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ECONOMETRIC MODELLING OF THE IMPACT OF METROLOGY ON THE ECONOMY IN POLAND

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Abstract

Research background: Studying the impact of metrology on the economy is a complicated matter. This is due to the specific nature of both metrology and the economy. There is no established method for determining the impact of metrology on the economy.
Purpose: The paper attempts to build an econometric model to determine the impact of metrological activity on the economy of Poland.
Research methodology: In the first part of the study, a proxy variable measuring metrological activity was proposed. Then a multiple-equation nonlinear econometric model was built. This is a dynamic model, estimated by the 2SLS method.
Results: Based on simulations, the impact of metrological activity on variables such as GDP and R&D spending was determined. The results of simulations using the obtained model show that the average annual share of metrology in global labor productivity in Poland from 2002 to 2020 was at 9.4%. As regards the second variable (the share of R&D spending in GDP), the average annual share of metrology is 7.4%.
Novelty: In the paper an econometric estimation of metrology impact on the economy based on a multiple-equation nonlinear econometric model was proposed.

Keywords: metrology, impact of metrology on economy, econometric models, systems of equations

JEL classification: C30, C32, C51, C52, L15, O33

Introduction

Metrology is a very broad concept, covering many aspects of the economic system's operations. The impact of metrology on the economy seems intuitively obvious, but to measure this impact is not so simple. It is important to be aware of what the economy is and what are the processes that characterize it. The economy is a complex environment where many interrelated processes take place, resulting from operations involved in the production of goods and services in order to meet the needs of social (e.g., the population of a country, region or the world) and economic actors (entities operating in the economy, such as companies, institutions). The production of goods or services is associated with the industry within which the goods or services occurs. The quality of goods and services is closely related to the degree of the local economic development, and, consequently, to the advancement of technology and techniques employed in the production processes. It is worth noting that recent years have been marked by the rapid transformation of the industrial sector, resulting from the current fast changes in production techniques and technologies. Analysts call this process the fourth industrial revolution, or "Industry 4.0". As far as the economy is concerned, such a situation is desirable both in terms of its development and competitiveness. Given that inertia and synergy processes occur naturally in the economy, the key in this regard is to invest in R&D and innovation. The inertia of economic processes is associated with the swiftness of response to changes and adaptation to changing conditions. This is a very complex issue linked to the pace of economic development. Synergy, on the other hand, results from the interrelationships that exist in the economy between sectors and/or their cooperation. The synergy is related to the fact that the economy is a system of 'communicating vessels'.

At the same time, there is a natural need in the economy for efforts to protect the economy to secure not only its competitiveness, but also its functioning, including its development. One of the areas that should be considered crucial in this regard is metrology.

According to the International Bureau of Weights and Measures (BIPM), metrology is the science of measurement, including both experimental and theoretical determinations at any level of uncertainty in any field of science and technology. Today, metrology is also defined as the science of ensuring, by technical and organizational means, the correctness of measurements in all fields of science, technology and the economy (Jakubiec et al. 2014). Within metrology, the following are distinguished: industrial, research and legal metrology (Figure 1).

