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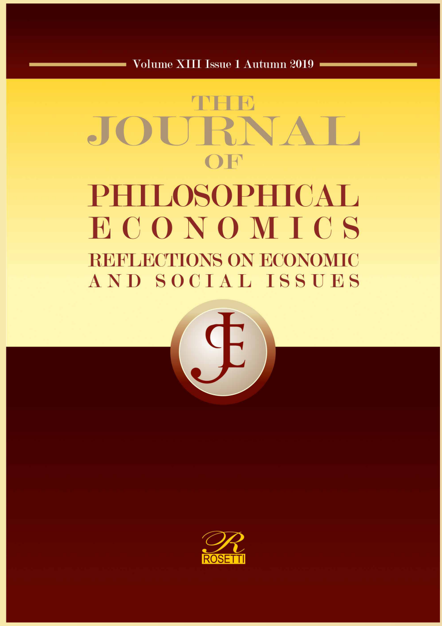

The unrealistic realist philosophy. The ontology of econometrics revisited

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ROSETTI

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Abstract: The argument put forth in this article shows that the hitherto scientific-realist approaches to econometrics are incongruent with the realistically reconstructed empirical macroeconomics. The SR approaches share in common being realist about the relations depicted by (successful) models. The economic models of data are sensitive to minor changes in sample and estimating methods what creates the 'emerging contrary result' phenomenon: the community of econometricians accept models that are inconsistent. Being SR about econometrics equals committing oneself to the following trilemma: (1) it is feasible to indicate the successful models that rightly isolate/idealize the regularities of the economy (the knowledge thesis); (2) econometric models are about the economic world (the independence thesis); and, at least in some areas of application, (3) successful econometric models contradict each other.

Keywords: philosophy of econometrics, contrary results, 'emerging contrary result' phenomenon, ERR phenomenon, instrumentalism, constructivism

Introduction

Considering their target systems, there are two types of models: (1) models of phenomena and (2) statistical models of data (Saatsi 2017; Frigg and Hartmann 2006). Econometrics is an empirical branch of economics that constructs models employing statistical and quantitative methods with the aim of uncovering empirical regularities in the observational, economic data (Tintner 1953). Econometric models are models of data defined as 'a corrected, rectified, regimented, and in many instances idealized version of the data gained from immediate observation, the so-called raw data' (Frigg and Hartmann 2006, pp. 743). Generally speaking, such models are obtained by estimating parameters that minimize the error term ε and choosing the functional form of the following equation:

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$$Y_t = F(X_{i,t}) \quad (1)$$

Y_t – endogenous variable (output)
$X_{i,t}$ – exogenous variables (determinants/inputs)
F(...) – a relation between a set of exogenous variables and endogenous variable

'Scientific realism' is an umbrella term (Leplin 1984, 1) that covers many versions of this stance. This positive approach to science is usually defined as the commitment to the (1) metaphysical/ontological, (2) semantic, and (3) epistemic dimension (Psillos 2005; Mäki 2005). In other words, SR accepts that models (1) describe the discourse-independent reality, (2) are made true or false by how the world is (i.e., true models isolate or idealize certain aspects of reality), and (3) (most successful ones) are (approximately) true. Papineau (1996, 2) defined being a realist about science as accepting the (1) independence thesis and (2) knowledge thesis. The former states that the world is independent of our discourse about it. The latter acknowledges that it is feasible to decide if a model is (at least approximately) right. Saatsi (2017) indicated that what is typical for different versions of realism is the belief that science is, to some degree, successful and grasps something (at least partially) about the world.

In line with Mäki's (2005) argument that various versions of realism are adequate for distinct sciences, the article focuses on analyzing and arguing against the localized version of SR. The realist philosophers interested in econometrics put forth a few slightly differentiated stances grounded in studying most successful (regarding adequacy and acceptance among economists) empirical models. In general, the SR interpretations of econometrics are realist about empirical regularities between variables depicted by models. Such regularities are interpreted either as probabilistic causal laws (Cartwright 1994, pp. 149-150; Hoover 2002) or as functional and correlational relations (Hoover 2010) that idealize or isolate such a relation in the world of economy. In other words, the SR readings of econometrics accept that (1) the empirical models are about the world (the independence thesis) and (2) it is feasible to indicate the successful models that rightly 'resemble' the regularities produced by the world of the economy (the knowledge thesis). Considering that (3) econometric models often contradict each other (cf. Moosa 2019; the case studies discussed below), being realist about econometrics equals to being committed to the trilemma of jointly inconsistent views.

The structure of the article is as follows. First, the scientific realist interpretations of econometrics are reviewed. Second, the following feature of econometrics absent from the hitherto realist interpretation is discussed: econometric models (at least in some areas of application) are shown to depend on minor changes in sample (such as including an additional variable or further observations) or method (e.g., applying weighted or unweighted averaging scheme and linear or exponential regression). Despite being inconsistent, such pairs of contrary models are accepted by the community of econometricians. Third, the hitherto SR interpretations of econometrics are argued to be inconsistent with the realistic reconstruction of the project. The viewpoint inherited from the philosophy of econometrics sketches out the empirical branch of economics as a more unified and more successful than it is. Therefore, the realist approaches seem more plausible than they are indeed. The article concludes by indicating that an instrumentalist and a constructivist framework are descriptively adequate and may be more fruitful in solving epistemological problems.

