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Econometrics as a tool for validation of economic theories

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Abstract:

Econometric modelling is a central tool in economics, making it possible to link theoretical assumptions to empirical data. It combines statistics, mathematical economics and economic theory to analyse the relationships between variables, evaluate public policies and forecast economic developments. Econometrics plays a dual role: validating existing theories (deductive approach) and identifying new regularities to stimulate the development of new theories (inductive approach). Despite some limitations related to model specification and data uncertainty, it remains essential to guide economic decisions and strengthen theoretical frameworks.

Keywords: Econometrics, Economic Modelling, Theory Validation, Policy Evaluation, Empirical Analysis, Forecasting.

JEL Classification Codes : C01 ; C50 ; C52 ;C53 ;C54.

1 Introduction

Nations and businesses are constantly striving to strengthen their competitiveness in order to ensure the strength and sustainability of their economies in a context marked by increasingly intense global competition. This dynamic has encouraged the emergence of a large amount of scientific research using modern and rigorous approaches, with the aim of informing the formulation of effective economic policies adapted to contemporary realities.

In this context, econometric analysis is a central tool in economic studies. It makes it possible to compare theoretical hypotheses with empirical data, by testing the validity of the observed economic relations. By combining economic theory, mathematical methods and statistical techniques, econometrics provides a structured methodological framework for modelling economic phenomena, estimating model parameters, testing assumptions and anticipating future developments.

Given the growing importance of econometric modelling in the production of economic knowledge, this research aims to analyze its role in the adoption, validation and innovation of economic theories. Thus, the central issue of this study can be formulated as follows:

To what extent does econometric modelling contribute to the adoption and renewal of economic theories?

Objectives of the study:

The main objective of this work is to examine the role of econometric modelling in the analysis and development of economic theories. This involves, more specifically, the following:

- Highlight the contribution of econometrics in the empirical validation of economic theories;
- Analyze the ability of econometric models to explain real economic phenomena;
- Examine the role of econometrics in improving and renewing theoretical frameworks;

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Identify the limitations of econometric modelling in the interpretation of economic relationships

Importance of the study:

The interest of this work lies in highlighting the fundamental role of econometrics as a tool for scientific analysis and decision support. In an economic environment characterized by complexity and uncertainty, econometric modeling makes it possible to move from a purely theoretical approach to empirical analysis based on real data. Econometrics provides a structured methodological framework for modelling economic phenomena, estimating model parameters, testing assumptions and anticipating future developments (Stock & Watson, 2020).

2 Theoretical framework of econometric modeling

The term “econometrics” was first used by the economist Ragnar Frisch, recognized as one of the pioneers of this discipline. However, the origin of econometrics remains subject to debate. Some authors place its birth in the 1930s, while others go back to the work of Cournot in the 19th century, who introduced quantitative analysis to the study of economic phenomena. Moreover, Engel's research, also in the 19th century, marked the history of econometrics through the use of data on household spending to formulate *Engel's famous Law*, according to which the share of income devoted to food decreases as income increases (Abdelkader Mohamed Abdelkader Attia, 2005, p. 03).

Despite these divergences on historical origins, it is widely accepted that econometric modelling finds its legitimacy in its ability to test economic theories and support the development of relevant public policies. It is also an essential tool for decision-makers, allowing them to understand the complex interactions between economic variables and anticipate the consequences of their decisions.

Before addressing the arguments justifying the use of econometrics in the construction and evolution of economic theories, it is necessary to clarify the main scientific concepts that structure this discipline.

Econometrics can be defined as the *measure applied to the economy*, or more simply as the *economic measure*. In more detail, it represents the branch of knowledge devoted to the evaluation of economic relations from real data, with the aim of:

- test the validity of the relationships formulated by economic theory;
- explain certain economic phenomena;
- Shaping public policies.
- predict the evolution of certain economic variables (Abdelkader Hamad Abdelkader Attia, 2005, p. 04).

3 The relationship between econometrics and other disciplines

Econometrics was born from the convergence of three scientific branches: **statistics**, **economic theory** and **mathematical economics**.

- **Statistics provides** the tools and methods necessary for the measurement and analysis of real data, such as correlation analysis, regression, and information organization and processing techniques.
- **Economic theory** identifies the economic relationships to be studied and formulates explanatory assumptions about the behaviour of variables.
- **Mathematical economics** makes it possible to translate these relationships into mathematical equations that can be estimated and analyzed quantitatively.

