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Kulinich Tetiana
PhD in Economics, Docent,
Associate Professor of the Department of Management of Organizations
Lviv Polytechnic National University

Кулініч Т.В.
кандидат економічних наук, доцент,
доцент кафедри менеджменту організацій
Національний університет «Львівська політехніка»

GENERAL CHARACTERIZATION OF THE FEATURES AND METHODS FOR FORMING FLEXIBLE REGRESSION EQUATIONS OF HICKS-LINDHAL INCOME STREAMS

ЗАГАЛЬНА ХАРАКТЕРИСТИКА ОСОБЛИВОСТЕЙ ТА МЕТОДІВ ФОРМУВАННЯ ГНУЧКИХ РІВНЯНЬ РЕГРЕСІЇ ПОТОКІВ ДОХОДІВ ХІКСА-ЛІНДАЛЯ

The study of methods for forming flexible regression equations of Hicks-Lindahl income flows is relevant in today's conditions, where modeling economic processes requires increasing adaptability and accuracy. Currently, flexible regression equations allow for accounting for nonlinearity and the complex nature of relationships between economic variables, which is important for analyzing income flows of economic entities that ensure stable consumption and reflect the sustainability of economic welfare. They also address the need for assessing inequality and provide the potential for forecasting economic growth. Thus, the article is aimed at providing a general characterization of the features and methods of forming flexible regression equations of Hicks-Lindahl income flows. The results of the study prove that regression equations (specifically those with transformations, using split data, flexible functions, and latent variables) not only reflect the variability of Hicksian and Lindahlian incomes but are also capable of adequately responding to the state of both external and internal environments. Furthermore, the prospects for future research lie in the empirical testing of adaptive regression models that account for the dynamic variability of external and internal factors influencing Hicks-Lindahl incomes.

Keywords: income flows, Hicksian income concept, Lindahlian income concept, minimum income level, accurate forecasting, economic process analysis.

Дослідження методів формування гнучких рівнянь регресії потоків доходів Хікса-Ліндаля є актуальним у сучасних умовах, коли моделювання економічних процесів потребує все більшої адаптивності та точності. Наразі саме гнучкі рівняння регресії дозволяють враховувати нелінійність та складну природу взаємозв'язків між економічними змінними, що є важливим для аналізу потоків доходів суб'єктів господарювання, які забезпечують стабільне споживання та відбивають сталість економічного добробуту, забезпечують потреби оцінки нерівності та можливості з прогнозування економічного зростання. Відтак, стаття спрямована на загальну характеристику особливостей та методів формування гнучких рівнянь регресії потоків доходів Хікса-Ліндаля. За результатами дослідження доведено, що рівняння регресії (а саме з трансформаціями, з використанням спліт-даних, гнучких функцій та з латентними змінними) не просто відбивають змінність Хіксових та Ліндалевих доходів, а здатні адекватно реагувати на стан зовнішнього та внутрішнього середовища. Доведено, що контексті потоків доходів гнучкість може виражатися в здатності рівнянь, що відбивають Хіксові доходи (пов'язані з мінімальним рівнем доходів, необхідним для забезпечення стабільного споживання, покриття витрат і підтримки безперервної діяльності підприємства) реагувати на зміни таких внутрішніх та зовнішніх факторів, як загальний попит на продукцію, середні виробничі витрати, інвестиції у модернізацію виробничих ліній, доступність фінансування та позики тощо. Доведено, що контексті потоків доходів гнучкість може виражатися в здатності рівнянь, що відбивають Ліндалеві (доходи пов'язані з вигодами від участі в суспільних програмах або отриманням підтримки з боку держави чи інших організацій) реагувати на зміни таких важливих економічних та соціальних факторів, зокрема: державні субсидії та пільги, податкові пільги та знижки, зміни у регулювальній політиці тощо. При цьому перспективи подальших досліджень полягають в емпіричній перевірці адаптивних регресійних моделей, що враховують динамічну змінність зовнішніх і внутрішніх факторів впливу на доходи Хікса-Ліндаля.

Ключові слова: потоків доходів, Хіксова концепція доходів, Ліндалева концепція доходів, мінімальний рівень доходу, точне прогнозування, аналіз економічних процесів.

Statement of the problem. The study of methods for forming flexible regression equations of Hicks-Lindahl income flows is relevant in modern conditions, where modeling economic processes requires increasing adaptability and precision. Currently, flexible regression equations enable the consideration of nonlinearity and the complex nature of relationships between economic variables. This is crucial for analyzing income flows of economic entities that ensure stable consumption, reflect the sustainability of economic well-being, address the needs of inequality assessment, and facilitate the forecasting of economic growth. It should be noted that models based on the Hicks-Lindahl approaches provide the opportunity to integrate structural changes in the economic activities of individual entities and adapt them to rapidly changing external conditions, such as economic crises, globalization, or the impact of environmental factors.