The hitherto scientific realist approaches to econometrics

In the philosophy of science, scientific realism is an internally differentiated philosophical position (Alai 2017). This philosophy-of-science stance was coined with the aim at explaining the success of science: if the unobservable parts of theories were not at least approximately true (were not referring), then the success of science would be the effect of a miracle (Boyd 1983). In response to the criticism of earlier versions (e.g., the pessimistic meta-induction argument), the contemporary realist stances are selective in their commitment. One of the solutions is to accept only the approximate truth of the theoretical entities of those parts of theories that are responsible for their empirical success (entity realism). Giere (1979) enriched scientific realism with a pragmatist dimension. According to 'doubly local scientific realism', different versions of realism are adequate to various sciences. There is no single concept of realism 'that applies or does not apply to all of mature science, experimental sciences, string theory, and so on' (Mäki 2015, p. 232).

Unfortunately, the project of scientific realism in the philosophy of economics focuses mostly on the models of phenomena (Hardt 2017), and little attention was previously paid to the empirical models of data. Econometrics differs significantly from economics and hence the discussion should focus on a local version of scientific realism coined having in mind this empirical discipline. For example, a distinctive feature of a realist reading of econometrics is that such interpretations should be realist about models of data instead of models of phenomena. Despite the scarcity of attempts, one can find four different versions of the scientific-realist interpretation of econometrics. In general, all of them are common in being realist about the relations between variables: the estimated coefficients of successful econometric models are believed to correspond to empirical regularities.

In addition to the SR approaches, a notable realist stance in the philosophy of economics concerned with econometrics is critical realism (CR henceforth). This stance is excluded from further considerations on the ground of its social-ontology approach that differs from the usual discussions in the philosophy of science and not taking into consideration the actual research practices. First, in opposition to the SR tradition grounded in the observation of the scientific endeavors, the CR philosophy of economics starts from the aprioristic assumption that there are no constant regularities in economics. Second, it lacks descriptive adequacy. For example, in contrary to Lawson's assertion that the project is 'necessarily doomed to failure' (2007, p. 48), the role of empirical models in economics grows (Hamermesh 2013). However, considering that Hoover's SR interpretation of econometrics is a response to the CR criticism of econometrics, Lawson's views are briefly introduced.

The SR approaches to econometrics discussed below are differentiated to some degree. Hoover (2002) employed the 'usual' version of scientific realism according to which the dependencies depicted by models are isolations and idealization of true connections between variables. This approach is argued to be in line with the ideas developed by the project of scientific realism grounded in the studies of theoretical models (e.g., Mäki 2008). Cartwright (1983) strived for interpreting the empirical regularities depicted by econometric models as causal laws: the right-hand side of equations denotes determinants of the endogenous variable. Her position is referred to as 'causal realism'. Considering the implausibility of these approaches, Hoover (2012) modified his earlier position by including a pragmatist dimension and reanalyzed the project of econometric modeling from the position of perspectival realism.

The CR view on econometrics

The CR stance was introduced into the philosophy of economics by Tony Lawson (2007). The two most notable realist philosophies of science in the methodology-of-economics literature are divergent in regard to their approach. While scientific realists use scientific practices to address ontological questions, critical realism assumes *a priori* that there are no constant empirical regularities in the social sciences. Fleetwood (2017, p. 42) characterized this view as follows

> [i]n some natural sciences, an experimental set-up (artificially) creates conditions wherein event regularities, often referred to as 'laws', occur. Outside closed systems, where event regularities do not occur (i.e. in open systems) events are still causally governed by something, and this 'something' is generally believed to be laws [(...). CR is grounded in] rejecting the conception of laws as regularity laws and accepting laws as the powers or tendencies of causal mechanisms. The SCR conception of O&C systems, then, is the foundation stone upon which is built a rejection of positivism, and its replacement with a CR meta-theory rooted in laws as powers or tendencies and capable of dealing with irregularities in the flux of events.

This position is excluded from further analysis for the reasons [1] mentioned above. In line with Roy Bhaskar, Lawson (2007) assumed *a priori* that economics instantiates closed systems where no constant regularities exist (cf. Fleetwood 2017) and formulated epistemic guidance on this ground. The Cambridge-based philosopher explicitly wrote that the empirical branch of econometrics is incongruent with the ontological viewpoint of transcendental realism as set forth by Roy Bhaskar (2013). Lawson's skeptical opinion follows from the viewpoint according to which there are no covering laws in economics in contrary to, for instance, astronomy, which fruitfully generalized empirical regularities into abstract and widely applicable laws: 'outside of astronomy at least, most of the constant event conjunctions which are held to be significant in science, in fact occur only under the restricted conditions of experimental control.' (Lawson 2007, 27) Since econometrics attempts to observe and quantify such empirical regularities instead of setting up an experimental environment, its attempts are doomed to failure. In spite of the critical realist stance on the impossibility of econometrics, it is still practiced and even became more popular during the second half of the twentieth century (Hamermesh 2013). As Kevin Hoover (2002) noted, even though there are doubts about infant baptism expressed by the followers of a few denominations of Christianity, we can see it being done in the Catholic churches. A similar situation is faced by the critical realists. Namely, even though their presupposed ontology blue-pencils the empirical branch of macroeconomics, it still is done at the departments of econometrics and its success (degree of which can be disputed) is observed.

