MODELLING THE IMPACT OF SME LENDING ON BUSINESS VALUE ADDED

Alla Ivashchenko
Kyiv National Economic University named after Vadym Hetman
54/1 Peremogy ave., 03057 Kyiv, Ukraine, alla.ivashchenko@kneu.edu.ua
https://orcid.org/0000-0002-4599-7137

Yevheniia Polishchuk
Jagiellonian University in Krakow
4 prof. S. Łojasiewicza str., 30348 Kraków, Poland, polischuk.eugenia@gmail.com
https://orcid.org/0000-0002-6133-910X

Maksym Dubyna
Chernihiv Polytechnic National University
95 Shevchenko str., 14035 Chernihiv, Ukraine, maksim-32@ukr.net
https://orcid.org/0000-0002-5305-7815

Serhii Smerichevskyi
National Aviation University
1 Liubomyra Huzara ave., 03058 Kyiv, Ukraine, serhii.smerichevskyi@npp.nau.edu.ua
https://orcid.org/0000-0003-2102-1524

Anna Kornyliuk*
State Institution „Institute of Economics and Forecasting of NAS of Ukraine"
26 Panasa Myrnogo st., 01011 Kyiv, Ukraine, anna.kornelli@gmail.com
https://orcid.org/0000-0001-8713-0681

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Highlight

The paper deals with the revealing measure of the SME lending impact on its value added.

Abstract

The SME lending covers a list of its needs related to its day-to-day performance, fixed assets, development. Existing methods of identifying impact on economic indicators from using loans by SMEs are limited. The aim of the research is to develop a methodology which allows reveal the impact of SME lending on business value added on macroeconomic level. The methodology is based on correlation regression analysis in order to identify the level of loan influence on business development, value added in particular, due to the lack of adequate methods for SME development forecasting. The obtained results are sufficient for medium business and be used in forecasting medium business development in Ukraine. For small business model has insufficient density of the relationship between indicators, therefore, it was proposed to use additional factors as equity; liabilities and non-economic factors exemplified as the level of shadow economy.

Keywords

SME; lending; value added; modelling; correlation-regression analysis.

Introduction

The successful business development, SME in particular, leads to economic growth and increases the investment attractiveness of economy on national and multinational level. The main indicator which identifies the level of business development is its value added as on national as well as on sectoral level, e.g., large, medium, small. The financial potential of legal entities defines the level of a separate country economic growth and its sustainability. In the given research the financial potential of SMEs is considered as its ability to obtain loans from credit institutions considering the level of SME sustainability and attractiveness for such institutions according to scoring systems applied by them. It is well-known, that only those SMEs, which have stable growth of economic indicators, namely revenues, profit, value added could be attractive for credit institutions as a result to obtain loans from them. That is why it is important to assess impact of loan as a factor on value added formation which can be made by using approaches of economic and mathematical modelling, in particular correlation-regression analysis.

In the research the effect of SME loan volumes` impact on its value added was defined by determination regression model, using a cubic single-factor one, separately for small and medium business. It is also possible to forecast value added volumes of SMEs on macroeconomic level using the proposed model. So, the main aim of this research is to develop a methodology based on econometric modelling which allows reveal the SME lending impact on business value added on macroeconomic level. SMEs play a critical role in economic growth and development, but often face challenges in accessing financing to support their operations and expansion, making it essential to investigate the impact of SME lending on business value added, which the literature review aims to explore in this article.

A lot of papers are dedicated to SMEs financial issues during the pandemic period: Shrivastav [1] considered finance challenges; Zhao, Matthews, & Munday studied the specifics of relations between banking and SME during borrowing process [2]; Fasth, Akerman, Elliot, & Hilmersson investigated the effect of external funding for SMEs [3]; Elshaer notes that financial resources, along with social and human resources, are critical factors that contribute to entrepreneurial resilience during times of crisis [4]; Taghizadeh-Hesary, Phoumin, & Rasoulinez suggested that measures such as regional liquidity support facilities, targeted credit guarantee schemes, and collaboration between regional development banks and private sector institutions could help to support SMEs in accessing finance and navigating the financial risks posed by the pandemic [5]. Cecere, Corrocher, Mancusi revealed that public funding is perceived by SMEs and complicated and full of bureaucracy and that was the huge obstacle on perceiving support programs by SMEs [6]. Rupeika-Apoga, Petrovska, & Bule note that digitalization can offer SMEs various benefits, including improved financial management through the use of digital financial tools and platforms [7]; Eggers notes that access to finance is often a critical challenge for SMEs during times of crisis, and that this challenge can be compounded by factors such as increased uncertainty and risk aversion among lenders [8]; Cowling, Brown, and Rocha suggested that those companies that had more cash reserves proved to be more resilient in the face of COVID-19. They also discussed the article also discusses the challenges faced by SMEs in accessing government support programs, including those related to finance, and notes that more needs to be done to ensure that these programs are accessible and effective for SMEs [9]. Recent studies in general point out the role of SMEs lending and other borrowing instruments (including regional returning back money programs) in circular economy launching [10,11] and Eniola and Entebang explored the relationship between financial innovation and SME firm performance, including the role of banks in providing financial services to SMEs [12].

Most research on SMEs development has been carried out in access to finance problem in frame support of the competitiveness and sustainable growth of SMEs and the emergence of alternative financing models, such as crowdfunding and peer-to-peer lending, and their potential impact on traditional business lending by banks [13–15]. The dependence between financial literacy and financial potential of the SMEs in general are proved by Ye & Kulathunga [16]. El-Hamid, Eissa & Radwan using case method claim that financial resources service as drivers for SMEs growth [17]. Our previous research was related to the estimation of the investment potential of the SMEs throughout of machine learning tools [18]. The effects of different innovations implementation in SMEs activities are considered by (AI instruments) [19]; big data analytics adoption by SMEs [20]. Onikienko et al considered relatedness the long-term SME projects assessment with non-standard cash flows [21]. Khovrak related the level of financial safety of the banks to the financial potential of SMEs who get loans [22]. Mints et al. considered SMEs lending as a factor of banking stability during the crises [23]. In China family SMEs tends to use traditional banking rather than FinTech solutions in means that the clients of FinTechs are innovative companies [24]. Phraknoi, Busby and Stevenson explored SMEs in the context relationality, awareness, control are the core principles that are basis for forming supply chain finance (SCF) [25].

Using transactional data and payment network–based variables Kou et al. offered to predict bankruptcy of the SMEs avoiding financial indicators [26]. Zizi, Oudgou, El Moudden reviled the determinants and predictors of SMEs’ financial failure exploitering stepwise method of estimating logistic regression [27]. The decision-making process at SMEs has an impact on the capital structure and this was proved by Rao, Kumar, Madhavan using generalised method of moments [28]. Bielialov presents a risk management framework and identifies the key risks faced by startups in the innovation sector, as well as strategies to mitigate these risks, including leveraging external financing sources such as banks [29]. However, it is essential to identify which key financial indicators and resources SMEs use for making economy competitive.

