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В журнале публикуются оригинальные эмпирические и обзорные статьи, связанные с административно-управленческими, экономическими проблемами налоговых реформ, а также рассматривающие вопросы, связанные с историей налоговых реформ и практикой противодействия уклонению от уплаты налогов.

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The Journal of Tax Reform is aimed at presenting significant findings of original socio-economic research carried out by professionals from various countries in the field of tax reform and taxation in general.

The Journal publishes original empirical and review articles elucidating administrative-managerial and economic problems in tax reform, as well as those discussing issues related to historical tax reform and practices for countering tax evasion.

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СОДЕРЖАНИЕ

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CONTENTS

Original Paper

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Individual property tax to fund public transport

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ABSTRACT
Efficient and reliable public transport is of prime concern to city dwellers. To function efficiently, public transport generally needs subsidies from the state or local government. Our goal was to design and develop an alternative model of property tax that would provide financing for public transport. It was hypothesised that if the market value of real estate depends on the proximity of public transport, property tax can be a reliable source of financing for public transport. Based on the hedonic pricing theory, we used multiple regression to measure the impact of public transport proximity on the value of residential property. The data on the market value of property and property tax was taken from statistical tax reporting forms of the Federal Tax Service. The data on various public transport infrastructure facilities was used from the specialized open registers. We tested our alternative model of property tax, using the case of the Ekaterinburg Metro and the Tram and Trolleybus Company, through regression analysis of 7,685 objects of residential property in the City of Ekaterinburg. It was found that the efficiency of the underground service is higher than that of the city's tram network. On the average, the proximity of underground stations increases the value of housing by over 6%. As predictive estimation of the amount of tax determined by the proximity of public transport showed, the alternative model of property tax is sufficient to cover capital expenditures of the city's public transport operators and could, therefore, contribute to further expansion and modernization of the transport network.

KEYWORDS
property tax model, public transport, property tax, property value, metro, tram

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Оригинальная статья

УДК 336.22

Налог на недвижимость физических лиц как источник финансирования общественного транспорта

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АННОТАЦИЯ
Эффективный и надежный общественный транспорт представляет первоочередной интерес в жизни городских жителей. Для эффективного функционирования общественному транспорту как правило требуются субсидии от государства или органов местного самоуправления. Намерение состояло в том, чтобы

спроектировать и разработать альтернативную модель налога на имущество, которая обеспечила бы источник финансирования для общественного транспорта. Гипотеза исследования основана на предположении, что, если рыночная стоимость недвижимости зависит от близости остановок общественного транспорта, то налог на имущество может стать надежным источником финансирования общественного транспорта. Основываясь на теории гедонистического ценообразования, мы использовали множественную регрессию для измерения влияния близости общественного транспорта на стоимость жилой недвижимости. Источником информации о рыночной стоимости имущества и налоге на имущество являлись формы статистической налоговой отчетности Федеральной налоговой службы. Для получения информации о различных объектах инфраструктуры общественного транспорта использовались открытые данные из специализированных регистров. Предложенная альтернативная модель налога на имущество была протестирована на примере Екатеринбургского метрополитена и Трамвайно-троллейбусной компании путем регрессионного анализа 7 685 объектов жилой недвижимости в городе Екатеринбурге. Сделан вывод, что эффективность метро выше, чем у городской трамвайной сети. Близость станций метро в среднем увеличивает стоимость жилья более чем на 6%. Прогнозная оценка суммы налога, зависящей от близости общественного транспорта, показала, что альтернативная модель налога на имущество достаточна для покрытия капитальных затрат операторов общественного транспорта города и, следовательно, может способствовать дальнейшему расширению и модернизации транспортной сети.

КЛЮЧЕВЫЕ СЛОВА
модель налога на недвижимость, общественный транспорт, налог на имущество, стоимость недвижимости, метрополитен, трамвай

1. Introduction

An extensive, developed and easily accessible transport network is commonly seen as a major public good. Fiscal tools have traditionally been used by governments to finance public transport. The conceptual and methodological principles underpinning the application of these tools were described in numerous taxation theories.

An efficient and reliable municipal transport system stands high on the list of priorities of any city council. To handle this task, it is necessary to search for the ways of financing the transport network's operation and its expansion. Funding alternatives include, first and foremost, the fares charged for carrying passengers. In this case, the revenue comes from the direct users of the transport services. In the majority of cases, however, in addition to revenues from fares, to function efficiently, public transport also needs subsidies from the state and local government.

State subsidies to public transport are necessary if the revenue from fares does not cover the operating expenses. In this case, a question arises as to what can be an alternative source of funds to close this gap.