Moreover, the implementation of such methods in financial analytics allows for a better understanding of the dynamics of commercial income distribution, assessing the impact of economic policies on them, and creating forecasts based on modern approaches to data analysis.

Analysis of recent research and publications. The issue of sustainable development of economic entities has gained widespread recognition in the scientific literature, where it is considered an important component of economic and social policy. The essence of sustainable development and its main determinants are thoroughly analyzed in the works of researchers such as Todoryuk S.I., Kutarienko N.Ya. [6], Yudin O.I., and Klymova T.V. [7], who highlight the key factors contributing to the achievement of sustainability in enterprise development. Furthermore, in the research of Krysovaty A.I. [5], the appropriateness of measuring sustainable development through the lens of the Hicks-Lindahl total income flow is emphasized, while in the studies of Zahorsky V.S., attention is drawn to the significance of using regression equations for analyzing such income flows (with the indication that these equations should be flexible, meaning they relate to regression models capable of accounting for complex, nonlinear, and variable relationships between the variables).

However, despite significant scientific interest in the topic, specific attempts to characterize and develop methods for forming flexible regression equations of Hicks-Lindahl income flows in the context of the modern economy remain limited. The lack of detailed studies on the application of such models in the analysis of sustainable development of enterprises is a significant gap that needs to be filled in order to more accurately assess and forecast the effectiveness of sustainable development strategies at various levels of economic activity.

Formulation of the research task. The article is aimed at providing an overall characterization of the features and methods for forming flexible regression equations of Hicks-Lindahl income flows.

Summary of the main research material. The concept of Hicks-Lindahl income flows is based on the works of British economists John Hicks and Erik Lindahl, who examined economic processes from the perspective of the distribution and evaluation of the distribution of goods and income in society.

Moreover, John Hicks, in the context of economic analysis, was one of the first to develop the concept of income for an economic entity, focusing on maintaining a stable level of resource consumption over time. This concept is linked to the idea of utility maximization, where "income" is defined by the ability to sustain the desired level of consumption without reducing overall well-being.

It should be noted that Hicks considered the income of an economic entity as the sum of resources that it can attract without diminishing its existing capital or overall well-being. A typical example is the evaluation of income necessary for an entity to finance its own research and development, which ensures its economic growth. At the same time, Erik Lindahl, on the other hand, focused on the analysis of public goods created by an individual economic entity and the distribution of their value among members of society. This approach to identifying income flows focuses on marginal evaluations of the benefits that individuals receive from the public goods provided by a particular producer [2].

Currently, Hicks-Lindahl income flows are interpreted as a way to assess the income needed to maintain a certain level of well-being in the economy, taking into account the impact of public goods and consumer needs. This allows for making forecasts and modeling the relationships between economic entities, evaluating how changes in economic, social, and environmental parameters affect the overall level of income and well-being [2].

If we consider the example of Hicks-Lindahl income flows in the context of a specific enterprise, such as the private company “Infomir,” which manufactures industrial and household electronics as well as software products, we can state the following:

1. The Hicksian concept of income refers to the necessary resources for maintaining a stable level of consumption or the stability of the enterprise's well-being over time, particularly to ensure the normal operation of the company and maintain its financial stability. In particular, the economic entity must calculate the minimum level of income (or cash flows) required to cover its basic expenses, such as: employee salaries, costs for raw materials and supplies, rent and depreciation of equipment, energy expenses, and other resources for production. These expenses must be covered by the enterprise's stable income. This means that the economic entity must have a level of sales of its products that ensures a sufficient income to maintain uninterrupted operations. Thus, Hicksian income refers to the minimum amount of money that "Infomir" must receive each month to cover its operational expenses without reducing the level of productivity or quality.

2. Lindahl's concept of income relates to the assessment of benefits derived from public or social programs that directly impact the activities of an economic entity, such as government subsidies or programs that support infrastructure development. In particular, "Infomir" receives government support through subsidies for the implementation of environmentally friendly technologies or incentives for reducing CO_2 emissions. Thus, Lindahl's assessment could involve determining how much the enterprise is willing to pay for these initiatives (or what value this support has for its development), based on the benefits it gains from improving the environmental situation and the potential to reduce costs associated with emission fines or additional environmental investments.

We use the common term “Hicks-Lindahl income flows” because it combines two complementary concepts of economic theory that help to comprehensively assess

the well-being of economic entities and their economic stability, taking into account various aspects of income. In this context, the income flows of an economic entity, according to Hicks and Lindahl, can be envisioned as follows:

1. Hicksian income identifies the stable level of income necessary to cover expenses and ensure the continuity of the enterprise's operations.

