Organizing a Group of Students in order to Research the Rebound Effect in Industry 4.0

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The Barcelona Conference on Education 2020
Official Conference Proceedings

Abstract
The paper presents a framework with respect to organizing a group of students in order to research the rebound effect in Industry 4.0. The framework points two coordinates. The first one refers to conceptual delimitations and working hypotheses. The main coordinate is focused on carrying out the research process. It will develop aspects as: defining the concept of rebound effect, research challenge - working hypotheses, organizing the research process, awareness among students of industry-specific concepts 4.0, awareness among students of the concept of rebound effect, setting the purpose of the research, ways to achieve the set goal, establishing research teams and choosing topics, identification of studies in the scientific and professional literature relevant to research topics, critical analysis of relevant studies in the scientific and professional literature, carrying out literature review studies, quantitative analysis of the occurrence of the rebound effect in Industry 4.0 and critical analysis of the obtained results.

Keywords: Rebound Effect, Industry 4.0, Research

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Introduction

William Stanley Jevons, in his famous book, The Coal Question of 1865, argued that improved coal use efficiency would lead not to a reduction in national coal consumption, but rather to an increase. Jevons states: "It is a total confusion of ideas to assume that efficient fuel use is equivalent to reduced fuel consumption. On the contrary, the truth is ... Every improvement in the engine, when made, only accelerates the consumption of coal again." These ideas later developed under the name of Jevons Paradox.

Beginning with William Stanley Jevons in 1865, the concept of the rebound effect continued to be developed, especially after the 1970s, when the need for sustainable global development grew. Thus, a problem was identified regarding the possibility of energy efficiency in reducing energy consumption.

Technological advances and discoveries have led to a continuous increase in productivity in energy use, as a factor of production, at the same time, energy consumption increasing exponentially (Carl von Utfall Danielsson, 2009). Although this is not necessarily surprising (after all, energy increases with GDP and GDP has grown steadily over time), economic reasoning can be used to provide an explanation for the fact that energy efficiency it may not be as effective as hoped. When energy is used more efficiently, the price of a given amount of energy decreases (ceteris paribus, ie the other factors remain unchanged). When prices fall, demand increases, so that, indirectly, the improvement/efficiency of the energy industry leads to changes in consumption patterns. This mechanism is described in the literature as the ***rebound effect.***

Organizing the research process

The emergence of Industry 4.0, especially of the phenomena and processes generically called 4.0 challenges me to find out if the rebound effect in the sense of Jevons but also an extension of it is generated or not in the new economic context specific to the development of Industry 4.0. Therefore, I extend the concept of rebound effect giving it the following meaning, transformed into two working hypotheses:
• Hypothesis 1: 4.0 phenomena and processes, although aimed at increasing economic efficiency, in the form of a better use of production factors and a reduction in specific consumption, really lead to a decrease in total resource consumption.
• Hypothesis 2: if industry 4.0 does not diminish the rebound effect either then the circular economy can be considered a solution in diminishing the rebound effect.
The research is carried out together with the students of the Faculty of Cybernetics, Statistics and Economic Informatics, specialization Statistics and Economic Forecasting from the third year, by organizing them in work teams during seminars but also for drafting projects in the discipline, by individual work, outside seminar hours.

The research process is organized in ten stages, presented below:
• Awareness among students of industry-specific concepts 4.0
• Awareness among students of the concept of rebound effect
• Setting the purpose of the research

- Ways to achieve the set goal
- Fixing the research teams and choosing the topics
- Identification of studies in the scientific and professional literature relevant to research topics
- Critical analysis of relevant studies in the scientific and professional literature
- Carrying out literature review studies
- Quantitative analysis of the occurrence of the rebound effect in Industry 4.0
- Critical analysis of the obtained results

Awareness among students of industry-specific concepts 4.0

In the first phase, a review is made of the main types of industrial revolutions and what is the paradigm specific to each of them, presented in table 1.