Methods

A wide range of general and special scientific research methods was used, in particular, observation, measurement, abstraction, comparative analysis. A significant part of the research was carried out on the basis of the use of statistical analysis and econometric modeling. Particularly, index analysis was conducted to reveal modern trends of SME value added and their credit volumes. Correlation-regression analysis was used in order to specify the lending volume impact on the SMEs` development. The obtained results were the basis for identifying the dependence between the specified indicators. A preliminary analysis of the exogenous variable influence on the dependent factor determined that this dependence should be modeled by a nonlinear (cubic) one-factor regression model. Correlation coefficients and the F-criterion were calculated aimed at this model verification. The impact of such indicator as lending volumes on SME development was specifically determined through the correlation regression model development. It is quite logical that, in reality, there is a fairly significant range of different sources of financing for these enterprises, the availability of which also affects their development. In addition to these financial parameters, there is a significant range of different factors that also determine the trajectories of SME functioning. However, in this research, we will mostly focus on the description of the influence of SME lending on the general business development and specify this influence in the form of an econometric model. The general method of application of correlation-regression analysis in the process of econometric models` formation is considered in formulas 1-6. For modeling real economic processes, a reality-oriented calculated cubic one-factor model is used, which has the following form (1):

$$\hat{y} = \widehat{a_0} + \widehat{a_1} * x^3 + \widehat{a_2} * x^2 + \widehat{a_3} * x \quad (1)$$

where:
y - the calculated value of the internal variable;
x - the actual values of the external variable;
a_0, a_1, a_2, a_3 - the calculated parameters of the model.

Accordingly, the error will be equal to (2):

$$\mathcal{E} = y - \hat{y} \quad (2)$$

The calculated parameters a_0, a_1, a_2, a_3 could be determined using the method of least squares. The main idea of this technique is to approximate the deviations of the calculated values to the real ones, in particular with minimal error in all possible variants (3).

$$\mathcal{E} \rightarrow min \quad (3)$$

There is some dependence, the smaller the error value, the closer the model is to the real model of the relationship between the two indicators (4):

$$\sum_{i=1}^{n} \mathcal{E} = \sum_{i=1}^{n} (y_i - \widehat{a_0} + \widehat{a_1} * x^3 + \widehat{a_2} * x^2 + \widehat{a_3} * x) \quad (4)$$

where:
$\sum_{i=1}^{n} \mathcal{E}$ - the sum of deviations y from the trend value, which describes the approximate relationship between x and y.
$\sum_{i=1}^{n} \mathcal{E}$ can take both positive and negative values. So:

$$\sum_{i=1}^{n} (y - \widehat{a_0} + \widehat{a_1} * x^3 + \widehat{a_2} * x^2 + \widehat{a_1} * x)^2 \rightarrow min \quad (5)$$

To determine the calculated parameters a_0, a_1, a_2, a_3, an essential condition is to achieve the minimum value in the regression equation. The derivatives of this function must be equal to zero to perform the minimum of function (5). The cubic one-factor model is defined by the following system of equations (6):

$$\begin{cases} a_3\sum x_i^3 + a_2\sum x_i^2 + a_3\sum x_i + na_0 = \sum y_i \\ a_3\sum x_i^4 + a_2\sum x_i^3 + a_1\sum x_i^2 + a_0\sum x_i = \sum x_i y_i \\ a_3\sum x_i^5 + a_2\sum x_i^4 + a_1\sum x_i^3 + a_0\sum x_i^2 = \sum x_i^2 y_i \\ a_3\sum x_i^6 + a_2\sum x_i^5 + a_1\sum x_i^4 + a_0\sum x_i^3 = \sum x_i^3 y_i \end{cases} \quad (6)$$

For modelling the impact of SME lending on business value added the open data from State Statistic Service of Ukraine, National bank of Ukraine, Banque De France were used. These data were collected and processed through Tableau Desktop software.

Results and discussion

SME development significantly depends on the factors of the economic environment, in particular on the state policy of support and stimulation, the development of infrastructure, the ease of doing business. One of the main indicators that characterizes the level of business development is its Value Added (hereinafter VA), the dynamic trends of which are presented in Figure 1 both in national and foreign currency for small and medium-sized enterprises, respectively.

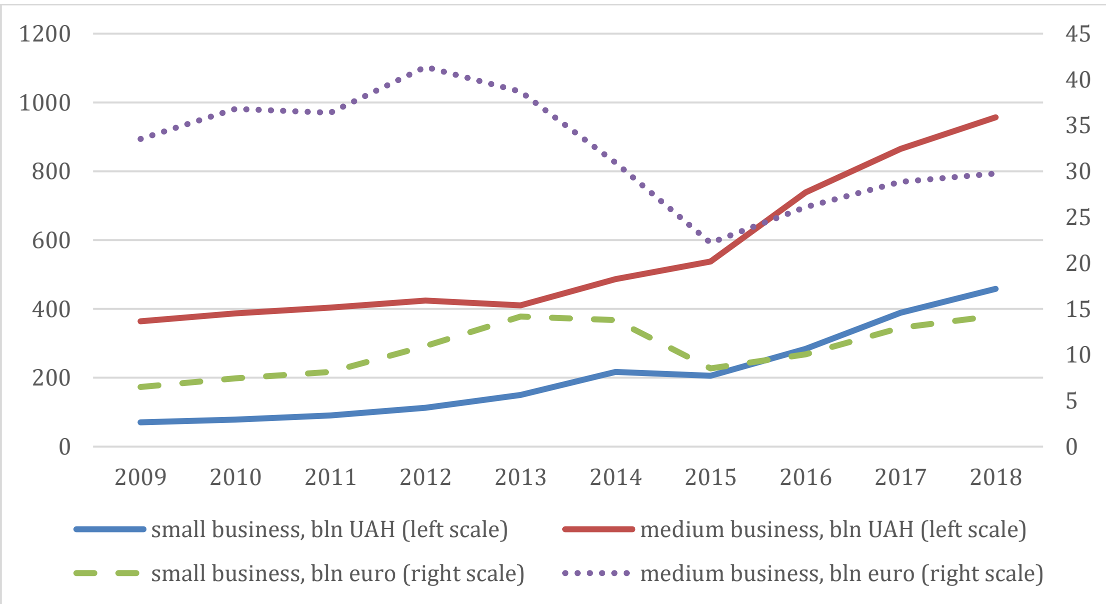

Figure 1. Dynamics of SME VA in UAH and equivalent of euro. *Source: Calculations based on [30–33].*

Bringing the level of VA to the equivalent of euro shows that its growth rate is much lower compared to the same indicator in the UAH equivalent, for both enterprise types. The difference in growth rates for 2014 and 2015 is especially noticeable:

- for small business: in the UAH equivalent the growth rate for 2014 was 44% and in the euro equivalent the rate of VA decrease was 3%; for 2015 the rate of decline in UAH was 5% and in euro equivalent about 38%;
- for medium business: the growth rate in 2014 compared to 2013 in hryvnia was 18% and in euro the rate of decrease was 20%; in 2015 the growth rate was 10.6% in hryvnia equivalent, while in the euro the rate of decrease was about 28%.