Even though there is a variety of models for financing the maintenance needs of transport infrastructure as well as the construction of a new one, in Russia most of these innovative funding techniques have found no practical application so far.

The aim of this research is to propose a new model of property tax that would provide a reliable source of financing for municipal transport.

To this end, we are going to address the following objectives:

1) prove that the individual property tax can serve as a possible source of co-funding for public transport;

2) describe a mechanism for identifying the portion of the tax generated by the vicinity of a developed public transport system;

3) test the possibility of using this tax as a source of financing of operational and/or capital expenses of public transport operators.

Our hypothesis is that it is possible to build a property tax model that would se-

cure a reliable source of financing of public transport depending on the impact that the vicinity of municipal public transport has on the market value of real estate property.

2. Literature review

2.1. Taxes as a tool for estimation of the cost of public services

One of the fundamental taxation theories is the theory of exchange, which is conceptually based on the benefit principle and emphasizes the contractual nature of public services.

The exchange theory also had a major impact on the studies of public finance as well as decision-making in concerning public expenditures and revenue policies. De Viti de Marco [1], Wicksell [2], Lindahl [3], and later Mazzola [4] adopted the methodology of the marginalist theory of value to study public spending. These studies consider the state as a group of persons paying taxes in exchange for services (public goods), which the ultimate consumers can take advantage of. The approaches to taxation as payment for public services underpinning the voluntary exchange theory are widely applied in contemporary studies on various kinds of public services and goods.

Enoch et al. [5] use as a point of departure the 'beneficiary pays' principle, meaning that it is the beneficiary or the user of public goods who pays for them. This explains the practice of using taxes and charges for public transport financing, e.g. the imposition of local charges on the inhabitants of specific areas and other taxpayer groups (e.g. employers) that would benefit from the access to public transport.

Keid [6] demonstrates that the cost-effectiveness of public transport as a public good, which can be replaced by commercial alternatives, can be measured through the quality to cost ratio, the latter taking the form of taxes spent on financing these goods. The assessment of cost-effectiveness normally encompasses the tax burden levels borne by groups of households depending on their income.

In practice, the principle 'beneficiary pays' may be difficult to realize since this approach is based on the estimation of the fairness and efficiency of the calculations of the tax-burden-to-income ratio, which makes it hard to compare the actual taxes paid with the value of the public goods one can benefit from [7].

Governments tax citizens not only to produce pure public goods but also to produce and distribute specific commodities. Aaron & McGuire [8] argue that it is difficult to break down the tax revenue from each household into distinct components, one of which is spent on public goods and the rest go to other purposes.

Access to certain types of public goods (including transport services) directly depends on the location of the taxpayer's household. This allows us to consider specific taxes as a fair price for the access to such public good (see Van den Branden et al. [9], Ubbels [10]).

The amount of public goods and sources of their financing are discussed at length in the works of Anthony B. Atkinson, who proposed a formula of the optimal balance of public production [11].

Atkinson also compares the optimal level of public goods provision in relation to distorting and non-distorting taxation. He demonstrates the possibility of achieving a higher level of public goods provision while using lump-sum (non-distorting) taxation [11].

Thus, there is considerable research evidence that financing of public goods involving the use of the least distorting taxes is an effective instrument for maintaining the optimal level of public goods provision.

2.2. Taxpayer funds as a source of public transport financing

Private vehicles are among the major causes of traffic congestion and air pollution in cities. The main theoretical premise behind transport taxation is the need to reduce private car usage and to curb its negative effects [12; 13]. Such regulations may rely on fiscal tools of different kinds. Some countries use toll charges to regulate the traffic on central streets with public transport being exempt from tolls.

Farrell [14] investigated the system of taxes and charges in Scandinavian countries for financing the development of the road network and municipal transport. She also mentions the Golden Gate Bridge toll in San Fransisco (USA), which also has a targeted character and is spent on the Bridge's maintenance and related public transit services [14]. These funds are then used to finance bus lines and ferry services.

Another variation of the 'polluter pays' principle is the model where a funding source for public transport is provided by consumption taxes. Taxes embedded in the price of commodities polluting the environment help regulate their consumption and engender extra revenue. Buehler & Pucher [15] analyzed and proved the efficiency of this approach in various countries.

In this case what matters is not only the direct financing for public transport from tax revenues but also an increase in ridership and in ticket sales. Austin & Dinan [16] associate this effect with the changes in consumer preferences found in completely different city types. Tanishita et al. [17] point to the much higher level of efficiency in this type of taxation in comparison with the taxation of private vehicle owners.