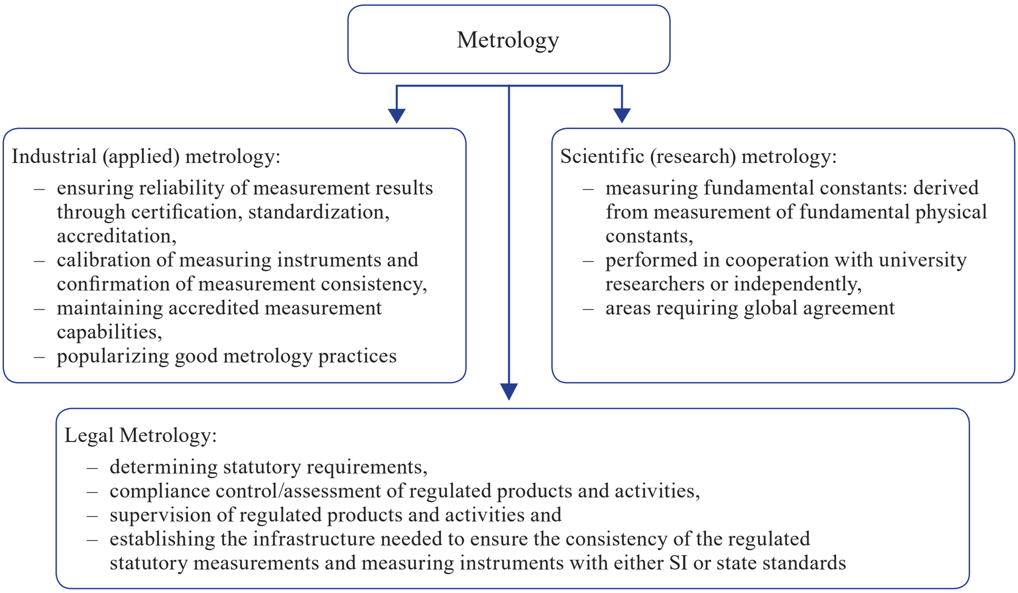

Figure 1. Branches of metrology

Source: own studies based on references.

Central to metrology is measurement, but there are many more levels within metrology, which indicates how complex the nature of metrology is. This is confirmed by the metrology division diagram shown in Figure 1. Also important is the functionality of metrology, related not only to measurement, reliability of measurement results or standardization of measurements, but to metrology infrastructure. In the general sense, metrology infrastructure is a kind of background thanks to which metrology functions and can develop. It is a complex system of interactions that encompasses all components and activities related to measurement. These include, for example, metrology laboratories, adopted and developed measurement standards or accreditations. Measurement machinery and equipment should also be considered as part of infrastructure.

The connection between metrology and the economy stems from the very definition of metrology, its functionality and the metrology's interaction with the economy, particularly on the sphere of production. For metrology to function effectively, the right conditions must be present in the economy, specifically such a level of economic development that allows the metrology infrastructure to function efficiently. While it is clear from the literature that the economy and metrology are interrelated (Chyla, 2014), it is still an open question to measure its impact on the economy.

The purpose of the study is to attempt to measure the impact of metrology on the economy in Poland using an econometric model. The study extracted a specific set of economic variables, which enabled the construction of a multivariate model to measure the impact of metrology on the economy. By introducing certain approaches and operations on the model, a metrology variable has been identified that is relevant to assessing the impact of metrology on the economy. The proposed approach fills an existing gap in the literature for measuring the impact of metrology on the economy. Given the assumptions applied, the study is novel in the subject area in question.

1. Literature review

The literature provides numerous examples of the successful estimation of econometric models that indicate the positive impact of metrology on the economy.

Mansfield's (1991, 1992) study of the impact of academic research results employed by 76 U.S. companies in seven industries found that their rates of return ranged from 22–28%. Mansfield used information from companies on the relevance of recent academic research to their innovation, the time lag between the research and the first commercialization of a relevant product, and the total sales of each relevant product to calculate the rough estimates of a company's return on academic research. In particular, he found that about 10% of new products and processes could not have been developed if not for the most recent academic research.

NIST (2003) prepared a summary of 29 case studies on the economic impact of various measurement activities. These are case studies conducted by either NIST or by consultants on behalf of NIST. Each summary lists the key mechanisms by which measurements were found to produce economic benefits such as increased productivity, higher R&D efficiency, reduced transaction costs, energy cost savings and better product quality.

Spencer and Williams (2002) describe the scope and dimensions of measurement and testing activity in the EU. Funding for the turnover of accreditation services, certification costs and expenditures on measurement and instrumentation are tabulated for each EU country, and internal industry expenditures on measurement are estimated at 1% of total industry costs. Expenses for legal metrology and social expenditure have not been included. Total spending on measurement in the EU amounts to 0.98% of GDP. Total gains include application benefits which are derived from econometric estimates of the contribution of measurement to aggregate final demand (GDP), and knowledge benefits which are derived from econometric estimates of the contribution of measurement knowledge to economic growth. The total benefits come to 2.67% of GDP, giving a benefit-cost ratio of 2.73.

Griliches (1987) analyzed the contribution of R&D to productivity and economic growth. He considered the value of the number of patents in such studies. Patent statistics have the advantage of their relative abundance, ease of access and objective legal definition. The value associated with patents varies widely, with most patents having little or no real value, while at the same time a much smaller proportion of patents carry substantial economic returns. This makes it difficult to make the number of patents an indicator of the "results" of R&D activities, unless at a highly aggregated level.

An empirical analysis by Link (2021) combined information on the extent of use of instruments and standards across 97 industries into a single variable designed to approximate the strength of an industry's relationship with the National Measurement System. Regression models of the five innovation measures included in the surveys were employed to estimate the marginal probabilities associated with the measurement intensity index. It turned out that a hypothetical company (similar in all other respects) experiencing a richer measurement environment – corresponding to one quartile of the distribution of standards or instrument coverage in its industry – experienced increased probability of being innovatively active by about 0.024.