Regarding the mentioned period of 2014-2015, the economy of Ukraine was characterized by significant inflation, which explains the significant lag in the rate of SME VA change in national and foreign currency. For 2016, both small and medium business were characterized by the same trends, namely the excess of the UAH

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growth rate over the euro value by 20% and for 2017 this value was 7.8% and 6.7% for small and medium business, respectively; for 2018 - 7.8% and 7.4%. The period 2009 - 2013 was characterized by opposite trends in excess of the level of growth in euro equivalent over UAH equivalent, which indicates a higher level of business protection at the national level in terms of currency risks.

This exacerbation of inflation and currency risks did not promote business development and reduced their potential attractiveness to financial institutions in regard to obtain loans by legal entities. As well known, financial security plays a significant role in enhancing the SME sector and strengthening its capacity. So, the identification of lending to VA ratio in Ukraine and comparison with European countries, namely Austria, Belgium, Croatia, Germany, France, Italy, Spain, Poland, Portugal and Slovakia, is appropriate to determine the thresholds that indicate the level of infrastructure. The analysis was conducted separately for small and medium business (Figure 2 and 3).

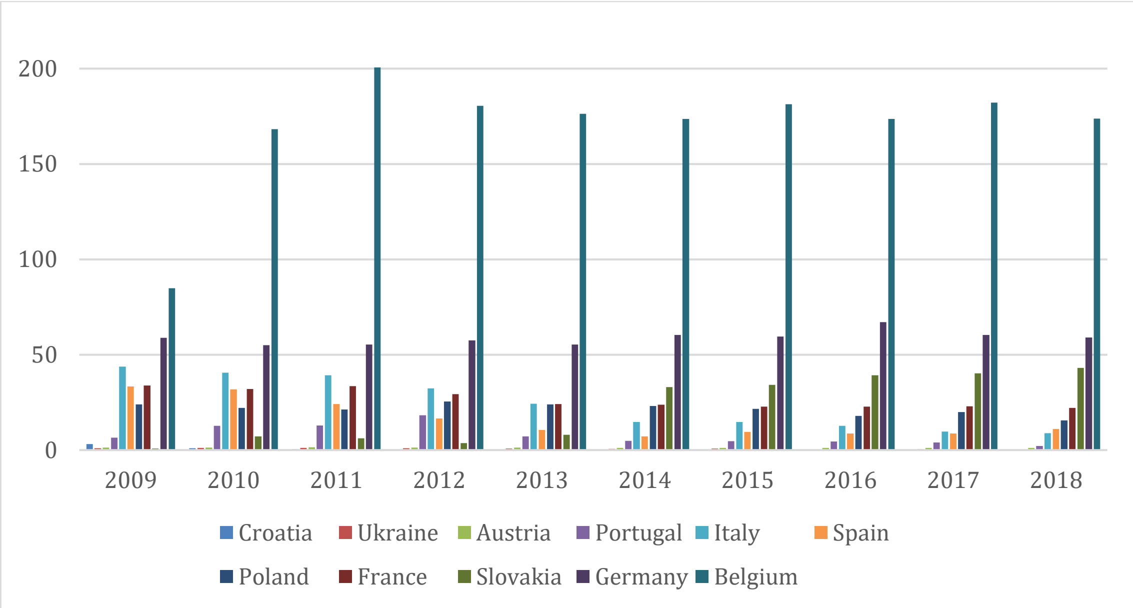

Figure 2. The ratio of loans attracted by small business to the total amount of value added, units. *Source: Calculations based on [31–34].*

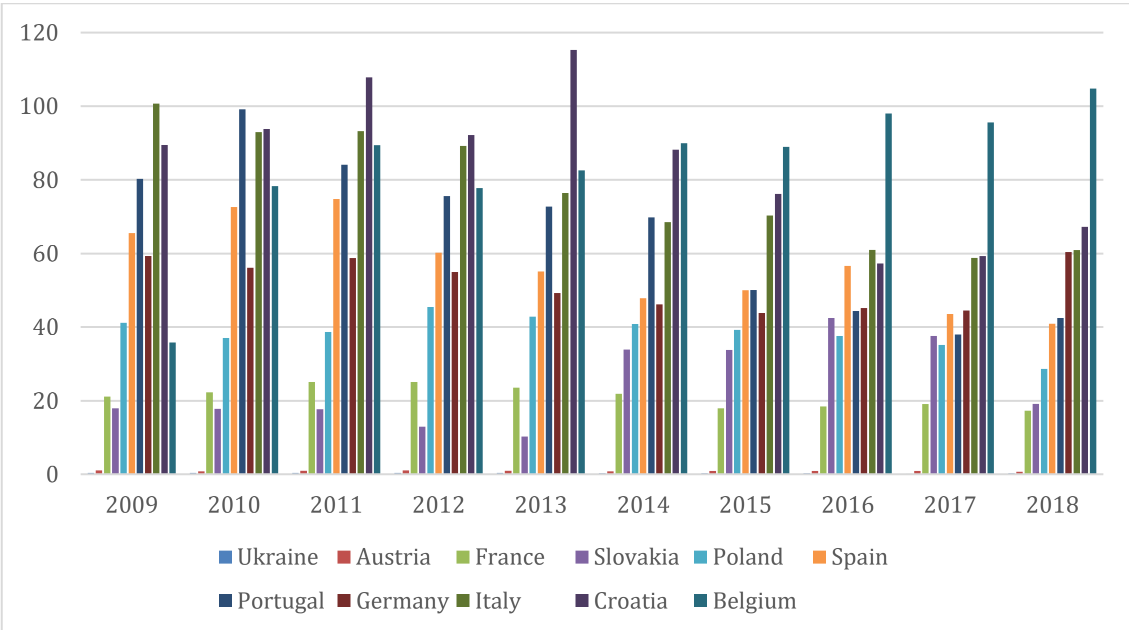

Figure 3. The ratio of loans raised by medium business to the total value added units. *Source: Calculations based on [31–34].*

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According to the calculated ratios, small business in Croatia and Ukraine is characterized by the lowest level of loans with an average for the period 2009-2018 of 0.5 and 0.7 respectively. The majority of the considered European countries have this indicator at a higher level (from 10 and above). Belgium, Germany, Slovakia and France have the highest ratios for small business, averaging 170; 59; 37 and 27 respectively, which indicates a high level of credit security for this type of enterprises. This fact may also be connected with the developed financial infrastructure and the willingness of financial institutions to lend to small business, as well as the appropriate level of state support and incentives in terms of loan guarantees, preferential interest rates and more. According to the calculations of this ratio for medium business, its values are much higher than for small ones in selected countries, which is explained by the higher level of financial stability of the entities in this sector. The exception is the value for Ukraine, which on average for 2009 - 2018 is 0.3. Austria, France and Slovakia have the lowest ratios in Europe, averaging 0.9; 21.1 and 24.3 respectively and the highest - Belgium, Croatia, Italy and Germany, which have an average ratio of 84.1; 84.7; 77.2 and 51.8 respectively. Given that most European countries have a sufficient level of credit ratio to VA, in contrast to Ukraine, it can be argued that there is a higher level of SME financial security in European countries. However, the different level of lending in the same country depending on the sector (small or medium business) is primarily related to the existing business support policy in the country.