Tax revenues from polluters may be raised not only through fuel taxes but also through taxes on car ownership [18]. In this case, there may be two possible influences on public transport: greater reliance on more environmentally friendly collective means of transportation and generation of extra funds for the development of the public transport and road network. Sandmo [18] described the conceptual framework for a large number of models focused on the replacement of private vehicles by public transport.

A fundamentally different approach to public transport financing is by taxing beneficiaries. White's [19] concept is a form of 'collective purchase' of services followed by benefiting from them. There are two distinct types of beneficiaries: employers and property owners. An example of such taxes raised on employers for transport purposes is the French *versement* tax levied on the total gross salaries. Ubbels & Nijkamp [20] in their study of taxation on property owners highlighted that such taxes may include an addition to the tax base generated through the adjacency to public transport.

Thus, the models of taxation of public transport users can be divided into three groups:

1. Financing public transport from the common funding 'pot' (the so-called 'all-in-one-pot' principle), replenished from tax receipts. This form of financing is the most common. It is based on the following conventional mechanism: money is allocated from the budget formed through 'general' taxation. In this model, the government raises revenue from different taxable sources and public transport has to compete for funds with other public services such as health care and education. Transport is often not among the top priorities of public spending. Moreover, the amount of tax in this case is unrelated to the taxpayer's use of this service.

2. The 'polluter pays' principle means that the revenues from taxes on private vehicle use and ownership are earmarked to specific spending purposes. These funds may be spent not only on pollution prevention and control but also on the development of public transport, which has a lower environmental impact.

3. The 'beneficiary pays' principle means that public transport is financed by taxing direct beneficiaries, that is, those enjoying direct or hidden benefits from the use of public transport.

Our literature review has shown that in global practices of public transport financing, these instruments may be employed differently and are based on different mechanisms of co-funding.

2.3. Modern approaches to financing public transit

In some cases public transport is financed from the special fund replenished through special taxes and charges earmarked for this purpose. Vigrass & Smith [21] described this model by using the case of the *versement* transport tax (VT) in France, which is a tax levied on the total

gross salaries of all employees of companies of more than 11 employees. It is a local tax earmarked specifically for financing transit. The general VT rate is 11.5%. The VT is a powerful tool that covers about 39% of the costs of public transport in France [21]. The amount of this tax does not depend on the consumption of transport services but is a payment for the possibility to use the transport network.

Owen et al. [22] discuss this approach by looking at the case of the transport program in Los Angeles (USA), which was funded through a half-cent (0.5%) sales tax. What is interesting about this program, which includes plans for development of bus routes and rail transport, is that the funds are raised through indirect taxation.

Pucher [23] argues that another viable approach is to tax car owners since private vehicles have a much greater negative impact on the environment. Such approach can be illustrated, for example, by the gas tax in the Provinces of Quebec and Ontario, a portion of which is transferred to finance public transit. This portion is expressed in kind and is added to the cost of every litre of gasoline. Apart from the apparent simplicity of this approach, it also discourages environmental pollution.

Jalon et al. [24], however, point out that the main drawback of this kind of financing resides in the lack of clear connection between the expenditures of public transport companies and the effects resulting from their operation.

Dye & Merriman [25] reveal the potential of the mechanism called Tax Increment Financing (TIF). TIF is a model of financing infrastructure development projects based on the expectation of the tax revenue growth resulting from the improvements of the area in question. An infrastructural project is expected to increase the cost of the property and/or land of the neighbouring areas and also increase the tax revenue, thus allowing the authorities to avoid raising the tax rate. All such tax increments or only their part, including the revenue from the infrastructural project itself, are redistributed in favour of the TIF-project's operator until the end of the project and are used to cover the initial investment into the project.

Man & Rosentraub [26] studied the outcomes of a TIF program and found that there was an increase in the revenue from the sales tax and an increase in the number of jobs. The conclusion they make is that the TIF program had a positive effect on urban economy.

Some authors are less appreciative of the benefits of this tool. According to Clark & O'Connor [27], TIF is based on the investment that implies an increase in the value of property, which in the conditions of an 'opaque' financial market can lead to dubious consequences. Housing bubbles can result in a collapse in property prices, which, in its turn, will make the developer's unable to return the investment.

Weber [28], on the contrary, shows that the application of the TIF tools during the real estate bubble crisis in the US allowed some of the municipalities that implemented infrastructural projects to avoid the harmful effects of the crisis. For instance, the crisis in 2007 had no effect on such projects in Chicago and other American cities.