Hoover's (2002) scientific realism

Hoover's (2002) article entitled *Econometrics and reality* is aimed at defending the project of econometrics as useful in depicting economic reality and dismissing criticism voiced by Lawson (2007) and (partially) Cartwright (1983). The argument put forth by Hoover (2002, 162) states that '[e]conometrics is possible and compatible with realism because the argument for realism implies the existence of robust regularities. Econometrics aims to characterize those regularities'. In other words, he disagreed with the critical realist viewpoint according to which there are no constant conjunctions in the social sciences and listed several commonsensical examples such as the existence of rush hours and patterns in electricity usage.

To exemplify the viewpoint according to which econometric models can indeed be successful, Hoover (2002) discussed Pissarides's (1992) model depicting how unemployment influences losing skills by the unemployed. Hoover disagreed with Cartwright's (1994) interpretation discussed below: Pissarides's model cannot be used to build a nomological machine (an experimental setting), but only to run a computer simulation. Hoover (2002) suggested that econometric models stand in the same relation to reality as a toy airplane to Boeing 747. Hence, without mentioning the term, he argued that econometric models do not correspond to reality in an exact way. Instead, they idealize or isolate only essential factors, as Mäki (1996) called the relation between (theoretical) models and their relata in his notable work discussing von Thünen's model called *the isolated state* (2009). The role of isolation and idealization of the economy by econometric models depends on the interpretation of error term . Accepting that econometric models deviate from data because of the influence of excluded factors (in line with the Cowles-Commission approach (Simon 1957) that presupposed the presence of deterministic regularities) leads to accepting the models-as-isolations stance. In contrary, acknowledging that the error term results from the stochastic nature of the regularities found in the economy leads to interpreting econometric models in terms of idealizations [2]. Later, Niiniluoto (2013) labeled such a relation between a model and reality 'essesimilitude', i.e., correspondence to ontic bases or essences of reality. In other words, models correspond only with those crucial aspects of reality that a model focuses on because a perfect map (a model corresponding to the whole world in detail), even if obtainable, would be useless (cf. Van Frassen 2008). Hoover (2002) did not take sides on the question whether estimated regressions should be interpreted as depicting causal or functional relationships between variables but voiced econometricians' belief that a mechanism produces the empirical regularities that are stable in time. Therefore, his stance on ontology is in this respect in line with Nancy Cartwright's views.

Causal realism

In contrary to the above-discussed scientific realist interpretation of the ontology of econometrics, Cartwright (1994, pp. 149-151) explicitly voiced her opinion that the goal of econometrics is to measure causal effects of nomological machines that cannot be isolated in an experimental setting [3]. According to the viewpoint presented in *Nature's Capacities and Their Measurement,* a coefficient estimated by econometricians, for instance, α in the empirical price-demand curve below, should be interpreted in a realist and casual way, as referring to a probabilistic, causal law (cf. Equation 2).

(2) $$q = \alpha p + \varepsilon$$

q – quantity of a good X sold at a price p;
α – estimated coefficient;
p – the price of a good;
ε – error term.

Regarding the law of demand, Cartwright (1994, p. 149) justified her causal-realist interpretation as follows:

> [T]he equation is supposed to represent a causal relationship, and not a mere functional relationship of the kind that Russell thinks typifies physics. Econometrics arises in an economic tradition that assumes that economic theory studies the relations between cause and effects. This assumption is so basic that, in a sense, it goes without mention. Few economists say, 'We are talking about causes'. Rather, this is a background [assumption] that becomes apparent when topics which are more controversial or more original are discussed.

Cartwright's (1994, p. 150) stance according to which 'the random terms reflect the *influences* of erratic causes, which operate in addition to the few systematic ones', is in line with the Cowles Commission interpretation of econometric models as isolations of regularities present in the world. Specifically, Cartwright believes that the economic models of data isolate the relation between cause and effect. First, as I previously mentioned, econometric models are aimed at measuring nomological machines generating observable patterns in the data. Second, estimated coefficients (α in the case of the empirical law of demand) refer to probabilistic, causal laws. For instance, an empirical model of the law of demand represents/resembles the following causal law produced by a nomological machine [4]: $\uparrow p \rightarrow q\downarrow$.

Perspectival realism

Despite the pragmatist orientation, perspectival realism can be considered as a version of scientific realism, especially considering the peculiarities of the philosophy of economics. First, this stance was put forth as a response to the criticism of the scientific-realist philosophy of science (Alai 2017). Second, Mäki's (2011a; 2011b; 2017; 2018) model of modeling [ModRep] evolved and now includes the pragmatic dimension (audience, purpose, etc.). The perspectival-realist stance in the philosophy of econometrics was voiced by Hoover (2012) who became aware of the difficulties of his previous SR approach to econometrics and employed a more liberal stance. He attempted at merging perspectival realism with a pragmatic position in the philosophy of science advocated by Charles Pierce (1958). Nevertheless, this interpretation is also committed to being realist about the relations depicted by econometric models what, similarly to the above-discussed approaches, is shown below to raise a serious obstacle.