Given the above, in order to deepen the understanding of the peculiarities of SME VA in Ukraine and find the relevant mechanisms to ensure its financing, it is advisable to carry out economic and mathematical modelling to identify dependence level between financial security and VA. Using the formula 6, we will determine the impact of changes in the volume of small business lending on the amount of its VA. Thus, using the appropriate analytical and statistical data, we determine the parameters a_0, a_1, a_2, a_3 based on the data of intermediate calculations (Annex A).

The coefficients a, b, c and d of the cubic regression equation $\hat{y} = ax^3 + bx^2 + cx + d$ determined from the system of equations, solved by the Cramer method (see details in the Annex B). Therefore, the initial cubic regression equation has the form:

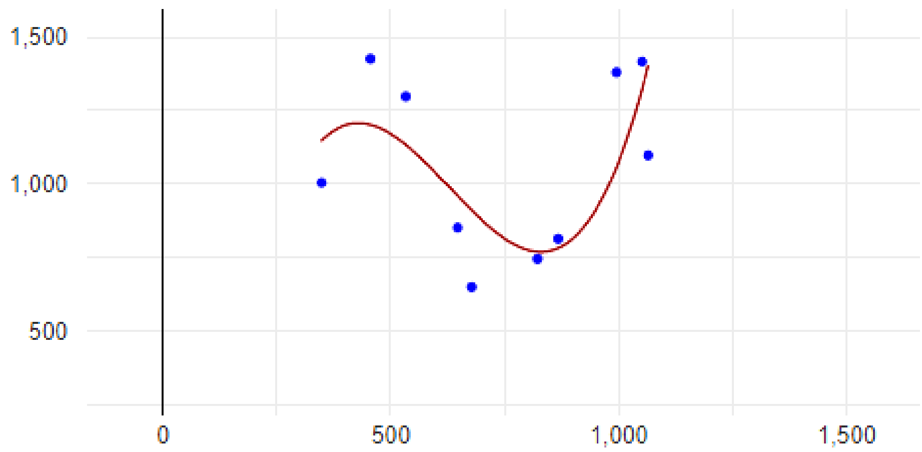
$$\hat{y} = 0{,}0257x^2 + 14{,}5489x - 1375{,}2277 \quad (7)$$

As a result of the relevant calculations, we obtain the following regression equation of the correlation between the volume of obtained loans by small business and its value added in Ukraine.

$$VA_{SE} = -0.02Cr_{SE}^2 + 14.55Cr_{SE} - 1375.23 \quad (8)$$

where:
VA_{se} - the volume of small business value added;
CR_{se} - the amount of small business loans.

The graphically illustrated dependence is presented in Figure 4.



R^2=0.7195;

F^{fact}=2.146

$F^{fact} < F^{tabl.}$

Figure 4. The relationship between the amount of lending and the added value of small business. *Source: Calculations based on [31–33].*

According to the correlation-regression analysis methodology, it is relevant to assess the adequacy of the obtained dependence. The estimation is carried out based on determining such indicators as correlation coefficient, coefficient of determination and Fisher's criterion.

The correlation coefficient determines the level (closeness) of the relationship between the two indicators and shows the level of influence of the independent variable on the dependent one. This indicator is determined by the formula (9):

$$R = \sqrt{1 - \frac{\sum(y_i - \hat{y_i})^2}{\sum(y_i - \overline{y_i})^2}}, \tag{9}$$

where:
y_i - the actual values of the dependent variable;
$\hat{y_i}$ - estimated values of the dependent variable;
$\overline{y_i}$ - the average value of the estimated values of the dependent variable.

The coefficient of determination shows the effect of the dependent variable change on the independent value and is defined as the square of the correlation coefficient. To test econometric models for adequacy it is feasible to use Fisher's criterion, which is determined by the following formula (10):

$$F = \frac{R^2}{1 - R^2} * \frac{n - k}{k - 1} \tag{10}$$

where:
R^2 - the coefficient of determination.
n - the number of observations.
k - the number of parameters of the evaluation model.
m - the number of factors in the regression equation.

To analyse the calculated value of the Fisher criterion, it is necessary to compare it with the tabular index for a certain conditional error. If Ffact > Ftable, the defined regression model is significant and corresponds as closely as possible to the actual functioning model. To determine the quantitative value of the parameters by which you can check the econometric models for adequacy, additional calculations should be performed, the results of which are presented in Annex A.

The correlation coefficient to verify the model adequacy for small business is calculated as follows:

$$R = \sqrt{1 - \frac{\sum(y_i - \hat{y_i})^2}{\sum(y_i - \overline{y_i})^2}} = \sqrt{1 - \frac{383685.9721}{795389.1174}} \approx 0.7195 \tag{11}$$

Thus, the relationship between the two parameters for small business is not strong enough, because the approximation of the correlation coefficient indicates that small business VA depends on the loan volumes, but not enough. However, the outlined relationship is logical, so it requires further research and consideration of additional factors when modelling of small business VA. The coefficient of determination is equal to:

$$R^2 = 0.7195^2 \approx 0.5176 \tag{12}$$

This means that approximately 51.76% of small business lending affects the amount of its VA. Fisher's F-criteria are defined as follows:

- Critical (tabular):

$$F_{tabl} = F(a, k_1, k_2 = F(0.05,3,6) \approx 4.7571 \tag{13}$$

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- Fact:

(14) $$F_{fact} = \frac{R^2}{1-R^2} * \frac{k_2}{k_1} = \frac{0.5176}{1-0.5176} * \frac{6}{3} \approx 2.146$$

- Since:

(15) $$k_1 = m = 3, k_2 = n - m - 1 = 10 - 3 - 1 = 6, a = 0.05$$

where:
m - the number of parameters for the variables of the regression equation.

Since Ffakt < Ftabl, it can be argued that the constructed regression model is not significant enough and does not correspond to reality. Thus, the calculated values of the correlation and determination coefficients, as well as Fisher's F test confirmed that this model should consider additional factors of influence for small business. For medium business, it is also advisable to design a model of the interdependence of value added on lending. A system of equations constructed as a result of algebraic transformations can be solved using the Cramer method.

As a result of the relevant calculations, we obtain the following equation between the volume of obtained loans by medium business and its VA in Ukraine.

(16) $$VA_{Me} = -0.08Cr_{Me}^2 + 8.15Cr_{Me} - 75{,}66$$

where:
VA_{ME} - the volume of medium business value added.
CR_{ME} - the amount of loans of medium business.

Therefore, the initial cubic regression equation has the form:

(17) $$\hat{y} = -0{,}008x^2 + 8{,}15x – 75{,}66$$

This dependence can be graphically illustrated in Figure 5. The results of additional calculations (the quantitative value of the parameters) for medium business in order to check the econometric models for adequacy are presented in Annex A.

The calculated correlation coefficient for checking the adequacy of the model for medium business lending impact on its VA in Ukraine is as follows:

(18) $$R = \sqrt{1 - \frac{\sum(y_i - \hat{y}_i)^2}{\sum(y_i - \bar{y})^2}} = \sqrt{1 - \frac{356960.3371}{3219290.4764}} \approx 0.9429$$

Thus, there is a strong relationship between the two parameters for medium business. This suggests that the amount of VA strongly depends on lending. It can be seen that the outlined relationship is logical and such a close correlation indicates the significant importance of financial security in the development of medium business (Annex C).