Blind et al. (2012) estimated a model where the dependent variable was economic growth, and the independent variables were gross fixed assets (capital), number of people employed (labor force), number of patents, license spending, and number of standards. They found that patents, licensing expenditures and standards have a positive effect on economic growth. It was also shown that after German reunification, standards had a stabilizing effect on economic growth equivalent to about 0.7–0.8% of the country's Gross Domestic Product.

Temple and Williams (2002) examined the impact on the U.K. economy of measurement activities that supply the underlying technology or infra-technology for a diverse set of economic activities. Drawing on data on R&D, patents and input-output relationships, they traced the nature and extent of the spillover effects of measurement technologies on the economy in a broader sense. The results have shown that the measurement-related R&D has a significant effect, equivalent to about 2% of GDP. These benefits apply to the economy as a whole but are particularly important for certain high-tech and other industries. The presence of measurement infrastructure is also important for promoting investment and exports.

Miotti (2009) employed an econometric analysis to analyze data provided by the survey of French companies and found that the contribution of standards to GDP growth between 1950 and 2007 was positive and statistically significant. Two-thirds (66%) of respondents associated voluntary standards with a benefit to their organization, while 34% associated them with a cost. The author starts from the transformation of the Cobb-Douglas function and shows that the increase in total factor productivity (technical progress) can be explained by the vitality of such factors as the standards portfolio robustness as well as scientific and technological knowledge. He also concludes that there is a close relationship between innovation and technical progress and their diffusion, and that this diffusion can be approximated by standardization activities.

Stokes et al. (2011) examined the relationship over time between changes in labor productivity and the number of standards. Using an econometric model, they tested the hypothesis that there was a positive relationship between the number of standards and the level of labor productivity in New Zealand. In this approach, the net benefit to the economy was measured by the number of standards published in a given year. The contribution of the number of standards to TFP growth between 1978 and 2009 was positive and statistically significant. In contrast, a 1.0 percent increase in the number of standards leads to a 0.054 percent increase in labor productivity.

2. Scientific problems and metrology activity measurement indicators

The number of publications on metrology was taken as a proxy variable indicating the intensity of metrology activity. This is justified for several reasons:

1. Metrology education and research indicator: the number of metrology publications is a measure of scientific and research activity in the field of metrology. This is important because the development of this field requires continuous expansion of knowledge, research and result sharing in the scientific community. A growing number of publications can indicate intensified research and education in metrology.
2. An indicator of innovation and technological development: metrology plays a key role in ensuring the quality of products, services as well as innovation in various sectors of the economy. The number of metrology publications can reflect a country's level of innovation and technological advancement, as new developments and technologies often require new developments in metrology.
3. Metrology awareness and understanding index: as metrology becomes increasingly essential to economic development, it is important that the public, businesses and policymakers have a proper awareness and understanding of the subject. The number of metrology publications can help assess how well metrology is understood and appreciated by the general public, which can have an impact on relevant policies and investments.

In the context of this article, the variable *Number of Publications on Metrology* is defined as the number of scientific articles and publications that deal with metrology or are directly related to it. The choice of this variable as an indicator of metrology activity can help researchers analyze how advanced the discipline of metrology is in Poland and what is its potential impact on the economic growth. Ultimately, the analysis of this variable can provide valuable information on the role of metrology in shaping the country's economy and provide a basis for assessing its impact on economic indicators such as GDP and R&D spending.

In order to determine the impact of the number of metrology publications, adopted as a metrology variable, on economic development in Poland, the key scientific problems can be defined as follows:

1. Understanding and quantifying the role of metrology in the context of economic development: the scientific problem is to determine how the number of metrology publications can serve as an indicator of metrology's impact on Poland's economy. In evaluating this variable, it was sought to understand how metrology contributes to

labor productivity and how it affects the share of research and development (R&D) spending in the country's economic productivity.

2. Identifying the mechanisms by which metrology impacts economic indicators: the second problem is to identify the specific mechanisms by which metrology impacts the economy. This includes analyzing how metrology can improve the quality of products and services, increase innovation and the efficiency of production processes, resulting in higher GDP and more R&D spending.
3. Forecasting the future impact of metrology: in the context of long-term economic policies, it is essential to forecast how developing metrology can affect Poland's future economic growth. Studies on this problem help to plan investments and activities in the field of metrology that can accelerate the country's economic growth.

