9. THE CONTRIBUTION OF ECONOMETRICS TO THE MANAGEMENT OF THE ENTERPRISE

Régis BOURBONNAIS[1]
Mara Magda MAFTEI[2]

Abstract

Econometrics has strongly evolved in recent years on both methodological level and in terms of applications. This article presents different econometric methods (time series econometrics, information panels, models of duration) and their applications to companies: demand analysis and forecasting of sales, financial econometrics, marketing and integration of macro-econometric forecasts in the general policy of the company. The generalization of the computer tool has contributed greatly to the spread of econometric techniques applied to the company.

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By assigning jointly, in 2003, the Nobel Prize in economics to the American Robert F. Engle and to the British Clive W. J. Granger, the Swedish Academy of Sciences took the decision to reward two economists whose work on econometric time series methods contributed to improve the reliability of economic and financial forecasts. The Academy wrote in a press release: "*this year's laureates developed in the 1980s new statistical methods applied to two properties of many time series: seasonal volatility and the non-stationarity*".

Specifically, it was the *dynamic* volatility that helped Robert F. Engle earned his price, in order to designate fluctuations likely to vary strongly in time. He highlighted the concept of error ARCH model (autoregressive model to conditional heteroskedasticity) as particularly suited to the study of the volatility of the prices of assets in the financial markets, characterized by calm periods and low amplitude followed by agitated episodes and significant changes.

At the same time, the distinction awarded to the British Clive Granger came at top of his work on the methods of economic time analyses with a common trend: co-

[1] LEDa, University Paris-Dauphine, France, regis.bourbonnais@dauphine.fr
[2] Academy of Economic Studies, Bucharest, mmmaftei@yahoo.com

integration. C.W.J Granger has shown that non-stationary data with conventional methods of stationary time series analysis can give spurious regressions and, therefore, erroneous conclusions.

By rewarding these two economists, the Swedish Royal Academy of Sciences stressed the growing importance of statistical analysis for the modeling of economic phenomena, but also as indispensable instrument of analysis and forecast improvement in an economic environment increasingly uncertain.

Let us go back almost thirty-five years, to 1969, the date of the creation of the Nobel Prize in economics. The first Nobel Prize in economics was awarded to two econometricians, R. A. Frisch and J. Tinbergen, the former for his work on the estimation problems connected to multi-collinearity, the latter for having built and considered a model of the Dutch economy. It is symbolic that this first recognition and official distinction in economics rewarded a domain rendered somehow marginal and sometimes despised by certain economists: econometrics. How much has this discipline evolved in thirty-five years! We can think that it is the area of economics that has progressed most during this period and whose dissemination (and, therefore, usage) has been mostly marked in business.

After decades spent in research laboratories, econometrics is now part of the essential decisional tools used in public or private companies and to the aid of governments.

We are dealing here with econometrics in a broad sense, that is to say with all econometric techniques (time series econometrics, information panels, models of duration, etc.) and with the methods of time series analysis.

1. The development of econometrics is closely related to that of computer science

If theoretical econometrics of statistical estimation has benefited from continuous and sustained increase over the last fifty years, the empirical econometric work quickly clashed with computational problems. In the 1950s, with the advent of computers it was possible to make estimations of the first econometric models, but until the 1980s this work remained confined to research centers or major administrations, because it was not also necessary to have a computer, but also computer processing programs. Thus, out of this information, J. Longley designed in 1967 a universal set of data to test the first computer programs.

However, those times are gone, and software for econometric analysis has entered the house of each of us since the existence of Excel, whose analysis tools allow to estimate from simple models (least squares minimization) to extremely powerful statistical treatment of SAS software, passing to software more focused on econometrics such as RATS or Eviews.

The consequences are very important for the evolution of econometrics:

- Researchers can easily access databases, treatment programs, etc. This greatly facilitates the applied research.
- For a long time, econometric models only stylized macroeconomic facts, now the microeconomic analysis is the object of econometric estimation.

- The trivialization of the use of spreadsheet is that any user of a micro-computer has, de facto, the possibility of his own econometric analysis, but also the dangers that this has with respect to wrong interpretations and to the consequences that may result.