However, econometrics is not limited to a simple combination of these disciplines. It has an autonomous status, as a distinct discipline, with its own methods and objectives, aimed at the quantitative analysis and empirical validation of economic relations.

4 Reasons for using econometric models

In any economy, there are institutions responsible for the design and implementation of macroeconomic policy, usually represented by the public authority. These economic policy makers are tasked with developing strategies to influence certain economic variables through economic policy instruments.

However, not all economic variables can be adjusted simultaneously, which complicates the task of decision-makers. Their responsibility is to choose often conflicting economic objectives and then select the most appropriate instruments to achieve those objectives (Ben Zarour Choukri, 2013, p. 97).

These challenges largely explain the use of econometric models, which offer tools to:

- Test the validity of economic assumptions under real conditions.
- Quantify the effects of economic policies on different variables.
- Predict future behaviour of economic variables based on different scenarios.
- Assist policymakers in selecting the most effective instruments to achieve their macroeconomic objectives.

The development of economic policies is a complex process that requires a precise identification of its different stages. It can be understood as a tension between the current situation, often unbalanced or below the desired level of equilibrium, and the desired future situation, characterized by a balanced state or a higher level of performance. In this context, the first step is to use economic forecasting to anticipate future developments.

Forecasting becomes all the more delicate as the time horizon extends beyond a year, as the effects of economic policy measures usually take some time to fully materialize. Thus, effective management of economic policies relies on rigorous anticipation, taking into account all the interconnected economic variables and the complex relationships that unite them.

It is also essential to avoid a common mistake among some decision-makers, which consists in basing their actions solely on the current state of the economy, thinking to directly influence the current situation. In reality, the measures adopted mainly affect the future situation, which almost always differs from current conditions.

Sources of complexity in the formulation of economic policies

4.2 Disagreement on mechanisms of influence

Part of the complexity lies in the lack of clarity regarding the functioning of many macroeconomic mechanisms. Some relationships between variables remain poorly defined, and there is notable disagreement among economists on key issues, such as currency neutrality. Moreover, discrepancies remain as to the effectiveness or practical validity of mechanisms whose influence is theoretically recognized.

4.3 Uncertainty

Uncertainty is a major obstacle to the development of sound economic policies. It arises both from the unpredictability of exogenous shocks (such as international price changes or financial crises) and from the limitations inherent in the economic models used for forecasting. Faced with this uncertainty, it is necessary for decision-makers to rely on sophisticated econometric models, capable of simulating different scenarios and providing indications as to the likely effectiveness of the measures envisaged.

5 The scientific methodology of econometric modelling

All research in econometrics is structured around four main stages, summarized as follows:

❖ Model specification

The specification of the model consists of translating the economic relations studied into mathematical form, in order to allow the estimation of their parameters using appropriate econometric methods. This step includes several essential elements: the identification of

variables, the definition of the mathematical form of the model as well as the formulation of a priori hypotheses.

❖ of the model's variables

The researcher determines the variables to be included in the model based on several sources: economic theory, the results of previous econometric studies, as well as available information on the phenomenon studied.

❖ Definition of the mathematical form of the model

The mathematical form of the model refers to the number of equations that compose it (a single equation or several), its degree of linearity (linear or non-linear model) as well as the degree of homogeneity of the equations (homogeneous or not).

Poor specification of the mathematical form can lead to significant errors in the measurement and interpretation of the studied relationships. Indeed, the results obtained largely depend on the formulation chosen by the researcher to represent the economic phenomenon.

❖ TimeSeries

The analysis of a time series makes it possible to distinguish several fundamental movements:

- **The Trend Component:** It expresses the long-term evolution of the economic variable (positive or negative slope). It reflects the general orientation of the phenomenon studied over time.
- **The Seasonal Component:** These are external influences that are repeated regularly on the time series. It is sometimes called the periodic component. It is the easiest to identify because its periodicity (monthly, quarterly) is known. The forecast here is based on the seasonal index rather than the precise moment of occurrence.
- **The Component of Economic Cycles:** It reflects long-term fluctuations in the time series, highlighting the impact of economic cycles (prosperity, recession, depression, then recovery). These are external factors that act cyclically but not necessarily uniformly.
- **The Random (or Residual) Component:** It represents irregular and unpredictable fluctuations. This component oscillates around a relatively stable arithmetic mean during the study period. It becomes predominant when the series is stable and its forecasts tend towards its average.