2. Lindahlian income identifies the benefits derived from participation in programs that support sustainable development or create additional opportunities for such development (through government subsidies or incentives).

In this context, the total income flow of an economic entity consists of the stable income from product sales (the Hicksian part) and the additional income derived from government initiatives or economic conditions that improve the entity's economic position (the Lindahlian part).

Thus, the formation of flexible regression equations for Hicks-Lindahl income flows opens up opportunities for their modeling and evaluation, provided that all the parameters involved in their formation are defined as accurately as possible.

In particular, Hicksian income is associated with the minimum level of income required to ensure stable consumption, cover expenses, and maintain the continuous operation of the enterprise.

Therefore, it is important to consider the stability of expenses and income for the continuous operation of the enterprise, with the components of which the following can be included:

1. Production costs (C_{prod}), which encompass expenses for raw materials, supplies, energy, equipment maintenance, and other production-related costs.

2. Labor costs (W), including base salaries and social expenses (payroll taxes).

3. Depreciation costs (A) for equipment, buildings, and other fixed assets of the enterprise.

4. Development investments (I_{dev}), covering expenses for research and development, technology upgrades, and other investments to maintain competitiveness.

5. Management and marketing expenses (M), including costs for advertising, management services, and other activities to ensure brand stability.

6. Financial costs (F), including expenses for loans, interest on borrowings, and other financial costs.

Regarding the performance indicator, we recommend focusing on income (H), which we interpret as the minimum income the enterprise must receive to cover all expenses and ensure stable operations, i.e.:

$$H = C_{prod} + W + A + I_{dev} + M + F, \quad (1);$$

where: H is the minimum income that ensures the stable functioning of the enterprise without diminishing its well-being and production quality.

Among the independent variables that can influence the value of H, there are many internal and external factors that determine the overall demand for products, average production costs, investments in production line modernization, availability of financing and loans, etc. (Table 1).

Lindahlian income is related to the benefits derived from participation in public programs or receiving support from the government or other organizations. Therefore, it is important to consider how much the enterprise is willing to pay or receive from programs that provide benefits for its activities, including the following components:

1. Government subsidies (S). This is the amount of government assistance provided to the enterprise, such as subsidies for the production of energy-efficient products or eco-friendly technologies.

2. Tax incentives (T). These are benefits from tax reductions or lower tax rates, such as a reduction in income tax or property tax.

3. Investments in ecological technologies (E). These are benefits from the implementation of energy-saving

Table 1

Characteristics of independent variables affecting the magnitude of the Hicksian income of an economic entity

Group of independent variables	Independent variables	Differentiation of possible numerical characteristics of the variable
Overall demand for products	Economic situation	GDP level, inflation, unemployment, consumer sentiment/
	Changes in consumer preferences	Number of purchases of specific types of goods, number of orders for the purchase of specific types of goods
Average production costs	Cost of raw materials and resources	Changes in the prices of raw materials and energy resources directly affect the enterprise's expenses
	Economies of scale	The number of cases where an increase in production volume reduces average production costs or the overall economies of scale
Investments in production line modernization	Investments in new technologies	Investments in the latest equipment, automation, and improvements in production processes that have reduced or may reduce the cost per unit of product
	Innovations and R&D	Investments in research and development of new products or technologies that have allowed or will allow the enterprise to increase competitiveness, boost demand for products, and reduce long-term costs
Financing and loans	Interest rates	Changes in interest rates, which affect the cost of financing the enterprise through loans or borrowings
	Availability of financing	Ease of attracting finance through banks or investment funds, which can help the enterprise maintain liquidity and finance expansion

Source: compiled based on [1; 3–4; 6]

technologies or other environmentally friendly solutions that are supported by the government or international organizations.

4. Financial support (F_{sup}) from banks or other financial institutions on favorable terms, enabling the enterprise to make investments in development without high financing costs.

5. Demand for products (D_{prod}). These are benefits from an increased demand for the enterprise's products due to public goods or investments that improve the quality of goods or services.

Regarding the performance indicator, we recommend focusing on income (L), interpreted as the benefits to the enterprise from public goods or government support, which allow for cost reduction or income increase through subsidies and other benefits, that is:

$$L = S + T + E + F_{sup} + D_{prod}, \quad (2);$$

where: L is the additional income or benefits to the enterprise that arise from participation in government programs or subsidies.

Among the independent variables that may influence the magnitude of Lindahlian income for an enterprise, several important economic and social factors can be highlighted, including: government subsidies and benefits, tax incentives and discounts, changes in regulatory policies, and so on (Table 2).