The coefficient of determination is equal to:

(19) $$R^2 = 0.9429^2 \approx 0.8891$$

This means that approximately 88.91% of the lending volumes of medium business affects the amount of its value added.
Fisher's F-criteria are defined as follows:

- Critical (tabular):

(20)
$$F_{tabl} = F(a, k_1, k_2) = F(0.05, 3, 6) \approx 4.7571$$

- Fact:

(21)
$$F_{fakt} = \frac{R^2}{1-R^2} \cdot \frac{k_2}{k_1} = \frac{0.8891}{1-0.8891} \cdot \frac{6}{3} \approx 16.0372$$

Since $F_{fakt} > F_{tabl}$, it can be argued that the constructed regression model is significant and true. Thus, the calculated values of the correlation coefficients, determination and Fisher's F-test allow to confirm the correctness of the defined model.

According to the obtained simulation results, it was found that there is a close relationship between the lending volume and the medium business VA (R^2 = 0.91), i.e., the growth of lending to the sector leads to an increase in business VA. At the same time, for small business there is an insufficient level of adequacy of the relationship between the volume of lending and business value added (R^2 = 0.71), which causes the expansion of the list of factors influencing the VA of small business.

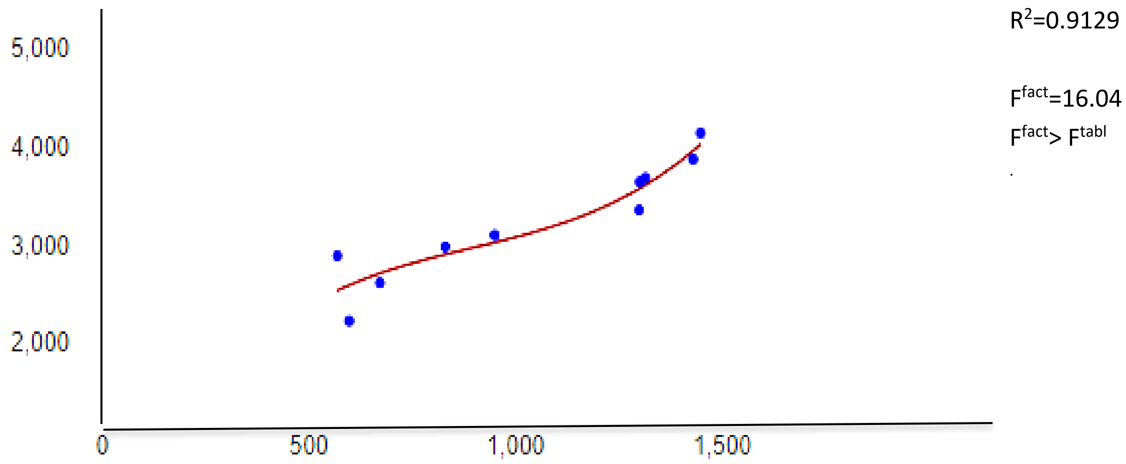

Figure 5. The relationship between the volume of lending and the value added of medium business. *Source: Calculations based on [31–33].*

Impact

The developed model is mainly aimed at value added identification for SMEs. SME sector plays the pivotal role in economic development of every country as well as in the employment level which identifies general social welfare and economic stability. It is well-known that business value added is one of the main indicators of financial solvency and profitability. Though it is important to have adequate methodic to forecast value added considering specific features of SMEs.The obtained results of SME value added modelling based on the impact of the loan volume can be used in forecasting the financial and investment potential on macroeconomic level. It could be useful not only for SMEs, but also for policymakers on macro and local level to forecast value added in SME sector and develop the adequate support policies (loan guarantees, soft loans, government loans, others) in order to business needs.

Conclusions

The obtained results of modeling of SME VA based on the impact of the loan volume can be used in forecasting the financial and investment potential on macroeconomic level. However, the insufficient density of the relationship between the volume of lending and VA for small business suggests the need to use the expanded list of influencing factors, in particular, it is proposed the following factors: equity; short-term liabilities; long-term liabilities. The designed model for medium business can be used in forecasting its development in Ukraine. It can also be argued that greater development of financial infrastructure, ensuring policies to promote SME development, including loan guarantees, soft loans, government loans are able to increase the VA of medium business in Ukraine. It is determined that it is necessary to take into account the data of non-economic impact (shadow financial flows, information asymmetry, underdeveloped infrastructure and other factors) in forecasting the value added of small business in Ukraine, which is confirmed by the results of regression-correlation analysis. The obtained results can be a basis for quantifying the level of dependence between the level of lending and the value added of small business in Ukraine and to take into account the indicator of the "shadow" sector. Further research will be devoted to the methodology development of the integrated indicator regarding shadow level of small business identification to forecast and modelling its development.

Conflict of interest
There are no conflicts to declare.

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References
[1] S. Shrivastav, Determinants for small and medium enterprises and entrepreneurship success post COVID-19, Int. J. Sci. Reports. 8 (2022) 194. https://doi.org/10.18203/issn.2454-2156.IntJSciRep20221591.
[2] T. Zhao, K. Matthews, M. Munday, Neither true nor fairweather friend: relationship banking and SME borrowing under Covid-19, Eur. J. Financ. (2022) 1–18. https://doi.org/10.1080/1351847X.2022.2092415.
[3] J. Fasth, N. Akerman, V. Elliot, M. Hilmersson, Small and medium-sized enterprises response to Covid-19: The effect of external openness and procedural management, Int. Small Bus. J. Res. Entrep. (2022) 026624262211015. https://doi.org/10.1177/02662426221101528.
[4] I.A. Elshaer, Dimensionality analysis of entrepreneurial resilience amid the COVID-19 pandemic: Comparative models with confirmatory factor analysis and structural equation modeling, Mathematics. 10 (2022) 2298. https://doi.org/10.3390/math10132298.
[5] F. Taghizadeh-Hesary, H. Phoumin, E. Rasoulinezhad, COVID-19 and regional solutions for mitigating the risk of SME finance in selected ASEAN member states, Econ. Anal. Policy. 74 (2022) 506–525. https://doi.org/10.1016/j.eap.2022.03.012.
[6] G. Cecere, N. Corrocher, M.L. Mancusi, Financial constraints and public funding of eco-innovation: empirical evidence from European SMEs, Small Bus. Econ. 54 (2020) 285–302. https://doi.org/10.1007/s11187-018-0090-9.
[7] R. Rupeika-Apoga, K. Petrovska, L. Bule, The effect of digital orientation and digital capability on digital transformation of SMEs during the COVID-19 Pandemic, J. Theor. Appl. Electron. Commer. Res. 17 (2022) 669–685. https://doi.org/10.3390/jtaer17020035.
[8] F. Eggers, Masters of disasters? Challenges and opportunities for SMEs in times of crisis, J. Bus. Res. 116 (2020) 199–208. https://doi.org/10.1016/j.jbusres.2020.05.025.
[9] M. Cowling, R. Brown, A. Rocha, Did you save some cash for a rainy COVID-19 day? The crisis and SMEs, Int. Small Bus. J. Res. Entrep. 38 (2020) 593–604. https://doi.org/10.1177/0266242620945102.
[10] A. Pinchuk, N. Tkalenko, V. Marhasova, Implementation of circular economy elements in the mining regions, E3S Web Conf. 105 (2019) 04048. https://doi.org/10.1051/e3sconf/201910504048.
[11] T. Shevchenko, R. Vavrek, Y. Danko, O. Gubanova, J. Chovancova, Clarifying a circularity phenomenon in a circular economy under the Notion of Potential, Probl. Ekorozwoju. 16 (2021) 79–89. https://doi.org/10.35784/pe.2021.1.09.
[12] A.A. Eniola, H. Entebang, SME firm performance-financial innovation and challenges, Procedia - Soc. Behav. Sci. 195 (2015) 334–342. https://doi.org/10.1016/j.sbspro.2015.06.361.
[13] S.J.M. Khan, A.R. Anuar, Access to finance, in: 2018: pp. 92–111. https://doi.org/10.4018/978-1-5225-2835-7.ch006.
[14] R. Rupeika-Apoga, A. Danovi, Availability of alternative financial resources for SMEs as a critical part of the entrepreneurial eco-system: Latvia and Italy, Procedia Econ. Financ. 33 (2015) 200–210. https://doi.org/10.1016/S2212-5671(15)01705-0.
[15] S. Muneer, R.A. Ahmad, A. Ali, Impact of financial management practices on SMEs profitability with moderating role of agency cost, Inf. Manag. Bus. Rev. 9 (2017) 23–30. https://doi.org/10.22610/imbr.v9i1.1593.
[16] J. Ye, K. Kulathunga, How does financial literacy promote sustainability in SMEs? A developing country perspective, Sustainability. 11 (2019) 2990. https://doi.org/10.3390/su11102990.
[17] A.A. El-Hamid, A. Eissa, A.M. Radwan, Financial resource as drivers of performance in small and micro enterprises in service retail Sector: A case of eldoret municipality, Uasin Gishu County,Kenya, Glob. J. Human-Social Sci. Res. 15 (2015).