A valuable study in this respect can provide guidance to politicians, scientists and entrepreneurs on what actions to take to use metrology as an effective tool to support Poland's economic growth.

2.1. Methodology for selecting publications from the journal list

Our methodology for selecting publications for further research includes a selection criterion based on CiteScore and filtering by keywords directly related to metrology.

Preliminary search: we began our analysis by conducting a preliminary bibliographic search in the SCOPUS database. We chose *metrology* as a keyword and limited the time limit to the period from 1930 to 2023. This initial search yielded more than 48,000 documents related to metrology. We decided to use the SCOPUS database for several important reasons. SCOPUS is one of the largest and most comprehensive bibliographic sources, containing scientific publications in various fields. It is a popular tool in scientific research. In addition, the SCOPUS database is international in scope, making it possible to analyze the impact of metrology on the development of different countries internationally.

The preliminary analysis of the data included the number of publications by year, the number of publications by country/territory, the affiliations of institutions in the publications, as well as the number of publications by source (journal). As a result of the preliminary analysis, we identified journals (of questionable reputation) whose average CiteScore count from 2011 was less than 1. The CiteScore calculation is based on the number of citations of documents (articles, reviews, conference papers, chapters in individual books and papers) by a journal over four years, divided by the number of the same types of documents indexed in Scopus and published in the same four years. For example, CiteScore 2022 sums the citations received in

2019–2022 to articles, reviews, conference papers, book chapters and documents published in 2019–2022, and divides this by the number of these documents published in 2019–2022. CiteScore thus allows one to identify a journal's policy of indiscriminately publishing content that is not read by an audience (readers). Such content is not recognized because it is not cited as they are of questionable quality. We decided to eliminate from further analysis the journals with CiteScore<1. Having eliminated journals with low CiteScore, the remaining number of publications was 31,600 items, which formed the basis for further analysis. We then conducted a keyword analysis on the set of 31,600 items. We extracted keywords directly related to metrology:

- Metrology
- Units of Measurement
- Measurements
- Calibration
- Uncertainty Analysis
- Measurement
- Uncertainty
- Measurement Uncertainty
- National Metrology Institutes
- Errors
- Traceability
- Error Analysis

In the next step, we applied data filtering, selecting the above-mentioned keywords related to metrology. Our goal was to obtain information that would enable an independent comparison of Polish metrology with the activities in other countries, focusing on differences in the activities of National Metrology Institutes (NMIs). After applying a keyword filter and eliminating journals with a low CiteScore, we obtained a final dataset of about 11,500 documents. This collection forms the basis for further research into the impact of metrology on economic and scientific development.

Our methodology for selecting publications from the SCOPUS database is based on accuracy, international coverage and CiteScore. The final dataset of 11,500 items enables us to investigate the impact of metrology on various scientific and economic fields. This is an important research tool for a thorough understanding of the role of metrology internationally.

3. Data and research results

The following variables were used in the study:

y_t – GDP per employee (thousands of PLN/person),

c_t – capital to labor ratio (gross stock of fixed assets/person – thousand PLN/person),

$gerd_t$ – share of R&D spending in GDP,

m_t – number of publications on metrology topics.

Variables in value terms were adjusted for inflation (using the GDP deflator) and expressed in prices at 2020 levels. All variables are in logarithmic form (natural logarithm). The dynamics of the variables are shown in the graphs below.

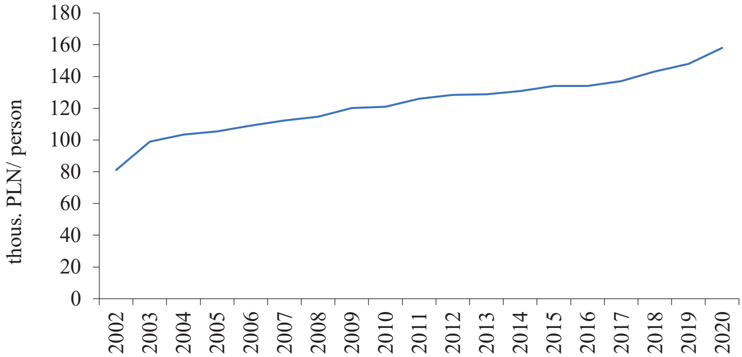

Figure 2. GDP per employed person in Poland from 2002 to 2020 (thousand PLN/person, 2020 prices)

Source: own elaboration.