The advent of the micro-computer and office tools is that all companies may have access today to such instrument of analysis. We shall see that the fields of application are many and various. We do not pretend to be exhaustive, but simply wish to provide an overview of the usefulness of econometrics in business.

2. All corporate functions are affected

If we identify the functions of an enterprise, likely to appeal to econometric methods, we would be surprised to see, as shown in Table 1, that no function represents an exception.

Table 1

Functions affected by the application of econometric methods

Function	Application	Methods
Commercial management	Sales forecasting Setting targets Design of sale forces	Analysis of time series Calculation of elasticity
Logistics and production management	Prediction of orders Analysis of reliability of production	Analysis of time series Modeling in Cup
Marketing	Analysis of the application Sales forecasting Life cycle of the product Analysis of customer Optimization of the marketing plan	Analysis of time series Panel data model Model of curve of life Data mining Calculation of elasticity
Finance and management control	Risk of supplier failure Analysis of markets Budget forecast Cash forecasting	Scoring Analysis of time series Estimation of cost functions
Plan	Forecasting and strategic planning	Macroeconomic modeling

Source: Authors.

This table provides an overview of the most classic applications.

We shall analyze more precisely four very different areas of the application of econometrics to the company:

- Analysis of demand and sales forecasting,
- Financial econometrics,
- Marketing and the fine knowledge of client using Data Mining,
- The integration of macroeconometric forecasts in the general policy of the company.

3. Area of significance: Demand analysis and forecasting[3]

The analysis of demand is a major concern for businesses. We shall discuss here the tools to quantify the determinants of demand: evolution of markets, prices and advertising-promotional investment.

3.1. Modeling the application through the evolution of markets

The forecast covers a set of methods whose objectives are to reduce the uncertainty associated with the non-knowledge of future. For the enterprise, the issue is important even if its capacity for voluntary action is strong, because it cannot escape from the outer evolution of its environment. The decision is delicate, because it may be costly if the forecasts on which it is based are set aside. We deduce, therefore, that some companies spend significant efforts to develop forecasts.

Causal models or explanatory models seek to explain the fluctuations of the series of sales by reference to representative external explanatory factors of the marketing of the company or of demand.

- **The logic of "upstream"**

Take the example of industrial goods, the industrial circuit that transmits changes to the final demand (consumption of households and enterprises). These variations of the final demand are transmitted through transformers to the stage of the manufacturer of intermediate industrial goods.

This upstream logic has two consequences:

- demand for steel, in our example, depends on changes in the various components of final car demand and household equipment.
- the effect is shifted over time, taking into account the existence of many intermediate stages, from the intermediate industrial goods to the product intended for final consumption. The delay is very important, because they may be stocks to finished products, but also stocks to materials (in the broad sense) at each stage of manufacture. From a significant variation in the demand for passenger cars to an impact on the demand for steel it passes several months: the modeling of this process in order to develop forecasts represents even the object of the model of advanced indicators.

- **The model of advanced indicators**

The use of the leading *indicators* for the purpose of forecasting is relatively conventional. The warning signals about the evolution of final demand crosses the entire industrial circuit; thus, steel orders will depend on the stock traders, on the production of certain goods, etc.

The goal is to try to highlight the mechanisms that govern this evolution. Thus, we will characterize the links between these different variables, in brief, in the form of a

[3] See Bourbonnais R., Usunier J.C., 2007.

lagged model[4]:

$$y_t = f(x_{1;t-\theta 1}, x_{2;t-\theta 2}, x_{3;t-\theta 3}, \ldots)$$

where: θ_I represents the lag between each of the variables $x_{i,t}$ (economic indicators) and the series y_t (sales or market).

$$y_t = a_1 x_{1;t-\theta 1} + a_2 x_{2;t-\theta 2} + a_3 x_{3;t-\theta 3} + \ldots + a_k x_{k\,;\,t-\theta k} + a_0$$

- **The explanatory factors**

In the industrial field, a large number of indicators are available:

- production indices of the sector of final consumers,
- price indices,
- interest rates,
- stock market evolutions,
- surveys, planned production, at the level of envisaged production, demand or inventories, which are available at a very fine level,
- statistics on the level of employment,
- failures of companies, bankruptcy and cash shortage,
- credit data: interest rates, statistics of debt in the short, medium and long term by different branches of activity,
- the turnover statistics of the various forms of trade,
- the building statistics: the rent acceptance, started buildings, finished buildings, etc.
- inventories by specialized distributors, etc.

