, either on the analytical level or on the empirical one, these operational models constructed by Samuelson can be understood mainly as heuristics, fundamental ways of approaching the analysis of individual choice.

2.5. Theory testing and contrast with experience

The contrast between theory and experience in Samuelson's framework relies on the epistemological status of the rationality principle. As already indicated, the principle is an analytical sentence that logically cannot be falsified. Consequently, the models inferred from the theory, instead of the theory itself, are confronted with experience. In this confrontation, the reliability of the model's predictions is analysed and the model evaluated. In the case of the *Foundations of Economic Analysis*, these predictions are only reliable on qualitative grounds. That means that they are not as precise as a quantitative predictions, but on their qualitative characteristics they are absolutely certain.

With the epistemological status of an analytical truth, the rationality principle is a statement classified as true with absolute certainty. Its use in the explanation of individual choice, however, is conventionally agreed on. That means that once the scientist aims at testing a theory inferred from the rationality principle and the initial conditions, it is conventionally agreed not to direct the falsification to the principle, but to the conditions of the measurement instruments, that is, the models. With the methodological agreement to preserve the rationality principle, it is only possible to link theory and experience in the particular models. That is achieved by substituting their typical initial conditions with singular initial conditions, as discussed in section 1.2. From that, one can deduce predictions and compare the results with experience. For instance, following the deduction of parameters' values in market demand curves, the relation between shifts in price and quantities can be compared to actual phenomena and the reliability of the model assessed. Theory testing, therefore, refers to models, not to theories. That is typical of a conventionalist position. Strict universality in

terms of strictly universal and empirical statements is rejected and substituted by analytical statements commonly (arbitrarily) agreed on.

To sustain this argument, I bring some of Samuelson's comments on theory testing. In the introduction to the theory of consumer behavior, he states that the rationality principle is "[…] a theorem which has no empirical implications […]", (Samuelson, 1947, p. 91) as I have already indicated. Following this sentence, he sheds light on the epistemological status of the theory as a whole. He proceeds: "...the modern utility theory with all its qualifications is not in a technical sense *meaningless*. It *is* a hypothesis which places definite restrictions upon demand functions and price-quantity data, these could be refuted or verified under ideal observational conditions."[34](Samuelson, 1947, p. 92) This suggests that the model is a hypothesis on the relation between price and quantity, and this hypothesis can be tested. In this case, the refutation or confirmation of the model by experience leads to an alteration solely in the epistemic status of the model, not of the theory. If falsified, the model is altered or amended to better generate reliable results. If confirmed, the model is maintained as a technical instrument of analysis and prediction.

To conclude his notes on consumer theory, Samuelson comments on the potentials of testing utility analysis. Once again we can understand that testing has no impact in the epistemological status of the foundational theory:

> Many writers have held the utility analysis to be an integral and important part of economic theory. Some have even sought to employ its applicability as a test criterion by which economics might be separated from the other social sciences. Nevertheless, I wonder how much economic theory would be changed if either of the two conditions [of price and quantity behavior] above [mentioned] were found to be empirically untrue. I suspect, very little. (Samuelson, 1947, p. 117)

In its most abstract and generic form, the epistemological status of the postulates from utility analysis is always preserved against empirical refutation. Because the source of the truth

---

[34] Contrary to what was pointed out in section 1.6., where the term "meaningful" had only a hermeneutic role, here Samuelson makes use of it following the positivist tradition. He indicates the existence of *some* empirical content in the modern utility theory, in the sense that it asserts something about the empirical world and it can be empirically verified.

values is not in the relation to experience, but in the analyticity of the foundational system, contrast with observations cannot verify or falsify the theory.