Table 1. The main types of industrial revolutions

Type of industry	Paradigm
1.0	introduction of mechanical devices powered by water and steam
2.0	introduction of the concept of mass production, based on electricity
3.0	introduction of integrated circuits, information technology for production automation - digital revolution
4.0	interconnection of digital, physical and biological systems (internet, sensors, smart, Artificial Intelligence, Virtual Reality, Augmented Reality, robots

Industry 4.0 aims to achieve more efficient production, which saves more resources and reduces the carbon footprint. It is characterized by:
■ Strong individualization of products (customization) in the conditions of an extremely flexible mass production
■ The technology needed for this empowerment is improved by introducing methods of self-optimization, self-configuration, self-diagnosis, understanding and intelligent support from people operating in an increasingly complex job.
■ Automation and data exchange in production technologies
■ Businesses are created as intelligent networks throughout the entire production chain through interconnected machines, components and systems that can be controlled with each other.
■ Smart factory: sensors, IoT, robots

Awareness among students of the concept of rebound effect

To facilitate the understanding of the concept of rebound, students are presented with a film available at https://www.youtube.com/watch?v=PXf4KVWyfjs&feature=youtu.be which presents the Jevons paradox as well as specific industries in which it manifests itself.

After discussions on the concept of rebound effect, students follow documentation activities on the concept of rebound, by searching in the most important scientific literature resources available online:
- Google

- Web of Science - Core Collection, InCites Journal Citation Reports, Derwent Innovations Index, Clarivate Analytics
- Emerald Management EJournals
- Euromonitor Passport
- de Gruyter ebooks
- CAB ebooks
- CEEOL
- JSTOR Business Collections I, II, III si IV
- PROQUEST Central
- Scopus, Elsevier

Setting the purpose of the research

The purpose of the research was set for all students as being: ***use of statistical methods and econometric models for the analysis of phenomena and processes specific to Industry 4.0. Identifying the occurrence of the rebound effect***
Students included in the research process are guided with reference to the steps to be taken to achieve the goal. These are presented in box 1.

Box 1. Components of the research approach

In order for the research process to generate new results, it is suggested to avoid the beaten paths and to follow some patterns used for the elaboration of the projects, proposing the development and application of soft skils in the approach of the scientific approach. These are highlighted in box 2.

Box 2. Soft skills needed to achieve the goal of the research

Setting research teams and choosing topics

The research is performed individually or in teams of 2-3 members. Students identify areas of interest both from the immediate perspective of the development of undergraduate work and the career path after graduation, in the context of achieving the purpose of research. The distribution of teams by topics is presented in table 2.

Table 2. Distribution of research teams

Team	Topic
1	Rebound effect on the car market - Automation
2	Study on the rebound effect for CO2 emissions from passenger transport
3	Manifestation of the rebound effect by applying new technologies in the educational system
4	The rebound effect in the economy
5	The rebound effect of electric / hybrid cars against conventional ones (in terms of consumption)
6	The rebound effect in the stock market
7	The rebound effect in technology development
8	Combating the Jevons Paradox
9	Technology development in the labor market - the rebound effect
10	The rebound effect on the solar house
11	The impact of Industry 4.0 on the labor market - prospects for the rebound effect
12	The rebound effect and the influence of technology in sports
13	The rebound effect in the aeronautical industry
14	The circular economy in the fashion industry
15	The rebound effect on the future of the labor market
16	The rebound effect and new technologies used in agriculture
17	Increasing the consumption of plastics from the perspective of the rebound effect

Students are asked to identify 10-12 scientific and professional studies that are suitable to be used in conducting a critical analysis of the literature. The online sources of the studies selected by each team are presented below.

Critical analysis of relevant studies in the scientific and professional literature

In the first phase, students are asked to identify common issues that appear in the identified scientific studies, with reference to the research topic to be developed. These are extracted in the form of a survey.

In the second phase, students identify different and contradictory aspects that appear in the identified scientific studies.

At this stage, each team starts research actions specific to conducting a literature review study. Thus, the common aspects identified in established scientific studies are written in the form of a literature review study, while the contradictory aspects identified are considered working hypotheses for quantitative analyzes to be developed in the later stages of the research approach.