Many companies are modeling, by econometric methods, their markets and develop forecasts that are closely linked to demand. These forecasting methods allow predicting the reversal of the situation, which is impossible by conventional techniques of extrapolation.

3.2. The size of price

The price is a determining element of demand and, therefore, of any marketing policy of a company; knowing its impact on sales with the greater possible precision is, therefore, a constant interrogation. The econometric estimates of price elasticity coefficients meet this concern.

A coefficient of elasticity is used to measure the growth of a variable (sales) as from changes in other variables[5] (price, promotion, advertising, the number of commercials, etc.). The interest is clear; it allows the forecaster to understand the impact of the variation of a marketing sales variable.

[4] This temporal shift model is also used in the field of sustainable consumer products or of consumer taking into account the advertisement-promotional variables whose effect is not instantaneous.

[5] The coefficient of elasticity of sales price is a relative change report and, therefore, has no unit; it is very easily interpreted. For example, if the estimate of this coefficient is e = - 0.85 it means that if the price increases by 5%, then the sales decrease by $-0.85 \times 5 = -4.25$, namely by 4.25%.

The issue is framed, for example, as follows:

- If the advertising budget increases by 12%, by how much are the sales increasing?
- If the number of health visitors increases from 85 to 95, how much will the medical prescription increase? etc.

The answer to such questions allows evaluating the profitability of the investment.

Estimation of the elasticity method is based on the simple and multiple regression models and, therefore, easily implemented on spreadsheet. The variables are previously transformed by the application of logarithms and since the elasticity coefficient is a ratio of logarithmic derivative, the regression coefficient (s) is interpreted directly as the (of course valid within a local interval) elasticity coefficient (s).

Table 2 presents some examples of calculation of elasticity.

Table 2

Example of the calculation of elasticity coefficients

VARIABLE A EXPLAIN (in Log)	VARIABLE EXPLANATORY (in Log)	TYPE OF ELASTICITY
Sales	Price	Price Direct
Sales	Advertising	Direct advertising
Sales	Price competitor	Price cross
Sales	Advertising competitor	Advertising crossroads
Market share	Price index	Price Direct
Market share	Competitor price index	Price cross
Market share	Share advertising	Direct advertising
Market share	Share advertising competitor	Advertising crossroads

Source: Authors.

3.3. Assessment of the effectiveness of promotional action models

The consumer represents the main interest for the theory and the practice of marketing. The purpose of the product manager is to maintain and increase the market share. The means of observation (panels, market research, etc.) are important and, more than in any other field, a good comprehension of what is happening in the market, both at the level of consumer, distribution channels, and competitors is important.

We can cite the example of econometric models (Gupta, 1988) that allow analyzing the impact of sales promotion on three consumer decisions: When? What? How to buy? It combines two models: one to represent the temporal purchase decisions, a multinomial Logit of brand choice model, and a cumulative Logit model for the quantities purchased. The empirical results allow to highlight the essential role of sales promotion in changing of brands by consumers: for example, 84% of sales increases related to promotion are due to mark changes, however, the acceleration of sales over time (advance purchases) accounts for only 14% of additional sales and for less than 2%, which is a negligible amount, and are due to the constitution of stocks by the consumer as a result of promotional offers.

Different models are used to predict the effectiveness of promotional actions (Volle, 1994), some promotions are directed to the type of consumer, and however, others are designed to predict the influence of distributor promotions. Type consumer models rely on promotions by distribution of coupons and the purpose is to estimate additional sales determined by these operations, whose effectiveness is related to the fact that the client actually presents coupon (redemption rate) to obtain a reduction. The explanatory models of redemption rates are estimated by multiple regressions on a set of possible explanatory variables: the face value of the coupon, the percentage of reduction in the price of the product, the different types of hardware support of the coupon, the product itself-same, etc. The coefficients of the regression model estimated on instant coupons of promotional operations allow predicting the effects of a promotion, in terms of rate of redemption, based on the particular characteristics of a transaction of *couponing*.