Smolka & Furtado [29] demonstrated that large public transport stations provide ample opportunities for the development of commerce and commercial property. Such projects in Brazil, namely in Porto Alegre and Belo Horizonte, were quite successful primarily thanks to the modernization and clustering of residential property areas along the lines of public transport. In Curitibe, however, a similar project was not successful due to land speculation and the displacement of the poor to the suburbs.

Cocconcelli & Medda [30] showed that in order to prevent the appearance of speculative bubbles in the real estate market, it is necessary to conduct property value assessment in due time and regulate the property tax rate in case of sharp fluctuations of the tax base.

Bourassa [31] uses the case of Pittsburgh to illustrate that an increase in the rates of land value taxes can cause significant resentment on the part of the tax-

payers and that the failure to generate good PR of an infrastructural project may also lead to the project's closure.

Our literature review has shown that the most widely spread approaches are those based on state financing of public transport. The TIF model appears to be practically applicable since it is based on a rather simple calculation mechanism and establishes the connection between the efficiency of public transport and its financing.

3. Methodology

Table 1 shows the key stages in our research and the corresponding methods.

Table 1

Key stages of the methodology

№	Stage	Description
1.	Identification of the beneficiaries	By applying the hedonic pricing model we determined the impact of public transport on the cost of property
2.	Identification of the property tax base generated by public transport	Calculation of the share of the tax base generated by public transport
3.	Analysis of the general property tax base	Identification of the property tax base generated by residential property alone
4.	Calculation of the amount of the property tax generated by public transport	Calculation of the portion of the property tax generated by the vicinity of a developed public transport infrastructure
5.	Projected estimates of the bonus payment to the public transport operator	Estimation of the operator's actual expenditures and the comparison of this figure with the amount of the bonus payment

The most widely used methodology for measuring the impact of a certain attribute on the general cost of a property is based on the hedonic theory. The hedonic pricing model is a standard econometric instrument for evaluation of determinant attributes of various goods, in particular residential property [32]. The hedonic model for calculating the value of property [33] determined by the proximity of transport infrastructure confirms the supposition that there is indeed a dependency between the value of property and public transport accessibility [34]. This model can also be used to estimate this dependency for taxation purposes [35].

The elements of our model for calculating the amount of the tax to be transferred to public transport operators as an efficiency bonus are as follows:

1. Sources of all the necessary data;
2. Methodology for data processing;
3. The frequency of iterations for calculating the base cost of a square metre and the coefficient of transport accessibility;
4. Methodology of calculating the share of the property tax to be transferred to a public transport operator;
5. Government agency responsible for the implementation of this mechanism

In our choice of data sources we followed the principle of transparency, which is the key principle used for mass appraisal of real property for taxation purposes. To estimate the impact of public transport on the value of property, we chose open sources of data over specialized registers with restricted access. Thus, we were able to justify the need to transfer tax receipts to public transport operators.

In our calculations of the model, we relied on the following data types:

- Information about the market value of property;
- Information about the amount of property tax accrued;
- Information about different objects of the public transport infrastructure

All of the above-mentioned types of data are publicly available. The Federal Tax Service publishes the accrued property tax data on their official web-site on an annual basis.

Objects of the public transport infrastructure are used in the model in the form of data on geographic coordinates of transport stops. Such coordinates were obtained from online map services, including free ones.

The information about the market value of property as well as the characteristics of these objects can also be ob-

tained from various sources such as the publicly available online information about the cost of property for sale and specialized property registers. The latter include the information about purchase and sale property transactions registered in the Federal Service for State Registration, Cadastre and Cartography (Rosreestr). Rosreest provides more accurate data since they take into account all the discounts made by sellers and included in the original cost of the property as shown in real estate ads. Eventually we chose publicly available information sources to increase the transparency of our analysis.

To measure the impact of transport infrastructure proximity on the cost of a residential property, it is better to use multiple regression, which is the most widely used method for measuring the impact of a certain attribute on the object's total cost based on the hedonic pricing theory. According to this theory, the property can be considered as a commodity whose price depends on the group of cumulative characteristics. These include not only inherent qualities of the property but also the overall ambience of the location and accessibility of certain infrastructure objects.

The next question to be considered is the choice of a model calculation method for the whole individual property tax base. The most suitable method, in our view, is to calculate the share for each individual property and then extrapolate the results of the model proportionally to the whole tax base.