A few years later, Samuelson revisits his own text as a response to Fritz Machlup. With the title "Theory and realism: a reply" (Samuelson, 1964), Samuelson explicitly objects to the strict falsification of theories as a method to theory evaluation and classification. According to him, even when parts of theories are falsified, there is still usefulness in them and they should not be rejected until better ones appear. Correspondingly, he makes the same consideration in the *Foundations* regarding Hicks' hypothesis of stable equilibria. In his words: "In principle the Hicks procedure is clearly wrong, although in some empirical cases it may be useful to make the hypothesis that the equilibrium is stable […]." (Samuelson, 1947, p. 273) Economic analysis, therefore, presents a degree of instrumentalism in the sense that the deduction of models aims at something else than truth.

The models are technical tools whose reliability is evaluated in respect to the [high partial] certainty of their predictions. But these predictions have a special character that Samuelson named "qualitative behavior". (Samuelson, 1947, p. 21) In the second chapter of his book, Samuelson indicates the following:

> In the absence of complete quantitative information concerning our equilibrium equations it is hoped to be able to formulate qualitative restrictions on slopes curvatures etc of our equilibrium equations so as to be able to derive definite qualitative restrictions upon the responses of our system to changes in certain parameters. It is the primary purpose of this work to indicate how this is possible in a wide range of economic problems. (Samuelson, 1947, p. 20)

In this sense, the author aims at inferring models that can predict qualitative shifts of the economic phenomena. These shifts are the signals the functional relations have, that is, if they are negative or positive relations. For instance the signal from the partial second derivative of consumption in respect to prices indicates if they are in a positive or negative relation with each other. That enables the scientist to derive a dimensional result from his model.

These results are generic predictions – the term was coined by Rosenberg (1992, p. 68) – indicating only the directions of change.[35] These directions of changes are highlighted in

[35] This statement goes in the direction of what Cartwright (2007) defended regarding models as illuminating general trends in economic phenomena. Rosenberg, however, criticizes the lack of

Samuelson's book multiple times, for instance as restrictions upon the slope of demand functions.[36] (Samuelson, 1947, p. 111) Another important consequence of the possibility in determining qualitative changes is to make conclusions regarding the effects of changes in one or more variables. Robert Solow highlights this matter in his brief retrospective published in 2010 about Samuelson's work. He writes: In Samuelson's revolutionary view, economic theory had three parts…" proceeding a few paragraphs later:

> The third step was to ask and, in the abstract, answer questions like the following: Suppose something in the environment […] were to change. How would the equilibrium configuration change and how would the equilibrium prices and quantities change? Above all, are there general qualitative answers to those questions? (Solow, 2010)

That is explicitly indicated by Samuelson as one of his biggest accomplishments in the book's conclusion. He maintains that qualitative shifts can be deduced from his theory when changes in parameters are introduced attaining, at least on the qualitative ground, reliable results. (Samuelson, 1947, p. 350)

In conclusion, it is possible to test the models animated by the rationality principle to refine and develop them towards more precise results – remaining always on the possibility of verifying results, never actually falsifying the models. With the account that falsification plays little to no role in economic analysis, theory progress in the conventionalist approach proposed by Samuelson moves only throught instrumentalist standards. I will return to this claim on the last part of this work.

2.6. Becker and Stigler formulation

Observation of empirical phenomena through time raised a question that Samuelson's principal model for consumer behavior could not explain: how does demand change if

precision in the predictions and especially how throught the years it did not advance. That is, how economic theories do not present now predictions quantitatively closer to the empirical values observed, as they did decades ago. Whether the problem lies on the lack of data or on the inadequacy of the models is still a prominent debatable subject. See also Solow (2005) "How did Economics get that way and which way did it get?"

[36] For more comments on qualitative changes see (Samuelson, 1947, pp. 21, 81, 121, 125).

preferences and prices do not? With that, Becker and Stigler (1977) developed a model also aiming at explaining demand functions, however the type of curves to be explained are different and have larger empirical content than those Samuelson deduced from his analysis.