From these different examples, we see that the demand for business analysis and resulting forecast could now not ignore econometric the tools.

4. A developing domain: Financial econometrics[6]

For a decade we are witnessing an accelerated development of financial markets regarding the geographic perimeters due to the globalization of markets and financial products (options, bonds, derivatives, etc.). In conjunction with this development, the need for analysis instrument was felt by all the actors of the market. We present here two tools which are part now of the standards of the financial product analysis packages:

- the determination and the associated risk of a portfolio,
- the analysis of financial time series.

4.1. The market model

Financial market developments helped analysts to build econometric tools to understand better and, therefore, to anticipate the evolution of financial markets (equities, derivatives, etc.).

In the 1950s, Harry Markowitz has made an essential contribution to the financial modern theory by proposing a portfolio theory. According to him, the decision maker determines optimal portfolios by arbitrage between the average performance (expectancy) and its variance (measure of risk). The implementation of Markowitz approach proved extremely tedious: it indeed asks for the estimate of the covariance matrix of all financial assets, or the calculation of N^2 co-variances if N is active (1,000,000 of co-variances for 1,000 assets!). Thus, Sharpe (1963) proposed the introduction of a reference economic index: in general, the market portfolio to which the co-variances are calculated or only as many co-variances as assets. This choice of the portfolio theory determined especially the risk premium of financial assets.

[6] See Bourbonnais R. Terraza M., 2010.

According to the equilibrium model of financial assets (*CAPM - Capital Asset Pricing Model*), the performance of each action *i* at the time *t* is written:

$$R_{i,t} = \alpha_i + \beta_i \, RM_t + \varepsilon_{it}$$

with:

$R_{i,t}$ = efficiency of the action *i* for the period *t*,

RM_t = efficiency of the portfolio of market (index CAC40 for example the France) for the period *t*,

α_i, β_i = model coefficients,

ε_{it} = specification error.

The interpretation of the coefficient β_i (conventionally called the "Beta" or coefficient of volatility or Sharpe) is very interesting. This coefficient measures the volatility of the assets profitability, *i*.

- If β_i>1, it means that a variation in the average profitability of the portfolio is amplified by the assets *i* . The assets are considered as being "aggressive."
- In a symmetrical manner, if β_i< 1, a variation in the average profitability of the portfolio will be mitigated by the detention of the assets *i*. The assets *i* will then described as "defensive".
- If β_i=1, the average profitability of the portfolio and the asset changes are identical.

The coefficient β_i, therefore, measures the risk of detention of the assets *i*. Specifically, it measures the contribution of assets *i* to the risk of portfolio. Therefore, consider *a* meaning of Markowitz efficient portfolio. The calculation of coefficient β_i*i* for each asset will allow to evaluate and prioritize the risks of each of the assets *i*. The coefficient α_i represents the profitability obtained from the assets if the profitability of the market was zero.

The procedure is relatively simple. Indeed, knowing the composition of the portfolio, the coefficients α_i and β_i are estimated by the application of a square method.

4.2 Analysis of financial time series

The recent work on time series analysis methods are interested in the financial series with two characteristics: high volatilities and long memories.

- **Taking into account the volatility**

The study of financial time series faced two types of problems:

- non-stationarity of the series.
- the leptokurtic character[7] of the data distribution.

The classical prediction models based on ARMA models assume time series with constant variance (the hypothesis of homoskedasticity). This modeling neglects, eventually, the information contained in the residual factor of the time series.

[7] The probability is thicker and abnormal values are, therefore, more frequent.

The ARCH model (the *autoregressive heteroskedasticity conditional*) allow to model time series (mostly financial[8]) that have a volatility (or variance or variability) which depends on time. Thus, it is possible to develop a dynamic prediction of the time series in terms of average and variance.

Originally presented by Engle (1982), these models have been developed in very important applications during the following decades. We can cite the various classes of ARCH, GARCH (*Generalized Autoregressive Heteroskedasticity conditional*) and ARCH-M models (*Autoregressive Heteroskedasticity- Mean conditional*).

The model remains correct on its path – in average - because the conditional expectation is always zero.