Ronald Giere (1979) developed perspectival realism. In short, the theory of scientific perspectivism was coined to offer a framework consistent with the current practice of physicists who employ various and sometimes inconsistent models to address different questions. Giere (1979, 17-40) coined the metaphor of color vision, according to which various scientific models that describe different aspects of the same reality can be compared to producing pictures painted in different colors or, in other words, in various spectra of light. For instance, what humans and bats see looking at a flower differs because bats, in contrary to us, likely possess the ultraviolet vision (Winter et al. 2003). Similarly, one's cup of espresso can be described by quantum mechanics that catches the Brownian motion process or, if one is interested in its heat, the thermodynamic theory can be applied. However, the relatum of both theories is the same cup of coffee, and they are both true despite 'mirroring' different aspects of the same reality in different ways. Hoover (2012) argued that Giere's stance is a form of realism, because it is committed to the ontological dimension of SR: models are about (the same) reality, despite emphasizing different aspects thereof (cf. Alai 2017).

Hoover (2012) employed perspectival realism and argued that various econometric models describe the same reality from various perspectives determined by interests and incentives of a modeler. Hoover (2012, 12) highlighted that Giere's perspective is consistent with Pierce's (1958) pragmatism because both approaches emphasize the pragmatic context of representation. From the perspective of Giere's perspectival realism, the process of modeling depends on the purposes of modelers: 'whether the representation is successful is relative to the purposes of the agent' and instantiated this viewpoint with the case of two similar pictures raised by Pierce (1958, pp. 398). In other words, according to the perspectival-realist interpretation of econometrics, models are true as long as their use is beneficial. Similarly to the views of Mäki (2011a; 2011b; 2017; 2018) which evolved from the standard scientific realism that focused on the issues of relevant resemblance (target R) and now include the pragmatist dimension (purpose P, audience E, commentary C, context X), one can observe that the realist reading of econometrics evolves in a similar direction. As Hoover (2012, 12) put it, even though

> Giere fails to emphasize that there are features of the relationship between a model or theory X and an aspect of the world W that transcends S and P [agent and purposes], [...] it is implicit in his example of color vision, which is explicated through a particular account of the sciences of light and vision that Giere takes as given and independent of any particular S or P.

Despite employing a pragmatically-oriented stance, Hoover's latter (2012) reading of econometrics is committed to being realist about the relations depicted by models. The assumption that the inconsistent models isolate/idealize the same reality underlies Hoover's advice to look for consistency: 'the power that comes from finding a common perspective makes an effort worthwhile. That there is no view from nowhere does not imply that we should give up looking for a higher place to stand' (2012, 232). It is also apparently visible in the following suggestion: '[the] successful perspectival realism needs to make sense of the transcendence of the relationship between model and theory and the aspect of the world it represents, on the one hand, without giving up on the irreducibly perspectival nature of knowledge, on the other' (2012, 230).

In summary, the three scientific realist approaches to econometrics are committed to a version of realism about the relations between variables depicted by models. Next section discusses the feature of econometrics absent from the hitherto philosophical discussions: the dependence of results on the choice of sample, estimation technique, and model specification, while the subsequent section puts forth the argument that the above-discussed scientific realist approaches to the ontology of econometrics are inconsistent with the realistically reconstructed empirical branch of macroeconomics.

The two features of econometrics absent from the philosophy-of-economics literature

The SR analyses of econometrics focused on studying most successful models. Therefore, the project of econometrics is reconstructed in an idealized way and is viewed as a more optimistic and more successful than it is. In contrary to the reconstruction delivered by the philosophers of economics, econometric models are sensitive to small changes in the model specification [5] and method what makes the scientific realist interpretation unrealistic.

Model specification

Sala-I-Martin (1997) [6] was concerned that econometric results lack robustness over models containing different sets of variables. When running four million regressions (as the title of his notable article states), the Catalan economist observed the influence of incorporating new variables on coefficients of other variables. As he ran regressions with different permutations of the variables from a previously collected database containing over 60 variables believed to be potential growth determinants, Sala-I-Martin (1997) discovered that both values and signs of coefficients a_i in the growth regression (Equation 3) changed: '[i]f one starts running regressions combining the various variables, variable x_1 will soon be found significant when the regression includes variables x_2 and x_3, but it becomes nonsignificant when x_4 is included. Since the "true" variables are not known, one is left with the question: what are the variables that are really correlated with growth?' (1997, 178).

(3) $$Y = A + \sum_1^i a_i * X_i + \varepsilon$$

where:
Y – pace the of economic development
A – constant
a_i – estimated coefficients of X_i variables
ε – error term

For instance, the regression consisting of two variables (cf. model M_a) indicates that both exogenous variables are positively correlated with the pace of economic development. However, if a third variable (let it be X_3 to preserve the convention) is added, a sign of a coefficient standing by one of the variables from the first regression changes its sign, so that a_1 is positive (i.e., $\hat{a}_1 > 0$) when the regression was run with two variables (X_1 and X_2) and negative (i.e., $\hat{a}_1 < 0$) when the regression was run with three variables (X_1, X_2 and X_3). It should be noted that the economic theory is often not developed enough to help in choosing the right model specification:

> [t]he problem faced by empirical growth economists is that growth theories are not explicit enough about what variables x_j belong in the 'true' regression. That is, even if it is known that the 'true' model [(…) is given by Equation (3)], one does not know exactly what particular variables x_j should be used (Sala-I-Martin 1997, 178).