6 Choosing an Appropriate Estimation Method

There are several econometric methods for measuring the relationships between economic variables. The main ones are:

6.2 The Ordinary Least Squares (OLS) method

The Ordinary Least Squares (OLS) method is the most widely used estimation technique in econometrics (Gujarati & Porter, 2009; Wooldridge, 2013; Stock & Watson, 2020). Is written:

$$\hat{Y}_i = \hat{\beta}_0 + \hat{\beta}_1 X_i$$

When the model has more than two variables, the parameters are estimated by minimizing the sum of the squares of the residuals (SCR):

$$\text{Min} \sum_{i=1}^n e_i^2 = \text{Min} \sum_{i=1}^n (Y_i - \beta_0 - \beta_1 X_i)^2$$

To minimize this function with respect to the parameter vector β , we proceed to the derivation of the function:

$$\begin{cases} \hat{\beta}_1 = \frac{\sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y})}{\sum_{i=1}^n (X_i - \bar{X})^2} = \frac{\sum_{i=1}^n X_i Y_i - n\bar{X}\bar{Y}}{\sum_{i=1}^n X_i^2 - n\bar{X}^2} \\ \hat{\beta}_0 = \bar{Y} - \hat{\beta}_1 \bar{X} \end{cases}$$

By cancelling the partial derivative with respect to

$$\begin{aligned} S &= (Y - X\beta)'(Y - X\beta) = Y'Y - Y'X\beta - \beta'X'Y + \beta'X'X\beta. \\ S &= Y'Y - 2\beta'X'Y + \beta'X'X\beta \\ \frac{\partial S}{\partial \beta} &= -2X'Y + 2X'\hat{\beta} = 0 \end{aligned}$$

This allows us to obtain the MCO estimator:

$$\hat{\beta} = (X'X)^{-1}X'Y$$

6.3 Cointegration and the Error Correction Model (ECM)

The co-integration analysis technique emerged in the 1980s, mainly thanks to the work of **Granger (1983)** and **Engle and Granger (1987)**. It aims to identify the real equilibrium relationship between the variables over the long term.

Unlike traditional statistical models, the concept of cointegration is based on the idea that, although two time series may be non-stationary individually, they can evolve together so that a stable and fixed relationship exists between them over the long term. This relationship is called a **cointegration relationship**.

A. The co-integration test by the method of Engle and Granger

The procedure consists of several phases:

- Estimation of the long-term relationship between the variables using the Ordinary Least Squares (OLS) method: $Y_t = a + b X_t + \xi$ Here we use the level variables (undifferentiated) to obtain the estimated residues
- The stationarity of the residues obtained is tested. If they are stationary (in level), this confirms the existence of a long-term equilibrium relationship. In this case, it is possible to proceed to the estimation of an **Error Correction Model (ECM)**. Conversely, if the residuals are not stationary, no long-term relationship is validated, and the error-correction model cannot be applied.

6.4 ARDL model estimation and cointegration test

To determine and analyse the determinants, we use the ARDL (Autoregressive Distributed Lag) model. This dynamic model is particularly suitable for simultaneously capturing:

- Short-term effects on the dependent variable.
- Long-term effects, taking into account delays in explanatory variables.

- The combination of stationary and non-stationary data (I (0) or I (1)) in the same estimate.

6.4.1 General structure of the ARDL model

The ARDL model combines two essential components:

1. Autoregressive component (AR): The endogenous variable Y_t depends on its own past values:

$$Y_t = a_0 + \sum_{i=1}^p a_i Y_{t-i} + \varepsilon_t$$

The dependent variable Y_t is also explained by exogenous variables X_t and their delayed values:

$$Y_t = \beta + \sum_{j=0}^q b_j X_{t-j} + z_t$$

The combined form of the ARDL model is therefore:

$$Y_t = \phi + \sum_{i=1}^p a_i Y_{t-i} + \sum_{j=0}^q b_j X_{t-j} + e_t$$

where:

- Dependent variable
- Explanatory variables
- P and q: number of delays selected for Y and X respectively.

6.4.2 The distinction between short-term and medium and long-term

- Short-term effect: the immediate coefficients of the explanatory variables represent the direct and immediate impact on Y_t

Long-term effect: calculated from delayed coefficients as follows:

$$\lambda = \frac{\sum_{j=0}^q b_j}{1 - \sum_{i=1}^p a_i}$$

This formula provides the long-term multiplier, representing the cumulative effect of a permanent change in an explanatory variable on the dependent variable

7 Model Diagnostic Tests

To ensure the reliability of the estimates obtained, especially with the **ARDL** model, it is imperative to subject the results to a rigorous set of statistical tests. These tests make it possible to ensure that the model does not suffer from specification bias and that its residues comply with the Gauss-Markov assumptions.