The interest of this formulation is the interdependence of an endogenous variable in the model. For Engle, this concept is very important in finance, because the risk of failure is not the same depending on *t:* there are alternating periods of calm and periods of euphoria. This model is very interesting for players speculating on the financial markets.

- **Modeling long memory processes**

The traditional process of ARMA or ARCH types are short memory processes in the sense that the effect of a shock at a given time is not sustainable and, therefore, it does not affect the future development of the time series. The processes with infinite memory, such as the *DS* process (Difference Stationary, stationary in differences) have an opposite behavior: the effect of the shock is permanent and affects the whole future values of the time series. This dichotomy is insufficient to account for phenomena on long term.

Long memory processes, but not infinite, are an intermediate case in the sense that the effect of a shock has lasting consequences for the future values of the series - but these may find their natural equilibrium level. This type of behavior has been formalized as fractional Brownian motion and fractional Gaussian white noise. From this work, Granger and Joyeux (1980) define the ARIMA rated fractional process as ARFIMA. They take into account both the short term behavior through the parameters of the AR part and MA (autoregressive and moving average) and the behavior of long term through the parameter of fractional integration.

These two types of modeling (ARCH and long memory) are part of the classic range of *traders* and are used for predictive purposes. Specialized software packages include these models in their functionality.

5. Data mining: "The search" and the exploitation of data[9]

All businesses collect and store large amounts of data. This voluminous information, focused on marketing, accounting, production, management, or other aspects is

[8] Indeed, financial series are particularly concerned by the ARCH models, because there are strong speculation periods (high variability) followed by periods of lull (low variability).

[9] See Jambu M., 1998.

growing regularly. The experts estimate that the volume of data stored by a company doubles every 20 months. Significant resources are mobilized to collect and maintain the so-called called "*Data Warehouses*". The data, which constitute the memory of the enterprise, are little used, only 10% are exploited. It is undeniable that a large proportion of knowledge that can be decisive in competition is hidden in these huge amounts of data. From these, a new industry was born: the *Data mining*.

Originally known as "*Data Mining*", it refers to all the techniques used to draw relevant information from the mountains of stored data over the past decades in business to predict future events. To perform its projections, statistical processing methods are applied to data from the past. In the field of CRM (*Customer Relationship Management,* management of the relationship with the clients), the Data Mining may, for example, allow to evaluate the curve of a product being launched on the basis of the observation of the first customers behavior.

The capture of price by optical reading has developed over years in large scale distribution, but also in large specialized surfaces. Associated with the development of the bar code, this technique enables immediate computer capture of sales in a very fine way. It thus allows the creation of sales history in terms of the individual consumer, and not at the aggregate level. In the retail domain, it is possible to observe the buying behavior of consumers who have agreed, attracted by loyalty cards, to be part of panels. Gradually, the binary modeling of the consumer choice it has emerged (buy/do not buy in each period). This is an instrument of exploitation of the collected explanations of the choice of the consumer by a set of variables relevant for the marketing policy (product type, price, discounts and promotions, socio-demographic data on the consumer, attitudinal data[10], etc.).

The fields of application are very broad and diverse, and Data Mining, for example, can help:

- increase by 20% to 200% the response rate,
- identify 30% of clients who represent 70% of the profits of the company,
- evaluate the impact of demographic factors (for example) on sales,
- reduce the marketing costs and measure the success of a marketing campaign,
- optimize the business impact of e-business sites by understanding the behavior of visitors,
- determine the conversion rate of visitors into buyers of products on Websites,
- calculate the rate of acquisition of a new customer,
- knowing who buys what on a Website,
- determine the areas of the Websites that have a low or high impact.

The statistical techniques used rely very heavily on the econometric analysis: regression, analysis of time series, discriminate analysis, etc.

Studies of Data Mining are to choose variables and to analyze from the known functions. They also allow exploring the variance, the standard deviations and correlations between variables. Let us take a concrete example, the study of the

[10] The attitudinal data includes the measurement of attitudes (vis-à-vis the product, its attributes, etc.) and not the observed behavior of the consumer (for example, the purchase).

correlation between the purchases of various products from a store. "Do the consumers who purchase beer buy at the same time rice?"
The discovery of rules enables the discovery of finer relationships between the "If X then Y" data. Any rule can be characterized by a confidence factor and a factor of support.