The problem results from the phenomenon known as multicollinearity in the econometric literature. Multicollinearity denotes a situation where the 'independent' variables located on the right hand side of equation are correlated (Farrar and Glauber 1967). In such situations, the usual estimation techniques can be biased and/or inefficient, i.e., the results of estimation lack precision. The standard solutions to the problem of multicollinearity are ridge regression, principal components analysis, and the partial least squares (PLS) approach (Maddala and Lahiri 1992, 278ff). Given this and the fact that new econometric techniques are constantly developed, Sala-i-Martins's (1997) the econometric exercise involving simple linear regressions is a toy example. However, similarly to the choice of variables, the multitude of estimation techniques leads to the emergence of inconsistent results (cf. Moosa 2019).

Let me consider the two following models M_a and M_b:

(M_a) $$Y = A + a_1 * X_1 + a_2 * X_2 + \varepsilon$$

(M_b) $$Y = A + a_1 * X_1 + a_2 * X_2 + a_3 * X_3 + \varepsilon$$

For example, let X_1 denote 'schooling', the variable usually included in the growth-determinants regressions. If such a situation happens, then there are no grounds on which choosing one of the two estimates ($\hat{a}_{1a} > 0$; $\hat{a}_{1b} < 0$) of the coefficient $\hat{a}_1$ [7] that resembles the real influence of average length of education on economic growth can be made. One can either adhere to the higher productivity caused by longer education in order to explain and support the regression according to which schooling is positively correlated with growth ($\hat{a}_{1a} > 0$) or employ Plümper and Schneider's (2007) argument according to which raising number of students is an unemployment policy in order to support their regression when $\hat{a}_{1b} < 0$.

Considering that economic theory is not helpful in discriminating between two inconsistent models, one can strive for appraising them from the perspective of the standards of econometric methodology. However, at least in some areas of application, the standards of the econometric community do not deliver ground for discriminating between two inconsistent models [8]. In other words, they are both adequate to data. For example, their determination coefficients (e.g., R^2) and the values of information criteria (e.g., Akaike Information Criterion – AIC) are similar. Moreover, they are equally justified from the perspective of econometric methodology. For instance, the assumptions of the OLS regression are justified; variables are not cointegrated, etc. The observation of econometric modeling at work made by Sala-I-Martin (1997) raises the question about the relation between the two contrary models and the world of economy. Employing the realist commitment about the relation between X_1 and Y shared by all five SR stances considered in section 2 leads to being inconsistent. The question whether a positive change in X_1 correlates to or speeds up economic development (the case of obtaining $\hat{a}_{1a} > 0$) or, on the contrary, slows it down (when the estimated coefficient $\hat{a}_{1b} < 0$) depends on the choice of one of two competing models. Being realist about both models equals to accepting inconsistent results. A variable under consideration (for instance, schooling denoting the length of education) cannot be positively ($\hat{a}_{1a} > 0$) and negatively ($\hat{a}_{1b} < 0$) correlated to economic growth in the same population. One can be realist about either model A or model B, but not both. Nevertheless, both models fulfill the standards of econometric methodology and hence are accepted by the community of econometricians. The presence of models supporting inconsistent hypotheses about relations between variables raises an obstacle for the SR interpretation of the project of econometrics discussed in detail later. Nevertheless, sensitivity to small changes in data is not the only problem faced by econometricians [9]. Arriving at contrary empirical results is also possible due to changes in the employed econometric methods.

Contrary results despite the same data

Arriving at contrary results by different analysts despite having one data set is not the exclusive feature of econometrics. For example, Silberzahn et al. (2017) showed experimentally that various groups of analysts judge differently one data set about soccer players, red cards, and referees. However, the phenomenon of arriving at contrary results can be observed in the more serious areas where mistakes can potentially be lethal. Kopans (2015) recently described how several panels of specialists on breast cancer provided contradictory analyses. In the methodological literature, little attention was devoted to the issue regarding the empirical branch of economics. Goldfarb (1995; 1997) described a phenomenon called 'emerging contrary result' (emerging recalcitrant result, ERR). He coined this term to label the following paradox: econometricians often arrive at contrary conclusions about the same dataset despite a previously-established consensus. It would be perfectly natural if the consensus on, for instance, the influence of public debt on the pace of economic growth changed due to (1) improvements in econometric methodology such as, exemplifying and simplifying, a move from a linear to exponential regression or (2) new data becoming available. According to Goldfarb (1997, 231), the usual and uncontroversial reasons for opinion switches are as follows: 'more different and/or "richer" data, (...) new or different or "fancier" techniques [and] (...) make an exogenous variable endogenous'.

However, the ERR phenomenon is also created by non-meritocratic factors such as: 'publication bias at the journal level, [and] (...) researcher search strategy submission/publication bias', (1997, 231) that promotes obtaining novel results. In these cases, both methods that lead to contrary results are justified and widely accepted. Therefore, indicating the methodologically-justified grounds why an opinion held by econometricians switches (and often turns 180 degrees) is virtually possible. After the 2007-2008 financial crisis, cutting public debt and anti-crisis policy became widely-discussed issues. The profession of empirical macroeconomists experienced a profoundly influential instance of the 'emerging contrary result' phenomenon. The ERR phenomenon emerged in the empirical literature on the 90%-debt threshold hypothesis (Maziarz 2017).