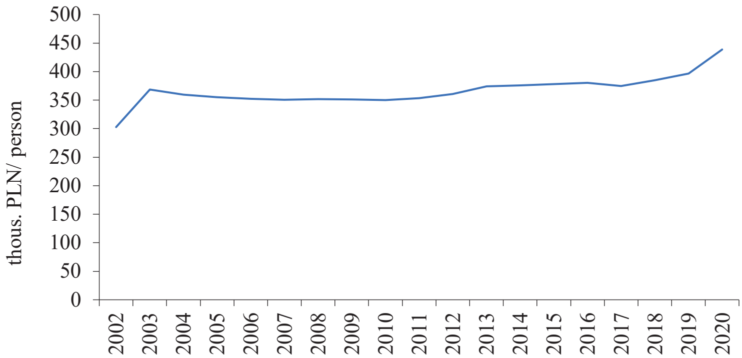

Figure 3. Gross fixed capital stock per employee in Poland from 2002 to 2020 (thousand PLN/person, 2020 prices)

Source: own elaboration.

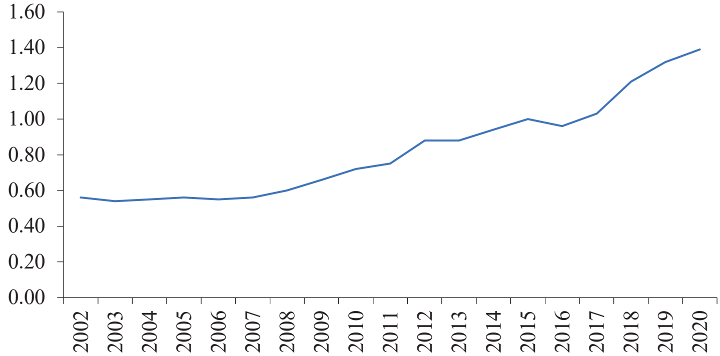

Figure 4. Share of R&D spending in GDP in Poland from 2002 to 2020

Source: own elaboration.

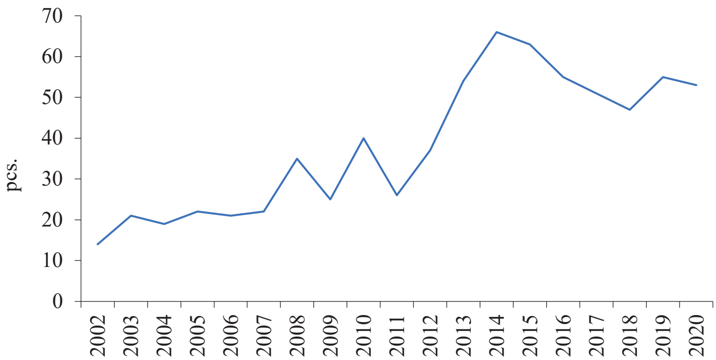

Figure 5. Number of publications on metrology in Poland from 2002 to 2020

Source: own elaboration.

Analyzing the dynamics of variables, it can be seen that they showed quite stable growing trends. The smallest increase was observed in capital per employee. The number of metrological publications showed the greatest variability.

A dynamic model was estimated, with one-period lagged endogenous variables. The parameters of each model equation were ambiguously identifiable (2MNK was used). Predetermined variables were taken as instruments: y_{t-1}, m_{t-1}, $gerd_{t-1}$, c_t. These were the lagged endogenous variables and the non-lagged exogenous variable c_t.

The estimated model took the following form:

$$\hat{y}_t = 0,084 m_t + 0,504 y_{t-1} + 0,486 c_t - 0,767, \overline{R}^2 = 0,938, \quad \hat{\rho} = 0,193 \tag{1}$$

$$\hat{m}_t = 2,077 y_t + 0,274 m_{t-1} - 7,389,\ \overline{R}^2 = 0,710, \quad \hat{\rho} = -0,087 \tag{2}$$

$$\widehat{gerd}_t = 0,791 y_t + 0,732 gerd_{t-1} - 3,837, \overline{R}^2 = 0,981, \quad \hat{\rho} = -0,176 \tag{3}$$

Equation (1) is a modified Cobb-Douglas production function. The Cobb-Douglas function has the power function form, but equations (1–3) have linear form. The reason is that all variables in the model (1–3) were transformed (logarithmized).

The above model introduces a variable that measures metrological activity (m_t) and lagged endogenous variables y_{t-1}, $gerd_{t-1}$. The parameter estimates of the model (1–3) are elasticities (all variables are logarithmized). Based on equations (1–2), it can be inferred that there is a positive relationship between the variables m_t and y_t.