The widespread critiques regarding the unrealisticness of assumptions, especially concerning individual preferences, was mentioned by the authors as a central motivation for their article. In their words: “On the traditional view, an explanation of economic phenomena that reaches difference in tastes between people or time is the terminus of the argument.” (Becker & Stigler, 1977, p. 76) In this traditional view mentioned, economics does not explain shifts in preferences, hence the critique that the concept of preferences is unreal and cannot account for real human behaviour. Individuals make incoherent choices across time, they change their tastes and revealed preference theory would cause more harm than it would enlighten our understanding of real behaviours. Against that, Becker and Stigler defend preferences as discussed in the *Foundations of Economic Analysis*, but introduce demand shifts in the framework of the already existing theory of consumer behaviour. That means that no additional assumption regarding tastes needs to be introduced beyond the traditional formulation of Samuelson. In their words:

> The ambitiousness of our agenda deserves emphasis: we are proposing the hypothesis that widespread and/or persistent human behavior can be explained by a generalized calculus of utility-maximizing behavior, without introducing the qualification "tastes remaining the same.” […] we assert that this traditional approach of the economist offers guidance in tackling these problems–and that no other approach of remotely comparable generality and power is available. (Becker & Stigler, 1977, p. 76)

Their approach is to propose the existence of a new commodity, named “consumption capital”.[37] (Becker & Stigler, 1977, p. 78) This approach lies with Becker and Michael’s (1973) understanding of the household as the basic economic unit for economic analysis and of *investment activities*, where capital is invested in labor force and remains with the individual as his capabilities, that is, *human capital*. The latter concept refers to the stock of knowledge, skills, education, and other attributes embodied in individuals that contribute to

[37] Commodities and market goods are distinguished in Becker and Stigler’s theory. Commodities, not goods, are the ultimate objects of choice.

their productivity and earning potential – either economic or not. It is central to the understanding of this concept that investments in education and training are akin to investments in physical capital, such as machinery or equipment, and can enhance an individual's productivity over time. In the context of "On the New Theory of Consumer Behavior" (1973), Becker and Michael extended the concept of human capital to consumer behavior. This involves analysing individual choices and resource allocation considering individuals' human capital as a crucial factor in the decision-making process. That, in the "De Gustibus Non Est Disputandum" (1977), is used to explain a shift in consumption behavior with fixed variables.

The idea behind consumption capital is that the more one consumes a good commodity – the example used is listening to music -, higher is the appreciation for this same commodity. The key to maintain the same concept of preferences as in Samuelson even with shifting demand curves is to understand *commodity appreciation* as the commodity to be consumed, instead of music, ballet or alcohol. One's utility is a function of the production and consumption of commodity appreciation and consumption of other commodities, that is

$$U = U(M, Z)$$

where M is the production and consumption of commodity appreciation, and Z other commodities to be consumed that are part of the individuals' utility scale.

Commodity appreciation (M), in turn, depends on the time spent consuming this one commodity and the human capital favourable to appreciate it, that is,

$$M = M_m(t_m, S_m)$$

where t_m is the time allocated for consumption of certain goods – thus the consumption demanded and what was previously understood as the object of choice –, and S_m the consumption capital or human capital favourable to consumption.[38] Becker and Stigler (1977) assume that the relation between time (t_m) and consumption capital (S_m), and their function's second order condition is positive when it is a matter of a *good* commodity – such as listening to music or watching a ballet concert -, and negative with a *bad* one – such as euphoria derived from drugs. Consequently, the more time one spends appreciating music, more

[38] Note that both equations are a direct reproduction of Becker and Stigler's paper. They are being used here to guarantee the clarity of my exposition.

consumption capital is achieved, and the inverse happens for bad commodities. For this reason, with increasing S_m, one could spend less time listening to music and still have in his utility function the same amount of M, thus earning the same utility from less consumption. The model can be described as follows:

Table 4

The theory of consumer behavior with shifting demand reconstructed using situational analysis