[18] Y. Ivashchenko, A. Polishchuk, Machine learning in estimating of SME investment potential in Ukraine, in: Int. Conf. Inf. Commun. Technol. Educ. Res. Ind. Appl., 2018.
[19] J. von Garrel, C. Jahn, Design framework for the implementation of AI-based (service) business models for small and medium-sized manufacturing enterprises, J. Knowl. Econ. (2022). https://doi.org/10.1007/s13132-022-01003-z.
[20] P. Maroufkhani, M. Iranmanesh, M. Ghobakhloo, Determinants of big data analytics adoption in small and medium-sized enterprises (SMEs), Ind. Manag. Data Syst. 123 (2023) 278–301. https://doi.org/10.1108/IMDS-11-2021-0695.
[21] S. Onikiienko, Y. Polishchuk, A. Ivashchenko, A. Kornyliuk, N. Demchyshak, Prior credit assessment of long-term SME projects with non-standard cash flows, Banks Bank Syst. 16 (2021) 148–158. https://doi.org/10.21511/bbs.16(2).2021.14.
[22] I.V. Khovrak, M.V. Petchenko, Estimating the level of financial safety in banking institutions, Actual Probl. Econ. 164 (2015) 347–354.
[23] O. Mints, V. Marhasova, H. Hlukha, R. Kurok, T. Kolodizieva, Analysis of the stability factors of Ukrainian banks during the 2014–2017 systemic crisis using the Kohonen self-organizing neural networks, Banks Bank Syst. 14 (2019) 86–98. https://doi.org/10.21511/bbs.14(3).2019.08.
[24] D. Xiang, Y. Zhang, A.C. Worthington, Determinants of the use of fintech finance among chinese small and medium-sized enterprises, IEEE Trans. Eng. Manag. 68 (2021) 1590–1604. https://doi.org/10.1109/TEM.2020.2989136.
[25] N. Phraknoi, J. Busby, M. Stevenson, The relational focus of small and medium sized actors' understandings of supply chain finance (SCF), Int. J. Oper. Prod. Manag. 42 (2022) 1435–1466. https://doi.org/10.1108/IJOPM-03-2022-0170.
[26] G. Kou, Y. Xu, Y. Peng, F. Shen, Y. Chen, K. Chang, S. Kou, Bankruptcy prediction for SMEs using transactional data and two-stage multiobjective feature selection, Decis. Support Syst. 140 (2021) 113429. https://doi.org/10.1016/j.dss.2020.113429.
[27] Y. Zizi, M. Oudgou, A. El Moudden, Determinants and predictors of SMEs' financial failure: A logistic regression approach, Risks. 8 (2020) 107. https://doi.org/10.3390/risks8040107.
[28] P. Rao, S. Kumar, V. Madhavan, A study on factors driving the capital structure decisions of small and medium enterprises (SMEs) in India, IIMB Manag. Rev. 31 (2019) 37–50. https://doi.org/10.1016/j.iimb.2018.08.010.
[29] T. Bielialov, Risk management of startups of innovative products, J. Risk Financ. Manag. 15 (2022) 202. https://doi.org/10.3390/jrfm15050202.
[30] NBU, Official exchange rate of hryvnia to foreign currencies (average for the period), (2021).
[31] State Statistics Service of Ukraine, Activities of large, medium, small and micro enterprises: statistical yearbook 2013, (2013).
[32] State Statistics Service of Ukraine, Activities of large, medium, small and micro enterprises: statistical yearbook 2018, (2018).
[33] State Statistics Service of Ukraine, Statistical information. Activities of enterprises. Value added at the cost of production of large, medium, small and micro enterprises by type of economic activity. http://www.ukrstat.gov.ua.
[34] Banque De France, Bank for the Accounts of Companies Harmonized.

Annex A

Table 1. Intermediate calculations to find the dependence equation between the volume of lending and the volume of its value added. *Source:* ……