It must be stated that there is no belief that the variable m_t (number of articles on metrology) has content related indirectly to macroeconomic variables (e.g. affecting GDP). However, it was assumed that variable m_t could be treated as a proxy for metrological activity. We are aware that even a high dependence between m_t and macroeconomic variables does not prove causative relationships. However, it could – to some extent – prove relationships between metrological activities and economic activity (on the macroeconomic level).

Based on parameter evaluations with lagged endogenous variables (y_{t-1}, m_{t-1}, $gerd_{t-1}$) it can be seen that these variables are characterized by a rather strong inertia. One can also note the positive effect of the variable c_t on y_t (equation 1) and y_t on $gerd_t$ (equation 3). The fit of the theoretical values determined from the individual equations of the model to the empirical values is quite good. The adjusted coefficient of determination $\overline{R}^2$ for the individual equations ranged from 0.710 to 0.981. The autocorrelation coefficients of the first-order residuals $\hat{\rho}_1$ were low. Their absolute values oscillated in the range of 0.087–0.193, indicating very weak autocorrelation of the residuals. Detailed estimation results are shown in Table 1.

It can be seen that for the adopted level of significance $\alpha = 0.1$ most of the parameters of the model (1–3) are significantly different from zero. As we can see, the significance level was inflated to 0.1 and not all parameters were statistically significant. However, the number of observation (and the number of degrees of freedom) is quite low. A small sample size was also the reason of not performing other statistical test verifying model quality (normality of residual test, autocorrelation tests, etc.). Verification is mostly based on the determination ratio of each equation. Also, first-order autocorrelation coefficients are provided.

Table 1. Model estimation results

Equation	Endogenous variable	Independent variables	Coefficients	Estimation errors	P-value
1	y_t	m_t	0.084	0.064	0.206
		y_{t-1}	0.504	0.150	**0.005**
		c_t	0.486	0.195	**0.026**
		const	–0.767	1.286	0.560
2	m_t	y_t	2.077	0.988	**0.053**
		m_{t-1}	0.274	0.261	0.311
		const	–7.389	3.971	**0.083**
3	$gerd_t$	y_t	0.791	0.310	**0.022**
		$gerd_{t-1}$	0.732	0.132	**<0.001**
		const	–3.837	1.528	**0.024**

Statistically significant parameters (significance level 0.1) are marked in bold.

Source: own elaboration.

In the Hausman test, which verifies the hypothesis that the parameter estimators are consistent, the p-values for individual equations of the model were equal 0.011; 0.060; 0.337, respectively. Hence, we can state that estimators are consistent only for the significance level $\alpha = 0.01$.

In the Sargan test, which verifies the hypothesis of the validity of the instruments, the p-values for the individual equations of the model were 0.6; 0.387; 0.3, respectively. Therefore, on the significance level $\alpha = 0.1$ we could assume that the instruments were correctly specified.

In summary, the model (1–3) has some drawbacks but it might be applicable in the analysis of the impact of metrological activity on other endogenous variables (y_t, $gerd_t$).

In the model (1–3) there are feedbacks between the variables y_t, m_t. The variable y_t also interacts with the variable $gerd_t$. To determine the impact of metrological activity on the other endogenous variables, a reduced form of the model was used, where the non-lagged endogenous variables depend only on predetermined variables, i.e. the lagged endogenous variables y_{t-1}, m_{t-1}, $gerd_{t-1}$ and on the exogenous variable c_t. The transition from the structured form (1–3) to the reduced form (5–7) is aimed at eliminating feedbacks between non-lagged endogenous variables. Without eliminating simultaneous feedbacks between non-lagged endogenous variables, we cannot directly determine the impact of these variables, such as the impact of the variable m_t on y_t, because simultaneously y_t affects m_t. Having eliminated the feedbacks between the non-lagged endogenous variables, we are able to determine the direct interaction between variables.

If the parameters of the structural form of the model are known, the parameters of the reduced form can be determined from the relationship

$$\boldsymbol{\pi} = -\mathbf{B}^{-1}\mathbf{G} \tag{4}$$

where

$\boldsymbol{\pi}$ – parameter matrix of the reduced model form of dimension [3×5],

B – parameter matrix with non-lagged endogenous variables of dimension [3×3],

G – parameter matrix with predetermined variables of dimension [3×5].

