The Effects of Investment and Research Expenditure on Chemical and Pharmaceutical Industries

MIHAELA SIMIONESCU[1], JENICA POPESCU[2], NELA LOREDANA CARABA MEITA[2]*

[1]Institute for Economic Forecasting of the Romanian Academy, 13 Calea 13 Septembrie, 050711, Bucharest, Romania.

[2]University of Craiova, Faculty of Economics and Business Administration, 13 Alexandru Ioan Cuza Str., 200764, Craiova, Romania

Considering the economic performance as a target for companies in chemical and pharmaceutical sectors, the main aim of this paper is to assess the impact of investment and research expenditure on the turnover and production of the Romanian firms in these domains. A panel data approach is applied and the main results suggested that actual and previous investment did not generate an increase in the production and turnover of the companies in the period 2005-2016. However, the increase in the number of researchers and in the research expenditure slowly stimulated the production and turnover. All in all, we can state that the investment in chemical and pharmaceutical sectors are still not sustainable in Romania and the future policies of the companies should be focus more on research and development activities.

Keywords: chemical industry, pharmaceutical industry, investment, research expenditure, turnover

In the past century, the chemical industry used petroleum as primary feedstock. The economic, social and political reasonsimposed the use of therenewable plant-based feedstocks in the chemical industry complementary or instead of petroleum. The advance in research will determine in the next century a progressive transition from petroleum to materials, chemicals, and liquid fuels as the primary feedstock. In case the transition will be made and chemical industry will be more sustainable, considerable efforts in research fieldwill be necessary. There are a lot of research and development priorities in order to achieve a green chemical industry using renewable plant resources [1].

In the 19th century, the leaders from the chemical industry used patents and secrecy in order to deter entry. After the Second World War, the role of patents changed. In petrochemicals and bulk organic chemicals, licensing is used as an important wayofobtaining revenue from process innovations. The technology licensing gained importance due to emergence of a class of specialized process design and engineering companies that developed and spread process innovations [2].

Determinants of the direction, rate, and scale of innovative processes in the chemical industry were identified even for the period 1830–1980. The data refer to three main sectors: pharmaceuticals, dyestuffs, and plastics. Theories of economic growth and technical change might be described in connection with material on the chemical industry [3,4].

The development of specialized upstream technology suppliers in developedstates lowers investment costs for downstream companies in less developed countries and improves technology access. The investments in chemical plants in the LDCs increase with the number of technology suppliers from developed countries [5].

Private companies invest more to growth the capacity prior to a positive demand shock compared to public companies. This conclusion confirms those theories in which public companies are subject to more agency concerns [6].

Numerous investments are made in the pharmaceutical sector to increase the profit of the companies. Empirical evidences showed that pharmaceutical research and development (R&D) spending grew with the real drug prices. A 10 percent increase in the rate of real drug prices generated an increase by almost 6 percent in the R&D intensity [7,8]. Models of new product development were built using the theoretical framework of the economics of innovation [9].

The response of pharmaceutical R&D investment to publicly supported biomedical research was assessed in case of nonprofit institutions and universities. Thecompanies' data on investment were used to measure this impact.Clinical research and public basic are complementary to pharmaceutical R&D investment [10,11].The R&D costs were estimated as to consider the innovation in the pharmaceutical industry [12].

Considering the effects of R&D and investment on chemistry and pharmaceutical industry, in this paper we assess the impact of the manufacture of chemical substances and products and main pharmaceutical products and pharmaceutical preparationson the turnover and production index of the companies in the field. After this introduction, the paper will focus on the method description and the presentation of empirical results. Last part concludes.

Experimental part

Methods

As the main aim of our research is to assess on statistical basis the impact of investment and research on the chemical and pharmaceutical industry in Romania, specific methods will be used. The indicators used in the analysis are: turnover, index of industrial production, number of researchers, research expenditure and net investment in chemical and pharmaceutical industry in Romania.

The turnover of a company with industrial main activity represents the total income from internal and external market that is registered in a certain period from main and secondary activities of the company. The turnover does not include value added tax and income generated by the sale or transfer of fix assets. In our research, the turnover is taken from the Statistical Research regarding turnover in

* email: loredanameita@yahoo.co.uk

industry, a publication edited by National Institute for Statistics in Romania.

The index of industrial production is calculated using selective method based on a representative sample of goods and services. The evolution of industrial production is determined using the index of physical volume for the series of representative products for each industrial sector and their weights based on added value. The Laspeyres formula is used in this case. The index of industrial production measures the evolution of the results for activities with industrial character from one period to another. The data are taken from the Statistical Research on industrial products and services. Industrial production includes total quantities that were made, including those that were consumed in the same company.

The number of researchers is expressed as number of persons in physical volume that work full-time in a certain period. The data are provided by Statistical Researches on the activity of Research and Development.

The research expenditure refers to current and capital expenditure in units that have activities of research and development. The current spending includes payment for covering the cost of labour force, materials and other current payments. The capital spending refers to payment for making workings of building, purchasing instruments, machines, equipment and appliances and other payments for increasing the volume of fixed means.