Law: "People behave as they behave", that is, accordingly to their situational aim.[39]	
Situational aim: Individuals choose as to maximize their utility within an ordinal preference scale.	
In this case, the typical utility function has the form $U=U[M=M_m(t_m,S_m),Z]$.	
Typical initial conditions:	
Subjective knowledge	Individuals have perfect knowledge.
	Every individual has a marginal rate of substitution between M and other commodities available (Z)
	The elasticity of M is given.
	The qualitative relation between t_m and S_m are given.
Objective knowledge	Individuals are bounded by their income (I).
	Prices (p_i), commodities available (Z; t_m), consumption capital (S_m) and income (I) are given.

The consequences of this model are that with time, an individual might not allocate more time to listen to music (t_m), but because his consumption capital (S_m) rose, he needs to spend less time listening to music (t_m) to obtain the same utility out of M as before. Therefore the

[39] 1947, p. 92.

demand falls with time. The inverse happens with the bad commodities. Because of the negative derivative assumption – or the inverse qualitative relationship -, it is understood that the more time allocated to the appreciation of the commodity, the smaller its consumption capital gets, therefore one has to spend more time consuming it to achieve the same utility as before. This would mean that one would reduce the time allocated for it, once time could be more efficiently allocated on the consumption of a different commodity, but because harmful commodities (M) have inelastic demands, individuals will increase time (t_m) to compensate the decrease in (S_m).

The central reason why this work was groundbreaking was that it enabled the revealed preference theorem of consumer behaviour traditionally proposed by Samuelson to be maintained while explaining a new phenomena: demand shifts. With Becker and Stigler's contribution, changes in the environment can also explain why preferences do not shift, even though consumption does, as well as the other way around, all depending on how much consumption capital different individuals have invested in the consumption and production of different commodities. The key for my analysis is to stress that their input to consumer behaviour theory builds up on the rationality principle and most typical initial conditions Samuelson posited without challenging them. For instance, they conclude that their "… hypothesis is trivial, for it merely asserts that we should apply standard economic logic as extensively as possible." (Becker & Stigler, 1977, p. 89) Meaning that the objection they mentioned in the beginning of the paper – that the economic argument ends when it encounters difference in tastes between people or time – is not well grounded. The theory of consumer behavior and its models explaining choice making based on prices and incomes can explain a broader class of problems than immediately thought. In the authors' words, the advantage of their approach is that "...all changes in behavior are explained by changes in prices and incomes, precisely the variables that organize and give power to economic analysis." (Becker & Stigler, 1977, p. 89)

As we discussed in length in the first part of this work, the conventionalist position makes the methodological choice of maintaining the truth values of the rationality principle and placing the falsification of the *explanans* in the typical initial conditions. Thus once the theory fails to explain a phenomenon, the model is reformulated but the fundamental axiom is maintained. The same way here, the reformulation of the model is done to increase the reliability of its

results, that is, increasing the theory's ability to deliver successful predictions that can be classified as true with absolute certainty. With the expansion of "standard economic logic" (Becker & Stigler, 1977, p. 89) and the refinement of its models, the rationality principle and the methodological choice of maintaining it as the fundamental axiom of economic theory improve the justification of the conventionalist theories.

It is also significant to note how the understanding of variables as presented in operationalism takes place here. For instance commodities are understood in the theory of consumer behavior as the objects of individual choice. These, in the previous theory, were the goods forming a consumption bundle. With the introduction of the concept of human capital and commodity appreciation, goods no longer are the objects of choice in the model, but the time spent consuming them is. Commodities remain the objects of consumption and the operational definition of this category is maintained. However, *goods* are no longer the objects of choice and they play now a different role in the model, thus its categorization differs with the change in its function within the model.