The tax base for the individual property tax comprises not only the value of residential but also non-residential property such as garages, parking space, etc. We can calculate the share of the tax revenue to be transferred to a public transport operator as an efficiency bonus in a computational model (using the real estate data) and the adjustment coefficient will be applied to calculate the share of the tax base corresponding to residential property. The information on the distribution of the tax base by property type can be obtained from statistical tax reporting forms 5-MN published on the official website of the Federal Tax Service.

In our study, we are going to rely on the aggregate statistical data from open official sources. The resulting model was estimated by using individual property tax revenue in Ekaterinburg.

4. Results

4.1. Analysis of public transportation funding models

There are three general models of public transport financing:

1. Reimbursement of the public transport operator's actual expenditures. In this scheme, the operator's expenditures are covered from the public budget formed through general taxation revenues. The amount of transfers to the operator depends on the operator's general operational expenses. Since the amount of the necessary funds will vary in different years and due to the lack of the tax base that could be assigned to the sum of the operator's expenses, the most widely used approach is the so-called 'all in one pot' method. Since in this model all sources of tax revenue are used, we can conclude that the costs of public transport are covered by all the taxpayers, regardless of whether they actually benefit from these services or not.

2. Reimbursement of the public transport operator's expenditures through the costs paid by owners or users of private vehicles since cars are the biggest contributors to air pollution in urban areas and other issues such as congestions, road accidents, etc. This principle is underpinned by the idea that public transport provides a 'healthier' alternative to private vehicles. Collective use of public transport reduces these negative effects and is, therefore, seen as a more sustainable and preferable alternative. In this model, transport taxes and fuel levies play a crucial role: the revenue coming from these sources is directed to fund the public transport network.

3. The bonus payment to the developer building a certain object of transport infrastructure comes from the tax revenue generated through the positive externali-

ties from this developer's work. What distinguishes this model is that the amount of financing depends on the positive effect of the operator's activities rather than on the operator's expenditures. This model may rely on general tax revenue as well as on specific taxes or on beneficiaries (Table 2).

All of the above-described models are by no means the optimal solution to this problem. What they have in common is that they all deal with the ways of reimbursing the expenses of public transport operators or developers engaged in construction of transport infrastructure. It should also be noted that these models do not take into account the efficiency of public transport operations and its utility for individual taxpayers.

In our view, the optimal model would be to use a part of the individual property tax for this purpose. The tax base for this tax is the value of property, which, in its turn, is partially affected by the accessibility and efficiency of the public transport network. It is this increase in the tax revenue that could serve as a source of financing for municipal transport and its modernization.

The main idea behind the proposed model is to estimate the possibility of identifying the amount of the property tax revenue generated through the development of the transport network in a given area and to test the sufficiency of this sum for financing transport operation and modernization depending on the efficiency of the operators.

4.2. Financing of public goods through distorting and non-distorting taxes

To demonstrate the role that taxation plays in public transport financing, we intend to use the formula reflecting the consumption of goods by the whole community. This formula was derived from Atkinson's equation [11]:

$$pHX + (p_g G_{loc} + p_g G_{gov}) = HL, \qquad (1)$$

where HL is the consumption of goods in the community (L is the individual level of consumption); p is the cost of a private good; HX is the consumption of a private good by the community (X is the individual level of consumption of a private good); G_{loc} and G_{gov} are the possibilities of production of public goods by local authorities and the national government respectively; p_g is the cost of production of public goods by local authorities and the national government.

Since public transport is one of the local public goods, it would make sense to present the production of public goods as a sum of production of different goods that qualify as local. To analyze ways of transport financing, we are going to consider the production of local public goods as a sum of public transportation services (denoted as $p_g G_{tran}$) and other local public goods (denoted as $p_g G_{loc.other}$):

$$pHX + (p_g G_{gov} + (p_g G_{loc.other} + p_g G_{tran}) = HL. \qquad (2)$$

This formula can be used to compare the results of financing of public goods production in different models.

Table 2

Relationship between the sources of public funding and mechanism of reimbursement for municipal transport operators

	Reimbursement of the operator's actual expenditures	Reimbursement of the operator's expenditures is provided from the funds collected from the owners of private vehicles, which have a negative environmental impact	Bonus payment to the developer building a certain object of transport infrastructure comes from the tax revenue generated through positive externalities from this developer's work
Reimbursement from general tax revenue ('all-in-one-pot')	+		+
'Polluter pays' reimbursement		+	
'Beneficiary pays' reimbursement	+		+

Let us now consider the alternative way of financing through the distorting tax charged on the consumption of private goods. To this end, we will present p as a sum $(p + t)$, where t is the tax rate:

$$(p + t)HX + \\ + (p_g G_{gov} + (p_g G_{loc.other} + p_g G_{tran})) = HL. \quad (3)$$

In the situation where all the taxes raised are spent to produce public goods, the sum of the tax (denoted as T) will be equal to the sum of all the public goods. The formula will look the following way:

$$(p + t)X + T = L. \quad (4)$$

To achieve the optimal public welfare, it is necessary to maximize individual utility (U_x):

$$U_x = a(p + t), \quad (5)$$

where a is the marginal individual utility equal to U_L.