In fact, using the constructs of results and variables of Lindahl and Hicks presented by us forms the basis for the development of flexible regression equations of income flows and allows each individual economic agent to assess not only all possible benefits that ensure sustainable development, but also potential additional benefits from the external environment and support policies.

According to the analysis of the scientific literature, the main methods for constructing such models are:

1. Linear regression with transformations. Linear regression is a classical method that allows modeling the relationship between a dependent variable and several independent variables. In the case of income streams, this approach enables the construction of an equation where the enterprise's income depends on various factors (as shown in Tables 1–2). Transformations of linear regression (such as logarithmic, quadratic, exponential, etc.) are used to improve the model when the linear relationship is not optimal and to reduce the influence of outliers or strongly nonlinear variables. Specifically, logarithmic transformations can be applied to model the enterprise's income, which depends on factors such as the amount of government subsidies, product demand, or changes in production costs.

2. Regression models using split data. This method involves dividing the data into two or more subgroups for a better analysis of dependencies between variables when there are different conditions or contexts that may significantly affect the outcome variable. For example, if a business receives varying levels of support depending on its location (e.g., urban or rural areas), regression can be built for each group separately. This allows for a more accurate assessment of the impact of the external environment on the enterprise's income.

3. Regression models for flexible functions. This method is used to estimate the parameters of a model when the regression function is not strictly linear but has a more flexible structure. The least squares method allows minimizing the sum of the squares of the deviations between observed and predicted values. In the case of flexible functions, this can be important for analyzing complex economic processes where the relationship

Table 2

Characteristics of independent variables affecting the magnitude of Lindahlian income for an enterprise

Group of independent variables	Independent variables	Differentiation of possible numerical characteristics of the variable
Government Subsidies and Benefits	Subsidies for production and development	Subsidies for energy efficiency or the development of innovative technologies, which can stimulate enterprises to increase production capacities and, as a result, enhance revenues
	Incentives for enterprises in specific sectors	Specific incentives for enterprises in certain sectors (e.g., agriculture, clean technologies, high-tech industries), which help reduce costs and increase revenues
Tax Benefits and Discounts	Tax rate reductions	Reduction in corporate tax rates or property tax rates, which can lead to a decrease in enterprise costs
	Tax holidays or discounts for new businesses	Tax holidays or other discounts, which allow business entities to reduce their tax burden and increase their income during the early years of operation
Changes in regulatory policy	Changes in environmental and technical standards	Government support for businesses transitioning to environmentally friendly technologies, specifically targeted tax incentives or subsidies for ecological modernization of production
	Market liberalization	Changes in business regulations (licensing, certification, removal of state control), which can influence business operations and reduce administrative costs
	International standards and agreements	Political agreements or international standards, which contribute to the integration of the enterprise into international markets, potentially opening new opportunities for maximizing revenues

Source: compiled based on [5–7]

between income and variables is nonlinear but cannot be represented by simple linear functions. In particular, if the relationship between a company's income and investments in production modernization has a complex nonlinear form, the least squares method for flexible functions will help accurately estimate the parameters of this relationship.

4. Regression models with latent variables are used when some variables cannot be directly observed but have a significant impact on the outcome. For example, if a business cannot directly measure the impact of variables such as the level of innovation activity, a model can be built where innovation activity is a latent variable that affects income through its interaction with other measurable variables (such as the number of patents or the level of R&D investments).

Such models can be constructed to respond to changes in the external environment (e.g., changes in government policy, economic conditions).

Conclusions. The term "flexible regression equations" in the context of Hicks-Lindahl income flows refers to regression models that are capable of accounting for complex, nonlinear, and variable relationships between variables. In other words, it is important for such equations to adapt to different economic conditions, dynamically adjusting their parameters depending on changes in the external and internal environment of the enterprise, as well as considering the impact of various factors on the income of the enterprise or economic entity.

It has been proven that, in the context of Hicks-Lindahl income streams, flexibility can be expressed in the following aspects:

1. The ability of equations reflecting Hicksian income (which is related to the minimum income level required to ensure stable consumption, cover costs, and maintain continuous operations of the enterprise) to respond to changes in internal and external factors such as overall product demand, average production costs, investments in production line modernization, availability of financing and loans, etc.

2. The ability of equations reflecting Lindahlian income (which is related to the benefits derived from participation in social programs or receiving support from the government or other organizations) to respond to changes in important economic and social factors, including: government subsidies and benefits, tax exemptions and discounts, changes in regulatory policies, etc.

The research results have shown that regression equations (specifically those with transformations, using split data, flexible functions, and latent variables) not only reflect the variability of Hicksian and Lindahlian income but are also capable of adequately responding to the state of both external and internal environments. In this context, the prospects for further research lie in the empirical testing of adaptive regression models that account for the dynamic variability of external and internal factors influencing Hicks-Lindahl income.

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