The relationship (4) allows the transition from the structural form to the reduced form. The transition from reduced to structural form is possible only if the model equations are identifiable. Parameters of the structural form were estimated which were later used in estimating parameters of the reduced form. At first, by means of 2STS, structural parameters were estimated. Then on the basis of relation (4) reduced form was obtained. The reason was the elimination of feedbacks between endogenous variables. Finally, reduced form enabled the estimation of the metrology impact.

Based on the evaluations of the model parameters (1–3) and the relationship (4), the following reduced form of the model was obtained

$$\hat{y}_t = 0,612y_{t-1} + 0,028m_{t-1} + 0,589c_t - 1,687 \tag{5}$$

$$\hat{m}_t = 1,271y_{t-1} + 0,332m_{t-1} + 1,224c_t - 10,893 \tag{6}$$

$$\widehat{gerd}_t = 0,484y_{t-1} + 0,022m_{t-1} + 0,732gerd_{t-1} + 0,466c_t - 5,171 \tag{7}$$

The reduced form of the model (5–7) does not include feedbacks between non-lagged endogenous variables. The parameter estimates at the variable $gerd_{t-1}$ in equations (5) and (6) are zero, so this variable was omitted from these equations. Model (5) was not statistically verified because its parameters were not indirectly estimated. They were obtained on the basis of the relation (4).

The empirical and theoretical values of the non-lagged endogenous variables, determined from the reduced form of the model, are shown in Figures 6–8. The theoretical values were determined by substituting the empirical values of the variables into the reduced model (5–7).

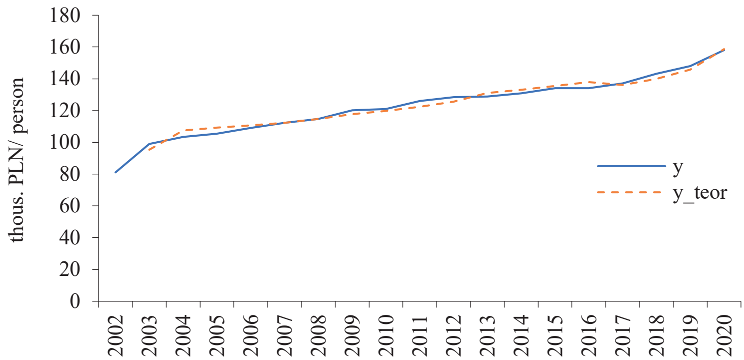

Figure 6. Empirical and theoretical values of the variable y_t (GDP per employee) from 2002 to 2020

Source: own elaboration.

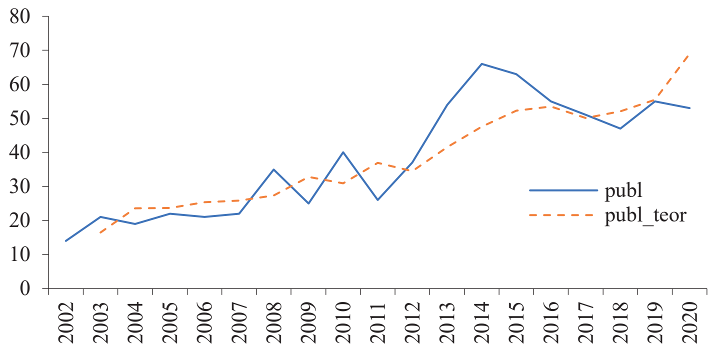

Figure 7. Empirical and theoretical values of the variable m_t (number of publications on metrology) from 2002 to 2020

Source: own elaboration.

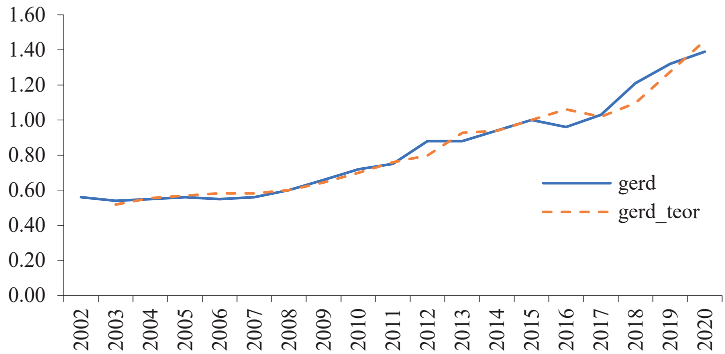

Figure 8. Empirical and theoretical values of the variable $gerd_t$ (share of R&D spending in GDP) from 2002 to 2020

Source: own elaboration.