An increase in public utility is achieved through maximization of the sum of individual utilities (HU) and can be expressed through the Lagrangian in the following way:

$$\mathcal{L} = HU(X, L, G) - \lambda(pH + p_G G - HL). \quad (6)$$

Extrema of this expression are equal to zero of the derivative function shown above.

$$\frac{\partial \mathcal{L}}{\partial G} = HU_G - \lambda\left(pH\frac{\partial X}{\partial G} + p_G - H\frac{\partial L}{\partial G}\right) = 0. \quad (7)$$

After transforming the resulting equation, we obtain the following:

$$\frac{HU_G}{a} = \frac{\lambda}{a}\left(p_G - tH\frac{\partial X}{\partial G}\right). \quad (8)$$

The main conclusion that can be made by looking at the right side of the given equation is that an increase in the level of public goods significantly limits the possibility of increasing the revenues from distorting taxes used to finance such goods.

Returning to formula (3), let us consider the impact of a non-distorting tax on the balance of the public goods production. In this case, the tax will be in the right-hand side of the equation, which will look the following way:

$$pHX + (p_g G_{gov} + (p_g G_{loc.other} + p_g G_{tran})) = \\ = HL + T. \quad (9)$$

The above formula illustrates the neutrality of non-distorting taxation in relation to private goods consumption.

A significant characteristic of local public goods is that the range of potential users is spatially limited. Therefore, a community (a city district or a city) can be considered as a single location with a more or less homogeneous public transport infrastructure. The access to public transport is thus enjoyed primarily by those who inhabit this territory (e.g. own a property located in this area). Although formally public transport can be used by non-locals, members of other communities, in practice this does not happen very often due to the distance factor.

Thus, we believe that, making a certain assumption, property taxes are the taxes with the minimal level of distortion in what regards public transport. Therefore, property taxes hold much promise for financing public transport.

This way of financing, however, does not exclude other mechanisms of funding local public goods such as transport.

4.3. The model was tested by using the case of Ekaterinburg (Russia)

To provide financing for urban transport operators through the mechanism described above, we need to calculate the share of the tax corresponding to the impact of the transport infrastructure on the value of residential property.

Since the fiscal period of the property tax is 1 year, it would be reasonable to estimate the impact of public transport on the value of residential property no more frequently than once a year.

Municipal public transport is controlled by local authorities, which is why it would make sense that local authorities should be made responsible for calculating the amount of bonus payments to the public transport operators.

For our study we chose two operators of public transport in Ekaterinburg: Ekaterinburg Metro (*Ekaterinburgskiy metropoliten*) and the tram and trolley-bus company (*Tramvayno-trolleybusnoye upravlenie*). Ekaterinburg is a large Russian city with a developed public transport network com-

prising almost all modes of public transport. The city's population size is about 1.5 million and the city ranks high in Russia in terms of the number of private vehicles The volume of passenger traffic of the city's public transport is over 400 million people a year. Lately, however, the passenger flow has been steadily decreasing, which can be explained by the low quality of transport services and the insufficient efficiency of public transport operations. The shrinking passenger flow creates a scarcity of funds of the public transport company for further development of the network.

The above-described mechanism for calculating bonus payments is shown in Figure 1.

This mechanism is based on estimating the impact of the proximity of the public transport infrastructure on the market value of residential property and it requires no complex calculations or computational tools, which is why no extra jobs or new software will be necessary for its implementation.

In our previous studies [36], we calculated the median values of the impact that the transport infrastructure proximity has on the cost of real estate property in Ekaterinburg. The closer is the property to the transportation network, the more benefits are enjoyed by the owner of this property. Moreover, the more efficient is the public transport, the more significant is the influence of its proximity on the value of the property. In our view, the latter may serve as an indirect indicator of the public transport operator's efficiency or inefficiency. The calculated values of the impact of public transport proximity on the cost of property are shown in Table 3.

Table 3

Impact of public transport stops proximity on property prices in Ekaterinburg, %

	Minimum value	Maximum value	Median value
Metro stations	3.00	12.00	6.09
Tram stops	3.20	8.80	5.47

These figures were obtained through regression analysis of 7,685 objects of residential property in Ekaterinburg. It can be concluded that the efficiency of the underground service is higher than that of the city's tram network. The proximity of underground stations on average increases the cost of housing by more than 6%.