The net investment refers to expenses made for buildings, installations, purchase of equipment, means of transport, and other expenditures destined for the creation of new fixed assets, for the development, modernization, reconstruction of the existing ones, as well as the value of the services related to the transfer of ownership for fixed assets and land (notary fees, commissions, transport, loading-unloading expenses etc.).

The data for all variables are directly taken from the Tempo online database of National Institute for Statistics in Romania.

The data for these variables are taken only for 2 sectors specializing in the manufacture of chemical substances and products and manufacture of main pharmaceutical products and pharmaceutical preparations. The period for which data are registered is 2005-2016. Due to the small set of available data, a panel data approach will be employed.

The methodology framework is based on a regression model using cross-section data and time series- pooled ordinary least squares [13]. The fixed-effect or random-effect panel data model can be represented as:

$$y_{it} = \beta_0 + \sum_j \beta_j X_{jit} + e_{it} \qquad (1)$$

i=1,2,...,N
t=1,2,...,T
y_{jt}- dependent variable for cross-section *i* and at time *t*
X_{jit}- the j-th independent variable for *i* unit and at time *t*
e_{it}- error term
β_j- coefficient
β_o- constant term

This model is transformed in order to make the estimation based on panel data methods with fixed effects that allow to showthe individual effects. Under the hypothesis that specific spatial effect is constant in time, the unobserved characteristics are explained as fixed effects that are included in the constant term of the panel model with various values for each unit (β_{0i}). The unobserved heterogenity is controlled as it does not modify in time and it might be eventually correlated with the explanatory variables in the model. The one-way fixed-effect model is represented as:

$$y_{it} = \beta_{0i} + \sum_j \beta_j X_{jit} + e_{it} \qquad (2)$$

i=1,2,...,N
t=1,2,...,T
y_{it}- dependent variable for cross-section*i* and at time *t*
x_{jit}- the j-th independent variable for cross-section *i* at time *t*
e_{it}- error term
β_j- coefficient
β_{oi}- unobserved individual effect for cross-section *i*, which is constant in time (it contains spatial fixed effects)

The two-way fixed-effect model is built by adding fixed effects to time dimension:

$$y_{it} = \beta_{0i} + \gamma_t + \sum_j \beta_j X_{jit} + e_{it} \qquad (3)$$

y_t- fixed effects in time

The fixed-effect model and the pooled ordinary least squares model are estimated in order to chose the one that is suitable. F-test is used to check the presence or absence of individual effects [14]. The assumptions of the F-test are:

H0:β_{oi}=0 (no fixed effects)
H1: $\beta_{oi}\neq 0$ (fixed effects)

The F-test has the following statistic:

$$F = \frac{\frac{ESS_{POLS} - ESS_{FE}}{N-1}}{\frac{ESS_{FE}}{(T-1)N-K}} \qquad (4)$$

K- number of explanatory variablesin the fixed-effect model
N- number of cross-sections
T- number of periods
ESS_{POLS}- sum of square errors for pooled ordinary least squares model
ESS_{FE}- sum of square errors for fixed-effect model

Fixed-effect model includes only individual constants, but random-effect model seesthis constant as a random variable of mean β_o. Moreover, differences between cross-sections are seen as random deviations from the mean.

$$\beta_{0i} = \beta_0 + \varepsilon_i \qquad (5)$$

ε_i is the error of zero mean and constant variance (σ_ε^2).
The composite error is computed as:

$$u_{it} = \varepsilon_i + e_{it} \qquad (6)$$

ε_i- error associated to cross-sections
e_{it}- random error

The random-effect model is represented as:

$$y_{it} = \beta_0 + \sum_j \beta_j X_{jit} + u_{it} \qquad (7)$$

i=1,2,...,N
t=1,2,...,T

Hausman test is applied to select between fixed-effect and random-effect model.

Results and discussions

The chemical industry in Romania is the industry with the highest commercial deficit. In Romania, the production of synthetic rubber, synthetic fiber, polystyrene, polyethylene, and pesticide disappeared and the local market became dependent of imports. If before economic crisis beginning, the first 10 companies in chemical industry had around 12000 employees in 2007, in 2017 the number of employees decreased to 5800 people. This dramatical change was caused by the bankruptcy of GHCL Upsom

Romania, the producer of soda asks, and by the insolvency of Oltchim Ramnicu Valcea and Amo-nil Slobozia.

S.C. Chimcomplex S.A. Borzesti is considered a successful company since its privatization in 2003 due to human, financial, informational and technological resources. The restructuration of the company was made as to respond to the demands of market economy. New low energy consumption installations were built. The strategy applied in this firm was to leave the profit to the company development for the last 12 years, not paying dividends at all. The energy integration achieved through the operation of soda plants and cogeneration plants is remarkable. Chimcomplex was placed thefirst in the European Union - as the most efficient combined chlorosodium product, in January 2014. The investment policy continued in 2015 when the Cogeneration 2 plant was put into operation and the water generation caustic soda electrolyzer was retrofitted.