2.7. Notes on the possibility of progress in economics

A theme that pervades the writings of all the economists mentioned here is that of scientific progress in economic science.[40] If my arguments regarding the epistemological position of their theories as conventionalism are accepted, an outline of the possibilities of progress in economics overlaps with an account of progress in any empirical science that adopts conventionalism. That means that inquiring about progress in economics, centrally in models where the rationality principle has the same epistemological status as in Samuelson, must coincide with the possibilities of progress in conventionalist terms. That is the theme of this brief section.

As noted by Popper in *The Logic of Scientific Discovery* (2002), conventionalist sciences rely on pragmatic constructs. As such, the constructs do not exhibit a regulative epistemic idea,

[40] See for instance Stigler (1983), where the author argues for a pre-scientific era in economics during mercantilism, where the theories were attempts to solve problems of their time, policies of the societies in which these theories were elaborated. This time component, or the change of problems would be responsible for reducing the discipline's epistemic cumulative opportunity. Differently than what I argue for, Stigler defends that a shift in problems to be explained is the reason why economics struggles to accumulate knowledge and show a clear progressive path.

only pragmatic ones. With this, as soon as a theory is not useful, it is discarded, but not when it is proven false. In the case of a regulative epistemic idea as truth decided objectively by contrasting theory and empirical observations, one is able to claim scientific progress by how closer theories are to attain truth, even if one cannot know when truth is in fact attained. In *The Logic of Scientific Discovery* the case where only pragmatic values regulate the use of theories, they are evaluated based on non-epistemic criteria. According to Popper, the core regulative criterion in conventionalism is simplicity.

That simplicity is a regulative pragmatic standard in the use of formal methods in economics is more evident in the contemporary discussions presented in section 1.3. Contemporary authors writing on the methodology of economics defend the use of formal methods for the simplicity in which it can communicate results. Differently than defending parsimony, where everything else being equal, the hypothesis with less assumptions shall be preferred, or the epistemological concept of simplicity, in which a simpler theory has a larger domain, simplicity for the conventionalist is a matter of aesthetics and of pragmatism. It is aesthetic because it refers to the form, presentation, and exposition of a theory. Simultaneously, it is pragmatic because it refers to simpler ways of carrying out the practical uses of theories. In this sense, simplicity adds no epistemic value to theories. If aiming conventionalist economic research and competing hypotheses towards simplicity does not affect the epistemic value of theories, what appears to be scientific development reveals to have no epistemological gain, therefore no epistemological progress. In this interpretation, and as already defended, conventionalist theories are techniques used to analyse empirical phenomena, not necessarily to increase our knowledge of them.

Simplicity, however, can be understood as an epistemological concept if it is combined with increasing empirical content. As mentioned above, a simpler theory or statement, in the epistemological sense, has a larger domain, because it poses less restrictions. In this sense, a simpler sentence explains a larger class of phenomena than a less simple one. As a consequence, simplicity enhances the epistemological value of an explication. In Popper words,

> To understand this there is no need for us to assume a ‘principle of economy of thought’ or anything of the kind. Simple statements, if knowledge is our object, are to be prized more highly than less simple ones *because they tell us more;*

> *because their empirical content is greater; and because they are better testable*. (Popper, 2002, p. 128)

In sum, simplicity as a criterion, if not combined with empirical content, does not enhances theories epistemic value, thus does not, by itself, lead to scientific progress. That has striking consequences for the empirical sciences, and specially to economics, once it challenges not only its methodology, but its overall episteme.

3. Conclusion

This thesis has studied the development of the concept of scientific knowledge, triggered by the Humean problem of induction and the epistemic challenges it presents to empirical sciences. I have introduced potential solutions to these problems and contextualized them within the history of ideas (Sections 1.2 – 1.4). Specifically, I have highlighted how one solution, the conventionalist position, materializes as operationalism in the first half of the 20th century (Section 1.5).

By analysing the revealed preference theorem and the theory of the firm, I argued that these are quintessential conventionalist theories, utilizing analytical initial statements to derive pragmatic constructs known as models (Sections 2.1-2.4). The role of experiments in these theories was explored (Section 2.5), later demonstrating how their unchallenged assumptions serve as a basis for further model development (Section 2.6). Finally, I provided brief notes on the [possibilities of] scientific progress in economics (Section 2.7).