We used the data gathered through our previous research to determine the projected values of transfers to the tram and trolley-bus company and Metro. To take into account the fact that the individual property tax is imposed not only on residential but also on non-residential properties, we introduced an adjustment

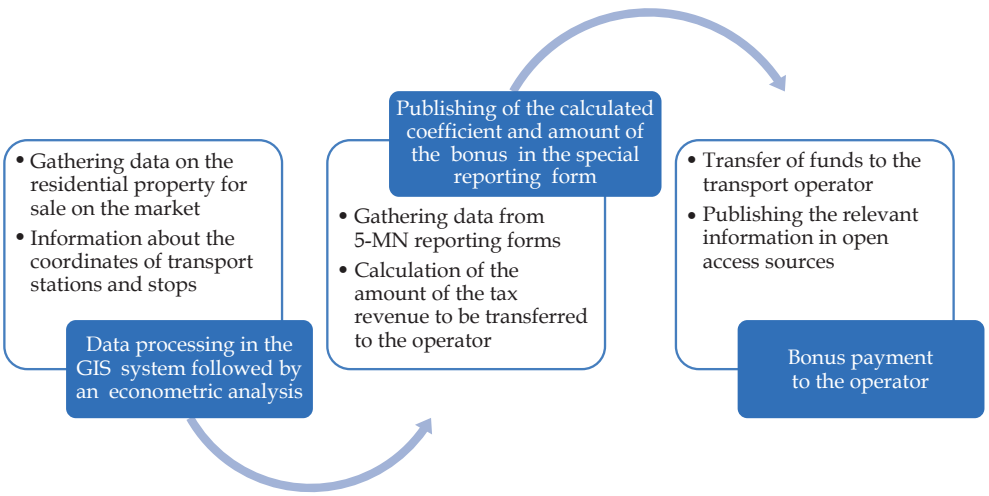

Fig. 1. **Mechanism for calculating bonus payments to public transport operators**

coefficient, which corresponds to the share of the tax base on residential property of the general property tax base. For Ekaterinburg, this coefficient is 0.76696.

According to the 2019 budget report, the total amount of the tax revenue was 1,337,546 thousand roubles. The sum resulting from the adjustment for the coefficient was 1,025,844 thousand roubles. We used the median values of the impact that the proximity of transport had on housing prices to calculate the tax revenue to be received by the operators (see Table 4).

Table 4

Projected amount of funding transfers to the public transport operator

Public transport operator	Projected funding in 2019, ths rbs
Tram and trolley-bus company	56,113
Metro	62,473
TOTAL	**118,586**

We will use the estimated value of the bonus to a public transport operator to find whether these funds will be sufficient to modernize the transport infrastructure or not. At the beginning of 2019, Ekaterinburg Metro had to borrow funds on loan – 486 million roubles for 8 years – to buy new carriages. The costs of servicing the credit line are 208.2 million roubles. At the same time, Ekaterinburg Metro raised their fares by 14.2% or 4 roubles in order to finance the investment program to modernize the underground fleet.

Thus, the Metro's capital costs were covered from the fares paid by the passengers. It should be noted that the 'beneficiary pays' funding was not used. The performance bonus paid to the Metro's operator would help either to reduce the interest paid on borrowed funds or to attract outside investment through the TIF mechanism with reduced rates due to the guaranteed receipt of funds in the form of bonus.

Our estimation of the amount of the bonus payment to operators of the tram and trolley-bus services and of the underground in Ekaterinburg has shown the feasibility of this mechanism. We have also illustrated the possible effect from such bonus payments for cutting the transport operating costs.

5. Conclusion

Efficient operation of public transport is impossible without state co-funding. In this case, the operating and investment costs of public transport are covered by the revenues gained from some taxes or charges. Despite the distorting influence of taxes, the most suitable tax is the individual property tax.

We conducted predictive estimation of the amount of tax determined by the accessibility of public transport. Our calculations took into account the proximity of transport on the value of property (the tax base for the individual property tax). Following the existing theoretical and empirical literature, we developed our own model of the individual property tax, capable of generating sufficient funding for public transport as a part of the revenue is earmarked specifically for this purpose.

This model was tested by using the case of Ekaterinburg. It was demonstrated that the amount of financial resources that could be generated through this source is sufficient to cover the capital expenditures of the city's public transport operators and could, therefore, contribute to further expansion and modernization of the transport network.