The pharmaceutical sector in Romania grew in the last 10 years in all segments and it had a contribution of 1% to the gross domestic product formation. The second part of 2007 came with a stagnation of this industry for almost 3 years. The reasons are related to the effects of recent world economic crisis on financial resources in health sector and the regulation measures that transferred a significant part of financing from health system to producers of pharmaceutical products. However, the pharmaceutical market in Romania is the most challenging one in Europe, especially for those companies based on R&D of innovative medicines. For example, Amgen România produces original medicinesand it exists on Romanian market for 5 years. The company plans to launch on the market other 6 new medicines for various pathologies: haematological, oncological, rheumatologic, and cardiovascular pathology.

More random-effect models were estimated to explain the turnover in chemical and pharmaceutical sector. The random-effect GLS regression suggested that investment in these industries had a slow and negative effects on turnover of the companies in these sectors. On the other hand, the number of researcher and research expenditure positively influenced the turnover.

These empirical results indicated that the investment in these industries are still insufficient to increase the turnover. The investment was not efficient since they reduced the turnover in the period 2005-2016. However, the progress in R&D had immediate effects on companies' turnover.

Since the investment has not immediate effects on turnover, we will build another panel data model by including the investment in the previous year among the explanatory variables.

The empirical results in this case showed that the investment in these industries made in the previous year were still insufficient to increase the turnover. However, R&D expenses and the researchers brought value to these sectors reflected in the turnover growth.

Other random-effect models are constructed to evaluate the impact of investment and R&D activities on the production growth.

Investment has a negative impact on production index while the effects of number of researchers and research expenditure are positive, but very low. This result shows that investment is not sustainable as to generate an increase in production of chemical substances and products and pharmaceutical products and preparations.

The investment made in the previous year still does not bring an increase in the production of chemical substances and products and pharmaceutical products and preparations. The progress in research in these sectors has a very low positive effect on production.

Table 1

RANDOM-EFFECT GLS REGRESSION FOR EXPLAINING TURNOVER IN CHEMICAL AND PHARMACEUTICAL INDUSTRY BASED ON INVESTMENT AND RESEEARCH PERFORMANCE IN THE SECTORS (2005-2016)

Variable	Coefficient	z	P>|z|
Investment	-0.0145	-2.3	0.021
Number of researchers	0.150	2.05	0.040
Research expenditure	0.00006	2.21	0.027
Constant	81.844	10.33	0.000

Table 2

RANDOM-EFFECT GLS REGRESSION FOR EXPLAINING TURNOVER IN CHEMICAL AND PHARMACEUTICAL INDUSTRY BASED ON INVESTMENT IN THE PREVIOUS YEAR AND RESEEARCH PERFORMANCE IN THE SECTORS (2005-2016)

Variable	Coefficient	z	P>|z|
Investment in the previous year	-0.0166	-2.58	0.009
Number of researchers	0.159	1.98	0.047
Research expenditure	0.000016	-2.06	0.039
Constant	86.3256	11.39	0.000

Table 3

RANDOM-EFFECT GLS REGRESSION FOR EXPLAINING PRODUCTION INDEX IN CHEMICAL AND PHARMACEUTICAL INDUSTRY BASED ON INVESTMENT AND RESEEARCH PERFORMANCE IN THE SECTORS (2005-2016)

Variable	Coefficient	z	P>|z|
Investment	-0.0194	-2.54	0.011
Number of researchers	0.020	2.2	0.027
Research expenditure	0.00018	2.92	0.003
Constant	108.5354	19.42	0.000

Table 4

RANDOM-EFFECT GLS REGRESSION FOR EXPLAINING PRODUCTION INDEX IN CHEMICAL AND PHARMACEUTICAL INDUSTRY BASED ON INVESTMENT IN THE PREVIOUS YEAR AND RESEEARCH PERFORMANCE IN THE SECTORS (2005-2016)

Variable	Coefficient	z	P>|z|
Investment in the previous year	-0.0216	-2.64	0.008
Number of researchers	0.05	1.97	0.048
Research expenditure	0.000064	2.31	0.039
Constant	110.93	18.82	0.000

Conclusions

This paper brings as novelty a statistical evaluation of the impact of investment and R&D activities on the chemistry and pharmaceutical sectors in Romania. Knowing that R&D activities are oriented in the end to economic targets like increase in production and turnover, our approach uses panel data models to check if investment and R&D expenditure had indeed the expected results in terms of economic performance of companies from chemistry and pharmaceutical industries. Our demarche is in line with that of White et al. (2013) who offered concrete solution for achieving a sustainable chemical industry [15].

The main results are contrary to expectations for investment, since in Romania the level of investment is low and not enough to generate an increase in production or turnover of the companies in these industries. On the other hand, R&D had the expected effects on chemical and pharmaceutical sectors translated by a low increase in production and companies' turnover. The conclusion being in line with the results of more studies [16-22]. The policies in these sectors should be focus more on R&D activities in order to have sustainable increase in production and profit.

However, our statistical analysis is limited by the use of a short time series (period 2005-2016) because of the data availability. There are more explanatory variables that could be connected to economic performance in terms of production and turnover. Therefore, in a future study more variables will be used.

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