To determine the influence of metrology, theoretical values of the variables y_t and $gerd_t$ are determined from equations (5) and (7) under the assumption that the evaluation of the parameter at the variable m_{t-1} in model (5–7) is equal to zero. Thus, the equations are identical, except that there is zero at the variable m_{t-1}. This means that this variable has no effect on the other variables in the model. Thus, the *metrology gap* can be estimated. It is presented in Tables 9 and 10.

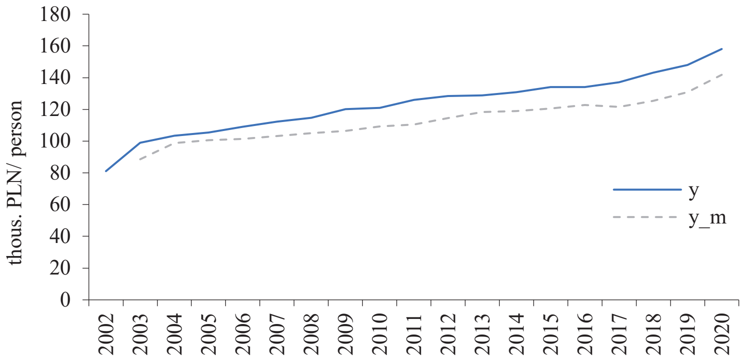

Figure 9. Actual values of variable y_t (GDP per employee) and its hypothetical values in absence of the impact of metrology (assuming no impact of variable m_{t-1})

Source: own elaboration.

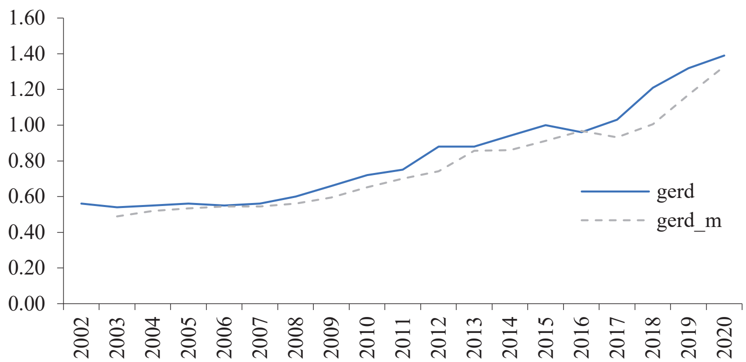

Figure 10. Actual values of variable $gerd_t$ and its hypothetical values in absence of the impact of metrology (assuming no impact of variable m_{t-1})

Source: own elaboration.

The elimination of the metrology impact as measured by the variable m_t significantly reduces the level of GDP per employee. The average annual share of the determined *metrology gap* is 0.094 (9.4%) of the value of GDP per employee. The variables are in a logarithmic form, so they were de-logarithmized before determining this gap. The metrology gap is determined as the difference between the real values of GDP per employee and the theoretical values of this variable, determined under the assumption that there is no metrology impact, i.e., the variable m_{t-1}. The difference for the entire period is divided by the number of years to get the annual metrology gap. The impact of metrology on the variable $gerd_t$ is slightly weaker and less marked. The average annual share of the metrology gap determined for this variable is 0.074 (7.4%) of the value of GDP per employee. As can be seen in the charts above, each of these shares showed an upward trend, which strengthens the conclusion about the growing role of activities of a metrological nature.

Conclusions

The purpose of the paper was to econometrically determine the impact of metrology on such variables as labor productivity in the economy and the share of R&D spending in Poland. To this end, a multi-equation dynamic econometric model with interdependent equations was estimated. The paper also includes a discussion of how to measure metrological activity on a macro scale. A proxy variable was proposed in the form of a number of appropriately selected publications on metrology. The results of simulations using the obtained model show that the average annual share of metrology in global labor productivity in Poland from 2002 to 2020 was at 9.4%. As regards the second variable (the share of R&D spending in GDP), the average annual share of metrology is 7.4%. These numbers are significant and will be verified in other research. These results testify to the important role of metrology in the economy. Its impact will increase together with advances in technology and with the progress of artificial intelligence.

The presented approach has a number of limitations. First of all, it may be questionable to accept the number of "metrological" publications as a measure of metrological activity. This is due to the lack of information on other variables measuring metrological activity. The search for these types of variables is perhaps crucial. Additionally, the presented model contains few variables and is general in nature. The influence of metrology is manifested today through complex systems of connections between sectors (scientific, industrial, etc.). Therefore, the presented approach is not final and requires further development.

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