If my arguments are accepted, the *Foundations of Economic Analysis* (1947) can be read as a conventionalist thesis expressing the shift in epistemological standards from proven true theories to theories classified as true with absolute [high partial] certainty. With the substitution of truth for [high partial] certainty, conventionalism adopts pragmatic standards for the development of its theories. With that, the expansion of formal methods in economic analysis is the consequence of an epistemological stance, which aims at certain knowledge with increasing precision. By adopting [high partial] certainty, and with the continuing use of verification and the aesthetic criteria of simplicity as a method for theory evaluation, the conventionalist position expressed in economic analysis fails to meet the current scientific standards for the empirical sciences.

In short, the theories explored generate analytical models whose scientific validity is determined by their practical utility. By prioritizing pragmatic values over truth, the conventionalist position moves towards increasing the precision of its instruments and enhancing the reliability of its results. This involves an operationalist mode of categorization, the rejection of strictly universal and empirical statements, and the adoption of empiricism not for the truth decision of theories, but for the calibration of the models and the confirmation of their [high partial] certainty. This pragmatic orientation, while valuable, highlights the need for ongoing scrutiny of the epistemological foundations underpinning economic theories. Ultimately, this thesis has studied how the conventionalist position, with its emphasis on certainty and formal models, has profoundly shaped modelling and economic thought. Above all, the ongoing vibrant dispute between formalism and its critiques is simply another symbol of the relevance and impact of economic theories.

Bibliography

Akerlof, G. A. (1970). The Market for "Lemons": Quality Uncertainty and the Market Mechanism. *The Quarterly Journal of Economics*, 84(3), 488–500. https://doi.org/10.2307/1879431

Becker, G. S. (1993). *Human Capital: A theoretical and Empirical Analysis, with Special Reference to Education* (3rd ed.). The University of Chicago Press.

Becker, G. S., & Michael, R. T. (1973). On the New Theory of Consumer Behavior. *The Swedish Journal of Economics*, 75(4), 378. https://doi.org/10.2307/3439147

Becker, G. S., & Stigler, G. J. (1977). De Gustibus Non Est Disputandum. *The American Economic Review*, 67(2), 76–90.

Bryant, C. G. A. (1985). *Positivism in Social Theory and Research*. Macmillan Education UK. https://doi.org/10.1007/978-1-349-17759-2

Carter, Z. D. (2020). *The Price of Peace: Money, Democracy, and the Life of John Maynard Keynes* (1st ed.). Random House.

Cartwright, N. (2007). The vanity of rigour in economics: Theoretical models and Galilean experiments. In *Hunting Causes and Using Them: Approaches in Philosophy and Economics* (1st ed.). Cambridge University Press. https://doi.org/10.1017/CBO9780511618758

Chang, H. (2021). Operationalism. In *The Stanford Encyclopedia of Philosophy*. https://plato.stanford.edu/archives/fall2021/entries/operationalism/

Cohen, J. (1995). Samuelson's operationalist-descriptivist thesis. *Journal of Economic Methodology*, 2(1), 53–78. https://doi.org/10.1080/13501789500000003

Friedman, M. (1966). The Methodology of Positive Economics. In *Essays In Positive Economics* (pp. 3–16). University of Chicago Press.

Frisch, R. (1936). On the Notion of Equilibrium and Disequilibrium. *The Review of Economic Studies*, 3(2), 100. https://doi.org/10.2307/2967500

Hausman, D. M. (1992). *Essays on philosophy and economic methodology*. Cambridge University Press.

Hicks, J. (2001). *Value and capital: An inquiry into some Fundamental Principles of Economic Theory* (2. ed., reprint). Clarendon Press.

Hume, D. (1896). *A Treatise of Human nature* (Vol. 1). Clarendon Press.