The question when austerity at treasury should be conducted, which the empirical verification of the expansionary fiscal contraction hypothesis is aimed at, was raised because of the popularly held opinion that public debt, above a certain threshold, harms the pace of economic growth. The belief was popular before the Reinhart-Rogoff affair exploded in 2013. The viewpoint was, among other premises, grounded in the famous Reinhart and Rogoff (2010) analysis (RR henceforth) that concluded as follows 'median growth rates for countries with public debt over roughly 90 per cent of GDP are about one percent lower than otherwise' (p. 573). *Growth in a Time of Debt* earned immediate attention from economists and policy-makers worldwide, inspiring austerity in several countries (the United States, the United Kingdom, and Germany are flagship examples) and making Paul Krugman (2013) call the article published by *American Economic Review* 'the most influential economic analysis of the recent years' (p. 3).

Herndon, Ash and Pollin (2014) (HAP henceforth), in their similarly influential article that switched the consensus among economists from pro-austerity moods to a left-wing or interventionist one, indicated the following three 'drawbacks' of the original study: unconventional averaging scheme, spreadsheet error, and unjustified exclusion of several country/year observations from the post-war period. Recently, the controversy was argued to instantiate the ERR phenomenon (Maziarz 2017). A detailed analysis of the methodological issues underlying the Reinhart-Rogoff controversy gives a hint that choosing weighted or unweighted averaging scheme is the most influential of the three 'drawbacks' indicated by HAP. The influence of the spreadsheet error (0,3 pp) is minor and negligible in comparison to the impact of the two differing averaging schemes (1,7 pp). Certainly, committing any, even a hardly influential error should not happen in the case of research of such importance for the evidence-based economic policy. However, the wave of comments published in popular economic press and, to some degree, scholarly journals in 2013 and 2014 seems to be driven by what Gustave Le Bon (2001 [1986]) called the popular mind rather than strict methodological analyses (cf. Rogoff 2015; Maziarz 2017; Hamilton 2017) for the discussion of justification of these two cliometric methods). Considering the ommitable influence of the spreadsheet error, the 'Growth in a Time of Debt' controversy can be simplified to a dispute on which of the two averaging schemes is more justified, which, as Maziarz (2017, p. 10) indicated, is impossible to decide: 'the weight of arguments (to use the Keynesian saying) supporting the cliometric techniques employed by RR and HAP is similar'. Therefore, considering a similar justification of the two methodologies leading to contrary results and the pattern in the literature that suggests that the reason why the contrary results emerged is publication bias at the journal level and researchers' search strategy.

The econometric literature on the 90%-debt hypothesis is rapidly growing. In contrary to the cliometric method of calculating averages, econometricians mined the same dataset constructed by Reinhart and Rogoff (2009) with the more advanced econometric techniques of building empirical models. The results are also divided and inconclusive. Most recent results (e.g., Hukkinen and Viren 2017; Chiu and Chien-Chiang 2017) suggest that the lack of robustness of the research on the threshold hypothesis is caused by the fact that the thresholds in the public debt/economic growth relation are country-specific. According to Goldfarb's (1997) estimate on the basis of studying articles four issues of *American Economic Review*, the emerging contrary result phenomenon might be quite standard (up to one in ten econometric research published by *AER* might instantiate it). My systematic literature review covering the studies published in the three top economic journals (*American Economic Review, Journal of Political Economy,* and *Quarterly Journal of Economics*) between 2005-2015 suggests a lower estimate (5 per cent, cf. Maziarz 2018). However, both studies indicate that the recalcitrant results are a usual feature of econometrics and constitute a serious obstacle for the SR interpretation.

Contrary empirical results and the scientific realist interpretation

Above, the two cases of contrary econometric results were discussed. They likely constitute the most significant obstacle for the SR interpretations of econometrics. In some areas of application of econometrics (e.g., growth econometrics, macroeconometrics, cliometrics), the results are sensitive to small changes in data sets or minor modifications to the estimation methods. The above-discussed cases show that the choice between two contrary models is in some cases impossible. Both inconsistent models are acceptable on the grounds of (1) their adequacy (i.e., two models equally fit the data) (2) econometric methodology (i.e., both model specifications and estimating methods are accepted by the community of econometricians) and (3) economic theory (which is either split or underdeveloped in some areas). In other words, both models are 'successful' according to the standards of econometricians' community. The epistemic commitment of scientific realism is usually defined as a positive attitude towards the successful, current models. The hitherto SR literature about econometrics has in common being realist about the relations between variables depicted by models. Therefore, being realist about two inconsistent models M_a and M_b lead to accepting the following two contradictory statements [10]:

$$M_a\ (\hat{a}_{1a} > 0):\ \uparrow X_1 \xrightarrow[causes]{} \uparrow Y$$

$$M_b\ (\hat{a}_{1b} < 0):\ \uparrow X_1 \xrightarrow[causes]{} \downarrow Y$$

For instance, two such models justify drawing the following hypotheses: 'according to model A, a growing level of public debt promotes economic development' and 'according to model B, a growing level of public debt hampers economic development.' These models, according to the ontological commitment, relate to the same reality of economic facts 'Ω_F (cf. Stigum 2015, pp. 37ff) [11]. Therefore, employing the SR philosophy of econometrics and accepting the law of noncontradiction [12] leads to the conclusion that one of the two models is false about the reality:

$\hat{a}_{1a} \neq \hat{a}_{1b} \Rightarrow \hat{a}_{1a} \dot{\vee} \hat{a}_{1b}$

However, as I argued above, both models supporting recalcitrant hypotheses are right according to the standards of the econometric community. Therefore, being SR about both models leads to accepting the contradiction and undermines the epistemic commitment of scientific realism. Both models M_a and M_b cannot be true about the same world of economics.