i	x_i	y_i	x_i^2	x_i^3	x_i^4	x_i^5	x_i^6	x_iy_i	$x_i^2y_i$	$x_i^3y_i$
Small business										
1	677.393	650.051	458861.2764	310829416.6376	210553671024.4057	142627582876235.25	96614926247281630	440339.997	298283231.6169	202054973114.6999
2	822.277	745.249	676139.4647	555973930.639	457164575764.0188	375915915865510.1	309107011550144060	612801.112	503892259.9498	414339015834.7604
3	867.61	813.45	752747.1121	653090921.9291	566628214774.89	491612305420842.3	426527752306177000	705757.3545	612322138.3377	531256810443.2111
4	1064.751	1098.114	1133694.692	1207102557.0028	1285263654671.2424	1368485761574860	1457096583122593800	1169217.9796	1244926013.012	1325536217280.5254
5	1051.508	1417.021	1105669.0741	1162619876.7309	1222504101341.5432	1285472842593443.5	1351684977769746700	1490008.9177	1566756296.9992	1647456780345.0806
6	995.128	1379.179	990279.7364	985455093.5083	980653956292.7646	975876210217706.2	971121741321525800	1372459.6399	1365773016.5463	1359118970409.735
7	646.786	850.96	418332.1298	270571364.9022	175001770819.6573	113188695341362.88	73208863505058720	550389.0146	355983909.1712	230245408677.2064
8	348.64	1004.311	121549.8496	42377139.5645	14774365937.7826	5150934940548.531	1795821957672839.8	350142.987	122073851.0016	42559827413.2067
9	532.936	1297.187	284020.7801	151364898.4612	80667803526.3404	42990776540113.766	22911332486182070	691317.651	368428063.6704	196348578540.243
10	455.866	1426.469	207813.81	94735250.2894	43186579608.4285	19687293299775.86	8974767647395622	650278.7172	296439957.6741	135136897745.0728
∑	7462.895	10681.991	6149107.9252	5434120449.6651	5036398693761.073	4821008318670400	4719043777913778000	8032713.3705	6734878737.9794	6084053479803.742
Medium business										
1	677.393	650.051	910.3445	−418.1481	174847.8335	−260.2935	67752.7043	0.4004	—	—
2	822.277	745.249	769.4438	−322.9501	104296.7671	−24.1948	585.3859	0.0325	236.0987	55742.6179
3	867.61	813.45	781.7772	−254.7491	64897.104	31.6728	1003.1671	0.0389	55.8676	3121.1847
4	1064.751	1098.114	1400.6227	29.9149	894.9012	−302.5087	91511.5402	0.2755	−334.1816	111677.3135
5	1051.508	1417.021	1322.6444	348.8219	121676.7179	94.3766	8906.9459	0.0666	396.8854	157517.99
6	995.128	1379.179	1056.1698	310.9799	96708.4982	323.0092	104334.9195	0.2342	228.6325	52272.8411
7	646.786	850.96	959.0824	−217.2391	47192.8266	−108.1224	11690.4476	0.1271	−431.1315	185874.4017
8	348.64	1004.311	1147.1131	−63.8881	4081.6893	−142.8021	20392.4388	0.1422	−34.6797	1202.6832
9	532.936	1297.187	1133.5878	228.9879	52435.4583	163.5992	26764.685	0.1261	306.4013	93881.7297
10	455.866	1426.469	1201.2053	358.2699	128357.3212	225.2637	50743.7378	0.1579	61.6645	3802.5164
∑	—	—	—	—	795389.1174	—	383685.9721	1.6014	—	665093.2782

Table 2. Additional data to determine the correlation coefficients, determination and F-criterion index. *Source: Calculations based on [42-44]*

i	x_i	y_i	$\hat{y}_i$	$y_i = \bar{y}$	$(y_i = \bar{y})^2$	ε_i	ε_i^2	A_i	$\Delta\varepsilon_i$	$(\Delta\varepsilon_i)^2$
Small business										
1	677.393	650.051	910.3445	−418.1481	174847.8335	−260.2935	67752.7043	0.4004	—	—
2	822.277	745.249	769.4438	−322.9501	104296.7671	−24.1948	585.3859	0.0325	236.0987	55742.6179
3	867.61	813.45	781.7772	−254.7491	64897.104	31.6728	1003.1671	0.0389	55.8676	3121.1847
4	1064.751	1098.114	1400.6227	29.9149	894.9012	−302.5087	91511.5402	0.2755	−334.1816	111677.3135
5	1051.508	1417.021	1322.6444	348.8219	121676.7179	94.3766	8906.9459	0.0666	396.8854	157517.99
6	995.128	1379.179	1056.1698	310.9799	96708.4982	323.0092	104334.9195	0.2342	228.6325	52272.8411
7	646.786	850.96	959.0824	−217.2391	47192.8266	−108.1224	11690.4476	0.1271	−431.1315	185874.4017
8	348.64	1004.311	1147.1131	−63.8881	4081.6893	−142.8021	20392.4388	0.1422	−34.6797	1202.6832
9	532.936	1297.187	1133.5878	228.9879	52435.4583	163.5992	26764.685	0.1261	306.4013	93881.7297
10	455.866	1426.469	1201.2053	358.2699	128357.3212	225.2637	50743.7378	0.1579	61.6645	3802.5164
∑	—	—	—	—	795389.1174	—	383685.9721	1.6014	—	665093.2782
Medium business										
1	1299.624	3351.906	3569.4801	105.3656	11101.9097	−217.5741	47338.5051	0.0649	—	—
2	1314.661	3679.257	3607.2358	432.7166	187243.6559	72.0212	5187.0468	0.0196	289.5953	83865.4335
3	1300.444	3639.469	3571.4968	392.9286	154392.8847	67.9722	4620.2181	0.0187	−4.049	16.3942
4	1447.859	4137.335	4021.795	890.7946	793515.0194	115.54	13349.4975	0.0279	47.5678	2262.6993
5	1429.85	3869.597	3956.5283	623.0566	388199.5268	−86.9313	7557.046	0.0225	−202.4713	40994.6262
6	949.852	3095.896	3021.1173	−150.6444	22693.7353	74.7787	5591.8472	0.0242	161.7099	26150.1003
7	597.67	2220.324	2583.9327	−1026.2164	1053120.0996	−363.6087	132211.3219	0.1638	−438.3874	192183.5149
8	672.326	2609.713	2705.4052	−636.8274	405549.1374	−95.6922	9156.989	0.0367	267.9166	71779.2997
9	569.138	2884.67	2530.1019	−361.8704	130950.1864	354.5681	125718.5171	0.1229	450.2602	202734.2735
10	830.24	2977.237	2898.3108	−269.3034	72524.3213	78.9262	6229.3485	0.0265	−275.6418	75978.4289
∑	—	—	—	—	3219290.4764	—	356960.3371	0.5276	—	695964.7704

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Annex B

(1)
$$\begin{cases} a\sum x_i^3 + b\sum x_i^2 + c\sum x_i + nd = \sum y_i, \\ a\sum x_i^4 + b\sum x_i^3 + c\sum x_i^2 + d\sum x_i = \sum x_i y_{i,} \\ a\sum x_i^5 + b\sum x_i^4 + c\sum x_i^3 + d\sum x_i^2 = \sum x_i^2 y_{i,} \\ a\sum x_i^6 + b\sum x_i^5 + c\sum x_i^4 + d\sum x_i^3 = \sum x_i^3 y_{i,} \end{cases} \leftrightarrow \begin{cases} 5434120449.6651a + 6149107.9252b + 7462.895c + 10d = 10681.991, \\ 5036398693761.073a + 5434120449.6651b + 6149107.9252c + 7462.895d = 8032713.3705, \\ 4821008318670400a + 5036398693761.073b + 5434120449.6651c + 6149107.9252d = 6734878737.9794, \\ 4719043777913778000a + 4821008318670400b + 5036398693761.073c + 5434120449.6651d = 6084053479803.742 \end{cases}$$

(2)
$$\Delta = \begin{vmatrix} 5434120449.6651 & 6149107.9252 & 7462.895 & 10 \\ 5036398693761.073 & 5434120449.6651 & 6149107.9252 & 7462.895 \\ 4821008318670400 & 5036398693761.073 & 5434120449.6651 & 6149107.9252 \\ 4719043777913778000 & 4821008318670400 & 5036398693761.073 & 5434120449.6651 \end{vmatrix} = 1.0340950915396628e + 32$$