For example, the rule: "if purchase (beer) and purchase (rice) then purchase (meat)" will be a factor of confidence of 70% (verified in 70% of cases) and an indicator of support of 30% (only 30% of the population buys then beer and rice.) This allows the hypermarkets to edit in real time your ticket fund comprising a good discount on products targeted by the composition of your basket: econometrics is truly at the service of the large distribution.

6. The integration of macroeconomic forecasts into the general policy of the company[11]

Another area more traditional and customary for the use of econometrics in business is the cyclical macroeconomic forecasting. The business economists use such forecasts to develop their own plans and to monitor the national and international situation. In the context of economic globalization, we understand the importance and the role that these macroeconomic indicators can play. They define the general policy of the company: investment in terms of productive capacity, international opportunities, a policy of hiring, outsourcing, etc. The growth forecast announcements are now more expected than the conventional statistics such as the number of job-seekers or the rate of inflation. By who and how these macroeconomic forecasts are developed?

The institutes that make such forecasts are now extremely numerous. At international level we can cite the OECD, the World Bank, the IMF, etc. The number of organizations developing macroeconomic forecasts is important, but all have in common the usage of econometric techniques and macro econometric modeling: simultaneous equations models, VAR (Autoregressive Vectors) and VECM (Vector Error Correction Model).

The econometric modeling with several structural equations has many criticisms and failures from the part of disturbed economic environment. The forecasting using these templates was very poor in the 1980s. The main criticism against these structural models is the simultaneity of relations and the concept of exogenous variables. The VAR representation[12] - the generalization of the univariate autoregressive process (AR) to multivariate case - provides a statistical answer to all this criticism. In this representation - because we can no longer speak of a model - variables all have, *a priori*, the same status and, then, purely statistical relationships. The VAR representations can analyze the effects of economic policy and the reactions of the

[11] See Bourbonnais R., 2011.
[12] The representation term is better suited than the term of modeling, since the economist specifies no economic relations as such.

variables to environment changes through simulations of random shocks[13] and the decomposition of the variance of error.

More recently, the co-integration analysis allows identifying clearly the true relationship between variables by looking for one or more vectors of co-integration and eliminating its or their effects, if applicable. In this case, it is necessary to appeal to the vector error correction (vector) representation. This type of model aims to identify clearly short-term to long-term relationships (the co-integrating vector) between the variables.

Not only the vectors are a powerful tool of analysis and forecast, but as VAR representations they also analyze the effects of economic policy through simulations of random shocks.

7. In conclusion

Through these examples, we have shown of what use the econometrics could be for the business public or private contributions. The various domains presented illustrate applications which are now commonly used. The seemingly limitless development of the IT, both in terms of processing capacity and data storage, coupled with training in the econometric techniques in universities and in schools help the diffusion of business applied econometrics applied.

References

Bourbonnais R., Usunier J.C., 2007, *Prévision des ventes,* Economica, 4th ed.

Bourbonnais R., 2011, *Econométrie*, Dunod, 8th ed.

Bourbonnais R. Terraza M., 2010, *Analyse des séries temporelles*, Dunod, 8th ed.

Engle R. F., Granger, C.W.J., 1991, *Long-run economic relationships,* Oxford University Press.

Granger C.W.J and Happy R., 1980, An introduction to long-range time series models and fractional differencing, *Journal of Time Series Analysis*, 1, 15-30.

Gupta S., 1988, Impact of sales promotions on when, what, and how much to buy", *Journal of Marketing Research*, Vol.XXV, November, pp. 342-355.

Jambu M., 1988, *Introduction au Data Mining*, Eyrolles.

Longley J., 1967, An appraisal of ballast Squares Programs from the point of the User, *Journal of the American Statistical Association* Vol. 62.

Markowitz H., *Portfolio selection: Efficient diversification of investments*, John Wiley and sons, 1959.

Racicot F., Theoret R., 2001, *Econométrie Financière,* University of Quebec press.

Sharpe W. F., 1963, A simplified model for portfolio analysis, *Management Science,* January.

Volle P., 1994, Measuring the effectiveness of promotions: Models, data, methodologies, *Document of the 6th the Sales Promotion Challenge*, April.

[13] The term innovation is also often used.