Krugman, P. (1998). Two Cheers for Formalism. *The Economic Journal*, 108(451), 1829–1836. https://doi.org/10.1111/1468-0297.00378

Lucas, R. E. (1976). Econometric policy evaluation: A critique. *Carnegie-Rochester Conference Series on Public Policy*, 1, 19–46. https://doi.org/10.1016/S0167-2231(76)80003-6

Miller, D. (1994). *Critical rationalism: A restatement and defence*. Open Court.

Moyer, A. E. (1991). P.WW. Bridgman's operational perspective on physics Part II: Refinements, publication, and reception. *Studies in History and Philosophy of Science Part A*, 22(3), 373–397. https://doi.org/10.1016/0039-3681(91)90001-9

Musgrave, A. (1981). 'Unreal Assumptions' in Economic Theory: The F-Twist Untwisted. *Kyklos*, 34(3), 377–387. https://doi.org/10.1111/j.1467-6435.1981.tb01195.x

Musgrave, A. (1993). *Common sense, science, and scepticism: A historical introduction to the theory of knowledge*. Cambridge University Press.

Nelson, A. (1986). New Individualistic Foundations for Economics. *Noûs*, 20(4), 469–490. https://doi.org/10.2307/2214980

Poincaré, H. (1898). On the Foundations of Geometry. *The Monist*, 9(1), 1–43.

Popper, K. R. (1994). *The Myth of the Framework: In Defence of Science and Rationality* (L. McDonald, Ed.). Routledge. https://www.jstor.org/stable/3341577?origin=crossref

Popper, K. R. (2002). *The Logic of Scientific Discovery*. Routledge.

Rickert, H. (1986). *The Limits of Concept Formation in Natural Science* (G. Oakes, Ed.). Cambridge University Press.

Rodrik, D. (2015). *Economics Rules: The Rights and Wrongs of the Dismal Science*. W. W. Norton & Company.

Rosenberg, A. (1976). *Microeconomics Laws: A Philosophical Analysis.* University of Pittsburg Press.

Rosenberg, A. (1992). *Economics: Mathematical Politics or Science of Diminishing Returns?* The University of Chicago Press.

Russell, B. (1912). *The problems of philosophy*. Barnes & Noble.

Russell, B. (1927). *An Outline of Philosophy* (Issue 10). Routledge.

Samuelson, P. A. (1938). A Note on the Pure Theory of Consumer's Behaviour. *Economica*, 5(17), 61. https://doi.org/10.2307/2548836

Samuelson, P. A. (1947). *Foundations of Economic Analysis*. Harvard University Press.

Samuelson, P. A. (1964). Theory and Realism: A Reply. *The American Economic Review,* 54(5), 736–739.

Schelling, T. (1971). Dynamic Models of Segregation. *Journal of Mathematical Sociology*, 1, 143–186.

Schultz, H. (1938). *Theory and measurement of demand*. University of Chicago Press.

Schumpeter, J. A. (2006). History of Economic Analysis. Routledge.

Seligman, B. B. (1967). On the Question of Operationalism. *The American Economic Review*, 57(1), 146-161.

Sills, D. L., & Merton, R. K. (Eds.). (1991). *International Encyclopedia of The Social Sciences* (Vol. 19). Macmillan Publishing Company.

Simon, H. A. (1976). From substantive to procedural rationality. In *25 Years of Economic Theory* (pp. 65–86). Springer, Boston, MA. https://doi.org/10.1007/978-1-4613-4367-7_6

Solow, R. M. (2005). How did Economics get that way & what way did it get? *Daedalus*, 134(4), 87–100. https://doi.org/10.1162/001152605774431518

Solow, R. M. (2010). Paul A. Samuelson (1915–2009). *Science*, 327(5963), 282–282. https://doi.org/10.1126/science.1186205

Stigler, G. J. (1983). Nobel Lecture: The Process and Progress of Economics. J*ournal of Political Economy*, 91(4), 529–545. https://doi.org/10.1086/261165

Sugden, R. (2000). Credible worlds: The status of theoretical models in economics. *Journal of Economic Methodology*, 7(1), 1–31. https://doi.org/10.1080/135017800362220

Tarski, A. (1944). *The Semantic Conception of Truth: And the Foundations of Semantics*. 4, 341–376.