Scientific realism about econometrics can be supported by a few counterarguments. On the one hand, a SR philosopher of economics can acknowledge that X_1 and X_3 from the Sala-I-Martin case are causally related. In this case, Y and X_1 can be negatively related even though adding the third variable X_3 changes the sign of the relation between the latter. For instance, let Y denote the probability of suffering from lung cancer, X_1 – smoking and X_3 – physical activity. If there were a common cause that links the level of physical activity and smoking and, additionally, physical activity had a greater influence on health, then adding X_3 would indeed change the sign of a_1. Furthermore, the two models can be argued to resemble two divergent realities out of which $'\Omega_1$ is two-dimensional and $'\Omega_2$ is three-dimensional, but this argument does not defend realism about the cliometric research. On the other hand, a scientific realist can acknowledge that only one of a pair of inconsistent models currently accepted is correct but we are unable to decide today (but, someday in the future, we will).

Concluding remarks

In the philosophy of economics, the hitherto SR literature focuses mostly on models of phenomena, and little attention is paid to econometrics (models of data), even though the empirical methods became more popular in the last three decades (Hamermesh 2012). An important feature of econometrics is absent from the few philosophy-of-economics analyses that focused thereon. Above, it is shown that, on the ground of the empirical macroeconomics, it is possible to obtain two models of data that are inconsistent but are nevertheless acceptable on the ground of (1) empirical adequacy, (2) econometric methodology, and (3) theoretical economics.

The hitherto scientific realist approaches to econometrics are common in being committed to the ontological and epistemic dimensions of scientific realism. First, the relations between variables depicted by econometric models are believed to be about the world of economics $'\Omega_F$ (the independence thesis). Second, these causal (Cartwright 1994; Hoover 2002) or functional/correlational (Hoover 2012) relations postulated by successful models are believed to be (approximately) true (the knowledge thesis). Third, as the realistic reconstruction of econometrics shows, at least in some areas of application, successful econometric models contradict each other. Therefore, scientific realists are committed to accepting the following trilemma:

> (1) It is feasible to indicate the successful models that rightly resemble the regularities of the economy.
> (2) Econometric models are about the economic world.
> (3) At least in some areas of application, successful econometric models contradict each other.

There are a few solutions to the obstacle in the SR interpretation of econometrics raised above. First, the minimal version of scientific realism can be employed. Psillos (2017, 200) limited scientific realism to the ontological commitment (the independence thesis): the declaration of independence states that 'the world is mind-independent'. Mäki (2017), widely known for advocating SR, revised his previous viewpoint (e.g., Mäki (2011a) and his earlier articles) and argued that even false economic models (models of phenomena) can be read out in a realist way if minimal scientific realism is employed. According to the minimal version of SR, models are fallible. However, even if they are wrong about reality, they are realist because they relate to the world (to the economy). In other words, the minimal scientific realism rejects the epistemic commitment of the SR stance. For instance, if α, the estimated coefficient of the demand curve (cf. equation 2 above) does not equal its real value, the model still can be, according to the minimal scientific realism, interpreted in a realist way because it refers (mistakenly) to the regularity known as market demand. This version of realism certainly breaks with the tradition of SR, which was initially established with the aim to explain the success of science. However, considering that the inconsistency of pairs of contrary models breaks Chang's (2017) criterion of reality labeled 'pragmatist coherence', [13] further research on a version of minimal scientific realism adequate to a realistic reconstruction of econometrics is needed.

Second, the SR interpretation of the empirical models can be defended by acknowledging that the referents of models M_a and M_b are different. Finally, the argument put forth above is refuted if one of the pairs of contrary models can be chosen on some ground. A few questions regarding the SR interpretation of econometrics stay open. For instance, in the SR philosophy of economics no analysis addressed the question when two models M_a and M_b resemble the same reality of economic facts 'Ω_F and what differences between M_a and M_b uproot such interpretation.

On the other end of the spectrum of various interpretations of econometrics lie, virtually never voiced, the (1) instrumentalist and (2) constructivist approaches that seem to be supported by a notable majority of practicing econometricians. First, Hoover (2012, 223) voiced the commonsensical viewpoint according to which econometricians are not concerned with ontology. He cited Haavelmo's (1944) notable work and concluded that econometricians 'typically prefer such locus as the model is "approximately correct" or the world behaves "as if" the model is correct'. This interpretation of the empirical branch of macroeconomics is in line with Friedman's (2007 [1953]) seminal essay and Dewey's (1983 [1938]) consequentialism. Second, some econometricians seem to prefer a constructivist approach. For instance, Hendry, Leamer, and Poirier (1990, 197) voiced the opinion according to which 'parameters are useful constructs for helping me understand complexities in the world. They are creations of my own intellect and not real features of the world'. Such interpretation is in line with, for instance, Ludwik Fleck's (1979) constructivist philosophy of science. A constructivist view on econometrics can offer a fruitful framework for further methodological research on econometrics due to their rejection of the ontological dimension and (hence) not being committed to highlighting contradictoriness of the divergent models of the same data.