A.Diagnostic Tests (Residue Quality)

- **Error autocorrelation test (Breusch-Godfrey LM Test):** This test is crucial to verify residue independence. An autocorrelation of the errors would make the significance

tests (Student's t -test) invalid.

- **Heteroscedasticity test (ARCH Test):** It makes it possible to check the constancy of the variance of the errors. In economic time series, the presence of ARCH effects can bias the effectiveness of estimators.
- **Normality test (Jarque-Bera):** This test verifies whether the residues follow a normal law, a necessary condition for the validity of hypothesis tests in small samples.

B. Structural Stability Testing

The stability of the coefficients is fundamental, especially in a context of economic transition or exogenous shocks. We typically use tests based on recursive residuals:

- **CUSUM (Cumulative Sum of Recursive Residuals) test:** Detects systematic parameter drift. If the CUSUM curve remains within the confidence interval (usually 5%), the model is considered stable.
- **CUSUMSQ (CUSUM of Squares) test:** Complementary to the first, it is more sensitive to sudden and sudden breaks in the variance of errors.

8 Evaluation of the estimation model

The evaluation of the estimation model is an essential step to verify the statistical and economic validity of the model, through a set of indicators and criteria.

- **Model Quality Testing**

This step consists of assessing the quality of the model by examining the accuracy of the estimates as well as the significance of the estimated parameters. It is also based on the use of several statistical tests to assess the adequacy of the model to the data used.

In this context, the model coefficients are analyzed in terms of sign, magnitude and compliance with theoretical expectations, in addition to testing their statistical significance. The overall quality of the adjustment is also assessed using the coefficient of determination (R^2) and Fisher's test (F), as well as other tests to detect possible econometric problems, such as error autocorrelation or heteroscedasticity.

9 Econometric modelling and its role in the development of economic theory

Economic theory relies heavily on the deductive method to reach its conclusions. This method begins with simplified assumptions made by the researcher in order to schematize reality, from which logical and generalizable conclusions are drawn about the behaviour of economic variables.

Some approaches consider econometrics to be subordinate to theory: measurement can only be done on the basis of a pre-existing theory. In this context, econometrics plays an empirical validation role: it makes it possible to confirm or refute theoretical assumptions, to assess the relevance of existing models and to guide the development of economic policies. According to this vision, "there is no measurement without theory".

Conversely, econometrics can also adopt an inductive approach, called "measurement without theory". In this context, the researcher begins by observing the real data, without prior strict theoretical assumptions, and uses econometric methods to identify significant regularities or relationships between variables. this approach

- to reveal new economic relationships that had not been theorized;
- to propose explanatory hypotheses based directly on empirical data;
- stimulate the development of new theories or modify existing theoretical frameworks based on empirical evidence.

Thus, econometrics plays a dual role in the construction and renewal of economic knowledge: it is both a tool for validating theory (deductive approach) and an instrument for discovering and

formulating new theories (inductive approach). This methodological flexibility gives econometrics a central status in modern economic research, allowing it to reconcile scientific rigor and empirical relevance.

10 Conclusion

Econometric modelling is an essential pillar of contemporary economic research. It not only makes it possible to compare theoretical hypotheses with empirical data, but also to strengthen the relevance of economic policies through a rigorous analysis of the relationships between variables. By combining statistical tools, mathematical models and economic theory, econometrics offers a structured and flexible methodological framework, capable of analyzing both short-term phenomena and long-term trends.

This work highlighted the central role of econometrics in the empirical validation of economic theories, while highlighting its ability to generate new knowledge from real data. It makes it possible to identify significant relationships, assess the effects of public policies and anticipate future economic developments, thus offering decision-makers reliable instruments to guide their choices.

On the other hand, econometric modelling is not free of limitations. Model specification choices, uncertainties related to exogenous shocks, and the complexity of economic interactions can affect the quality and interpretation of results. Nevertheless, by combining theoretical rigor and empirical observations, econometrics promotes the development of solid and adaptable economic knowledge, capable of adjusting to changing realities and continuously enriching existing theoretical frameworks.

Ultimately, econometrics plays a dual role: it is both a tool for validating and consolidating economic theory and an instrument for innovation and the renewal of knowledge. Its rigorous use thus contributes to bringing economic science closer to empirical reality, while providing a reliable basis for the development of informed and effective economic policies. Bibliography List.

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