Appendix

Abstract (English)

The implementation of formal methods into economics is usually understood as solely a methodological position. In this Master's thesis I intend to explore whether a special characterization of genuine scientific knowledge, evident in the works of the economist Paul Anthony Samuelson and philosophers in the early 20th Century, contributed to this methodological shift, and what are the consequences of such to the epistemology of economics.

For that, this thesis reconstructs the epistemological problem of induction and its consequences on the notions of genuine scientific knowledge, followed by the attempts of solving it, according to the classification scheme. Further I show how the implementation of formal methods in economics can be studied as an attempt of solving such epistemic problem. Through a situational reconstruction of Samuelson's models, I find that, in the theory of maximizing behavior, the implementation of the rationality principle is an operational-conventionalist attempt to solve the epistemic conflicts triggered by the Humean problem. This implementation repercusses on the explanatory power of theories, on their technical character and on the possibilities of scientific progress in economics.

Furthermore, this thesis dives into the historical context of these developments, examining how the conventionalist approach, particularly operationalism, became integrated into economic methodology. By analysing Samuelson's contributions, I demonstrate how his work is a prominent symbol of formalism in economics, with a special focus in the development of technical instruments for prediction and attaining [high partial] certainty.

Abstract (German)

Die Implementierung formaler Methoden in den Wirtschaftswissenschaften wird üblicherweise ausschließlich als methodologische Position verstanden. In dieser Masterarbeit beabsichtige ich zu untersuchen, ob eine besondere Charakterisierung von echtem wissenschaftlichem Wissen, die in den Werken des Ökonomen Paul Anthony Samuelson und Philosophen des frühen 20. Jahrhunderts deutlich wird, zu diesem methodologischen Wandel beigetragen hat und welche Folgen dies für die Erkenntnistheorie der Wirtschaftswissenschaften hat.

Zu diesem Zweck rekonstruiert diese Arbeit das erkenntnistheoretische Problem der Induktion und dessen Auswirkungen auf die Vorstellungen von echtem wissenschaftlichem Wissen, gefolgt von den Versuchen, dieses Problem zu lösen, gemäß dem Klassifikationsschema. Weiterhin zeige ich, wie die Implementierung formaler Methoden in der Wirtschaftswissenschaften als ein Versuch betrachtet werden kann, dieses epistemische Problem zu lösen. Durch eine situative Rekonstruktion von Samuelson Modellen finde ich heraus, dass die Implementierung des Rationalitätsprinzips in der Theorie des maximierenden Verhaltens ein operativ-konventionalistischer Versuch ist, die epistemischen Konflikte, die durch das Hume'sche Problem ausgelöst werden, zu lösen. Diese Implementierung hat Auswirkungen auf die Erklärungskraft der Theorien, auf ihren technischen Charakter und auf die Möglichkeiten wissenschaftlichen Fortschritts in der Wirtschaftswissenschaft.

Darüber hinaus taucht diese Arbeit in den historischen Kontext dieser Entwicklungen ein und untersucht, wie der konventionalistische Ansatz, insbesondere der Operationalismus, in die wirtschaftswissenschaftliche Methodologie integriert wurde. Durch die Analyse von Samuelson Beiträgen zeige ich, wie seine Arbeit ein herausragendes Symbol des Formalismus in der Wirtschaftswissenschaft ist, mit einem besonderen Fokus auf die Entwicklung technischer Instrumente zur Vorhersage und zum Erreichen von [hoher teilweiser] Gewissheit.