The phenomenon of emerging contrary results is not a widely known feature of econometrics, and more in-depth analyses thereof are essential. Offering solutions to the question whether it is possible to practice econometrics in a way that would prevent emerging contrary empirical results similar to the Reinhart-Rogoff controversy in the future apparently exceeds the purpose of this article. Nevertheless, a few general remarks resulting from the above considerations can be voiced. First, considering the limited success of replication attempts, [14] journals should introduce demands of giving more explicit methodological descriptions in addition to delivering data. Second, in comparison to other disciplines, economists in general and econometricians in particular rarely attempt to replicate works of their colleagues (Chang and Li 2017) which should change to prevent, for instance, coding errors in policy-relevant research. Third, philosophers of causality recently developed several tools (cf., for instance, Pearl 2000) for inferring causal relations from datasets based on comparing various samples (subpopulations). Instead, econometrics can crudely be said to focus on time-series analyses, what, perhaps, is a misguiding approach. In other words, one of the cures for the current state of econometrics consists in putting more emphasis on analyzing macroeconomics in explicitly causal terms (cf. Hoover 2001; Woodward 2005) and going beyond studies of observational data. Finally, economic policy-makers should be aware of the pitfalls of econometrics and should not ground their decisions in unverified evidence: a higher dose of skepticism in employing empirical results is unavoidable.

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Endnotes

[1] However, reviewing this stance is fruitful for further analysis. For instance, Hoover (2002) formulated his SR stance as a response to Lawson's criticism and argued in favor of the possibility of econometrics.

[2] In order not to take sides on the issue whether econometric models isolate or idealize when the stance under consideration is silent about it, the relation of (partial or approximate) correspondence is labeled 'resemblance' in line with the tradition in the philosophy of economics.

[3] It should be noted that addressing the question whether Cartwright's viewpoint according to which the assumptions underlying the econometric methods can never be met in the social science but only in physics exceeds the scope of this paper. Instead, the emphasis is put on her interpretation of the ontology of econometric models.

[4] According to Cartwright's position, the effects of nomological machines are not always observable in the world of the economy because, for instance, there are usually many various causal mechanisms operating at the same time.

[5] Model specification is usually understood as choosing an appropriate functional form and deciding which variables should be included. Here, for simplicity, by 'model specification' I refer only to the latter because the functional form is constant in the discussed case (i.e., all the four million regressions run by Sala-I-Martin (1997) are linear.

[6] Sala-I-Martin's (1997) notable work is mainly devoted to the problem of averaging coefficients over various regressions obtained by changing model specifications. His method was criticized by Hoover and Perez (2004) who put forth a competing approach. However, because this analysis focuses on the introductory part of Sala-I-Martin's article, where the issue of contrary results is raised, addressing either the methodological justification of the two methods of averaging coefficients or the philosophical presuppositions thereof exceeds the scope of this article.

[7] The 'hat' over *a* denotes that â is an empirical estimate.

[8] The existence of right and inconsistent models is the ground on which the literature on the controversial methods of averaging coefficients over models developed [Hoover and Perez 2004; Mäki 2011a).

[9] Nowadays (i.e., in the last ten to fifteen years, approximately), conducting robustness checks seems to become progressively popular, but, to my best knowledge, there is no quantitative evidence for this observation besides the crude method of Google Scholar searches or looking up the data delivered by Ngram Viewer, according to which the annual number of the 'robustness check' phrase written in the indexed books exploded after 2000.

[10] Here, Cartwright's (1994) and Hoover's (2002) approach to interpreting econometric models in causal terms is employed. However, applying the correlational/functional interpretation does not change the conclusion. In such a case, the contradictory statements would be as follows: 'X_1 is positively correlated with Y_i' and 'X_1 is negatively correlated with Y_i'.

[11] The questions whether two slightly different econometric models resemble the same reality or different aspects thereof was not addressed in the philosophy-

of-economics literature. As long as the case of two models M_a ($Y = F(X_1; X_2)$) and M_b ($Y = F(X_1; X_2; X_3)$) entailing different numbers of variables grounded in Sala-I-Martin analysis can possibly be argued to 'mirror' two divergent economic worlds (i.e., a three-dimensional W_1 and a four-dimensional W_2), empirical models differing only in the aspect of estimation method are intuitively interpreted as having the same relatum.

[12] The law of noncontradiction is one of the three classic laws of logic. It states that *p* and ~*p* cannot both be true. As, for instance, Plato (2016, 7) put it, 'The same thing clearly cannot act or be acted upon the same part or in relation to the same thing at the same time, in contrary ways'.

[13] According to Cheng's version of minimal SR, we can only be realist about the entities that do not contradict each other in the chronological development of science.

[14] For instance, Chang and Li (2017) recently reported that in the case of journal publications requiring data and code replication files, they succeeded only in 33% of undertaken replication attempts without contacting the authors. Therefore, the low rate of success possibly resulted from inappropriate or undetailed descriptions of employed methods.

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