The main aspects from the literature review studies lead to the development of six major coordinates:
• Jevons Paradox

- Direct rebound effect
- Indirect rebound effect
- The rebound effect at the microeconomic level
- The rebound effect at the macroeconomic level
- The paradigm of technological development on the rebound effect

Quantitative analysis of the occurrence of the rebound effect in Industry 4.0

The steps of the quantitative analysis approach to be followed are described in Figure 1.
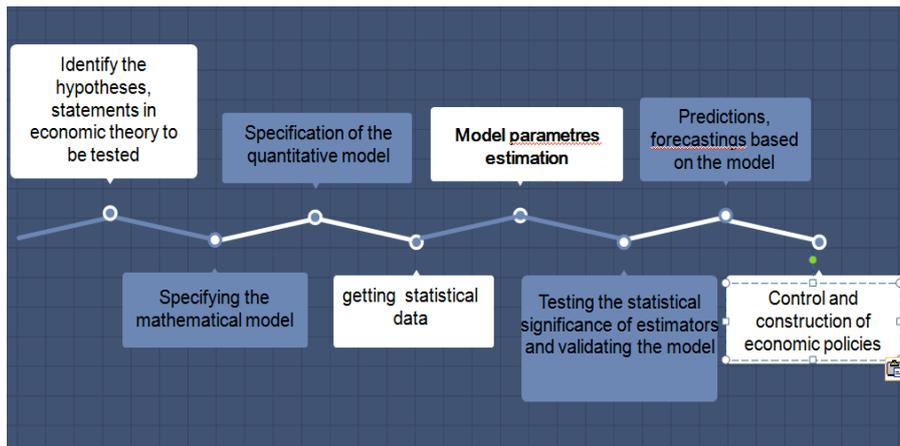

Figure 1: Stages of the quantitative analysis approach

Students are asked to identify a number of 18-20 statistical indicators for which to analyze the availability of data to the main data providers: National Institute of Statistics, Eurostat, WorldBank, OECD. The types of statistical data are described in box 3.

Box 3. Types of statistical data

For data processing it is proposed to use two types of models, specific to statistical-econometric modeling (figure 2):
- Deterministic models;
- Econometric models.

Deterministic models, of the form y = f (x) which are frequently used in economic analysis, in the factor analysis of the variation, in time or space, of socio-economic phenomena, reflecting deterministic or functional connections.

Econometric models that describe the statistical or stochastic connection between the inputs of the system (influencing factors X) and its outputs, the resultant variable Y, of the form   y = f(x)+u.

$$X \; \{ \rightrightarrows \boxed{s} \rightrightarrows \} \; Y$$

Figure 3: Statistical-econometric modeling

For the indicators organized with profile data, the following types of analysis are proposed, in order to highlight the manifestation of the rebound effect on the phenomena and processes specific to industry 4.0.:
• Regression analysis;
• Cluster analysis;
• Analysis in main components.
For the indicators organized with data observed in time, the following types of analysis are proposed, in order to highlight the manifestation of the rebound effect on the phenomena and processes specific to industry 4.0.:
• Data analysis using exponential smoothing method;
• Models ARIMA and SARIMA;
• Models VAR.
For the indicators organized with panel data, panel regression is proposed.

Conclusion

The approach of scientific research undertaken together with the students in order to research the rebound effect in Industry 4.0 generated four scientific main domains:
• Manifestation of the rebound effect in transports
• Structural changes in the labor market - manifestation of the rebound effect
• The development of Industry 4.0 accentuates the rebound effect
• The circular economy as a solution to diminish the rebound effect.
The research topics that can be used for develop the domain about the manifestation of the rebound effect in transport are:
• Rebound effect on the car market - Automation
• Study on the rebound effect for CO2 emissions from passenger transport
• The rebound effect in the economy
• The rebound effect of electric/hybrid cars against conventional ones (in terms of consumption)
• The rebound effect in the aeronautical industry
Research topics that can be used for develop the domain about structural changes in the labor market - the manifestation of the rebound effect are:
• Development of technology in the labor market - the rebound effect
• The rebound effect on the future of the labor market
Research topics that can be used for develop the domain about the development of Industry 4.0 that emphasizes the rebound effect are:

- Manifestation of the rebound effect by applying new technologies in the educational system
- The rebound effect in technology development
- The rebound effect on the solar house
- The impact of industry 4.0 on the labor market – perspectives of the appearance of the rebound effect
- The rebound effect and the influence of technology in sports
- The rebound effect and new technologies used in agriculture

Research topics that can be used for develop the domain about the circular economy as a solution to reduce the rebound effect are:

- Circular economy in the fashion industry
- Increasing the consumption of plastics from the perspective of the rebound effect

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