(3)
$$\Delta a = \begin{vmatrix} 10681.991 & 6149107.9252 & 7462.895 & 10 \\ 8032713.3705 & 5434120449.6651 & 6149107.9252 & 7462.895 \\ 6734878737.9794 & 5036398693761.073 & 5434120449.6651 & 6149107.9252 \\ 6084053479803.742 & 4821008318670400 & 5036398693761.073 & 5434120449.6651 \end{vmatrix} = 1.4098769082675717e + 27 \Longrightarrow a$$

(4)
$$a = \frac{\Delta a}{a} = \frac{1.4098769082675717e + 27}{1.0340950915396628e + 32} \approx 0$$

(5)
$$\Delta b = \begin{vmatrix} 5434120449.6651 & 10681.991 & 7462.895 & 10 \\ 5036398693761.073 & 8032713.3705 & 6149107.9252 & 7462.895 \\ 4821008318670400 & 6734878737.9794 & 5434120449.6651 & 6149107.9252 \\ 4719043777913778000 & 6084053479803.742 & 5036398693761.073 & 5434120449.6651 \end{vmatrix} = -2.66097556361248e + 30 \Longrightarrow b$$

(6)
$$b = \frac{\Delta b}{b} = \frac{-2.660975563612448e + 30}{1.0340950915396628e + 32} \approx -0.0257$$

(7)
$$\Delta c = \begin{vmatrix} 5434120449.6651 & 6149107.9252 & 10681.991 & 10 \\ 5036398693761.073 & 5434120449.6651 & 8032713.3705 & 7462.895 \\ 4821008318670400 & 5036398693761.073 & 6734878737.9794 & 6149107.9252 \\ 4719043777913778000 & 4821008318670400 & 6084053479803.742 & 5434120449.6651 \end{vmatrix} = 1.5044993446049503e + 33 \Longrightarrow c$$

(8)
$$c = \frac{\Delta c}{c} = \frac{1.5044993446049503e + 33}{1.0340950915396628e + 32} \approx 14.5489$$

(9)
$$\Delta d = \begin{vmatrix} 5434120449.6651 & 6149107.9252 & 7462.895 & 10681.991 \\ 5036398693761.073 & 5434120449.6651 & 6149107.9252 & 8032713.3705 \\ 4821008318670400 & 5036398693761.073 & 5434120449.6651 & 6734878737.9794 \\ 4719043777913778000 & 4821008318670400 & 5036398693761.073 & 6084053479803.742 \end{vmatrix} = -1.4221162020857555e + 35 \Longrightarrow d$$

(10)
$$d = \frac{\Delta d}{d} = \frac{-1.4221162020857555e + 35}{1.0340950915396628e + 32} \approx -1375.2277$$

Annex C

(1)

$$\begin{cases} a\sum x_i^3 + b\sum x_i^2 + c\sum x_i + nd = \sum y_i, \\ a\sum x_i^4 + b\sum x_i^3 + c\sum x_i^2 + d\sum x_i = \sum x_i y_{i,} \\ a\sum x_i^5 + b\sum x_i^4 + c\sum x_i^3 + d\sum x_i^2 = \sum x_i^2 y_{i,} \\ a\sum x_i^6 + b\sum x_i^5 + c\sum x_i^4 + d\sum x_i^3 = \sum x_i^3 y_{i,} \end{cases} \leftrightarrow \begin{cases} 14755957504.0559a + 11973944.4115b + 104115.664c + 10d = 32465.404, \\ 19000231983943.36a + 14755957504.0559b + 11973944.4115c + 10411.664d = 35585178.2969, \\ 25134040398632910a + 19000231983943.36b + 14755957504.0559c + 11973944.4115d = 42512235496.7012, \\ 33809438665908510000a + 25134040398632910b + 19000231983943.36c + 14755957504.0559d = 53746960697724.61 \end{cases}$$

(2)

$$\Delta = \begin{vmatrix} 14755957504.0559 & 11973944.4115 & 10411.664 & 10 \\ 19000231983943.36 & 14755957504.0559 & 11973944.4115 & 10411.644 \\ 25134040398632910 & 19000231983943.36 & 14755957504.0559 & 11973944.4115 \\ 33809438665908510000 & 25134040398632910 & 19000231983943.36 & 14755957504.0559 \end{vmatrix} = 1.817588096446771e + 33$$

(3)

$$a = \begin{vmatrix} 32465.404 & 11973944.4115 & 10411.664 & 10 \\ 35585178.2969 & 14755957504.0559 & 11973944.4115 & 10411.644 \\ 42512235496.7012 & 19000231983943.36 & 14755957504.0559 & 11973944.4115 \\ 53746960697724.61 & 25134040398632910 & 19000231983943.36 & 14755957504.0559 \end{vmatrix} =3.494444939093879e + 27 \Longrightarrow a$$

(4)

$$a = \frac{\Delta a}{a} = \frac{3.494444939093879e + 27}{1.8117588096446771e + 33} \approx 0$$

(5)

$$\Delta b = \begin{vmatrix} 14755957504.0559 & 32465.404 & 10411.664 & 10 \\ 19000231983943.36 & 35585178.2969 & 11973944.4115 & 10411.664 \\ 25134040398632910 & 42512235496.7012 & 14755957504.0559 & 11973944.4115 \\ 33809438665908510000 & 53746960697724.61 & 19000231983943.36 & 14755957504.0559 \end{vmatrix} =-9.399670927024799e + 30 \Longrightarrow b$$

(6)

$$b = \frac{\Delta b}{b} = \frac{-9.399670927024799e + 30}{1.8117588096446771e + 33} \approx -0.008$$

(7)

$$\Delta c = \begin{vmatrix} 14755957504.0559 & 11973944.4115 & 32465.404 & 10 \\ 19000231983943.36 & 14755957504.0559 & 35585178.2969 & 10411.664 \\ 25134040398632910 & 19000231983943.36 & 42512235496.7012 & 11973944.4115 \\ 33809438665908510000 & 25134040398632910 & 53746960697724.61 & 14755957504.0559 \end{vmatrix} = 9.628393262594711e + 33 \Longrightarrow c$$

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(8)
$$c = \frac{\Delta c}{c} = \frac{9.628393262594711e + 33}{1.8117588096446771e + 33} \approx 8.1475$$

(9)
$$\Delta d = \begin{vmatrix} 14755957504.0559 & 11973944.4115 & 10411.664 & 32465.404 \\ 19000231983943.36 & 14755957504.0559 & 11973944.4115 & 35585178.2969 \\ 25134040398632910 & 19000231983943.36 & 14755957504.0559 & 42512235496.7012 \\ 33809438665908510000 & 25134040398632910 & 19000231983943.36 & 53746960697724.61 \end{vmatrix} = -8.940621789553508e + 34 \Longrightarrow d$$

(10)
$$d = \frac{\Delta d}{d} = \frac{-8.940621789553508e + 34}{1.8117588096446771e + 33} \approx -75.6552$$

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