We have also confirmed our hypothesis that it is possible to build a property tax model that would provide a reliable source of financing for public transport depending on the impact of the transport infrastructure's proximity on the market value of property.

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Introduction of the personal tax-free allowance in Russia and its budget implications

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ABSTRACT
The social problem of poverty can be mitigated by introduction of a personal tax-free allowance. In this paper the likely effects that a personal tax-free allowance will have on the Russian budget is investigated. It has been assumed that a tax-free allowance will hit regional budgets because they depend greatly on income tax revenue. The indicated effects were estimated by applying a personal tax-free allowance to the data on economic conditions in 2019. Rosstat data on population, poverty, wages and gross regional product and Federal Tax Service data on the number of taxpayers and personal income tax revenues were used. For the purpose of the paper, two scenarios were calculated. In the first scenario, a zero personal income tax rate is applied to wages below the minimum cost of living. We found that under this scenario the consolidated budget of Russia loses over 1 trillion rubles while regional tax revenues reduce by more than 10%. In the second scenario, citizens whose income is below the minimum cost of living are exempt from personal income tax. We found that under this scenario regional tax revenues would be reduced by 1-5%. In both cases the introduction of the personal tax-free allowance puts greater pressure on regions that critically depend on the personal income tax receipts. It was concluded that the negative effect of an introduction of a personal tax-free allowance would be greater, the greater the prevalence of low-income taxpayers in a region. Also considerable regional disparities create a risk that such tax reform will deepen regional inequality and be disruptive for the Russian budgetary system.

KEYWORDS
income tax, progressive scale, tax deduction, tax-free allowance, tax reform

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Оригинальная статья

УДК 336.221

Оценка бюджетных последствий введения необлагаемого минимума в налогообложение личных доходов в России

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АННОТАЦИЯ
Социальную проблему бедности может смягчить введение необлагаемого подоходным налогом минимума доходов граждан. В статье исследуются вероятные бюджетные потери от введения в России необлагаемого подоходным налогом

минимума доходов граждан. Выдвигается гипотеза, что введение необлагаемого минимума негативно скажется на регионах, поскольку зависимость их бюджетов от поступления подоходного налога велика. Расчет последствий введения необлагаемого минимума проводился для экономических условий 2019 г. Источником данных являлись данные Росстата о населении, бедности, заработной плате и валовом региональном продукте, а также данные Федеральной налоговой службы о количестве налогоплательщиков и налоговых поступлениях. Для целей исследования были рассчитаны два сценария. По первому сценарию к заработной плате ниже прожиточного минимума применяется нулевая ставка налога на доходы физических лиц. Мы обнаружили, что при этом сценарии консолидированный бюджет России теряет более 1 трлн р., в то время как налоговые поступления в региональные бюджеты сокращаются более чем на 10%. По второму сценарию не облагаются налогом на доходы физических лиц граждане, чей доход ниже прожиточного минимума. Данные, полученные по второму сценарию, показывают, что региональные налоговые поступления сократятся на 1–5%. В любом случае, введение необлагаемого налогом минимума оказывает более сильное давление на те регионы, которые критически зависят от поступлений подоходного налога с физических лиц. Можно сделать вывод, что введение льготы при преобладании налогоплательщиков с низкими доходами приведет к существенным потерям для региональных бюджетов. Сделан вывод, что негативное влияние введения необлагаемого минимума будет тем больше, чем больше в регионе преобладают малообеспеченные налогоплательщики. Кроме того, значительные региональные диспропорции создают риск того, что такая налоговая реформа усугубит региональное неравенство и подорвет бюджетную систему России.

КЛЮЧЕВЫЕ СЛОВА
налоговая реформа, налоговый вычет, необлагаемый минимум, подоходный налог, прогрессивная шкала

1. Introduction

Flat personal income tax rate was adopted in Russia in 2001. This step was aimed at legalizing individual incomes and expanding the tax base in economy. Since then, the design of the Russian personal income tax has hinged upon the concept of budget efficiency of taxation. In accordance with this concept, the standard tax deduction of 400 roubles was cancelled in 2012. At the same time the absence of a tax-free allowance is still a much discussed question in Russia for the following reasons:

1. The tax burden is not lowered for disadvantaged groups. There is neither reduced tax rate nor tax exemption for low incomes. Even the subsistence minimum is fully taxed. For poor people, this burden is much heavier than for wealthier taxpayers because the lower is the income, the higher is the share of expenditures on basic necessities. Thus, the tax fairness is not observed.

2. According to the Federal State Statistics Service (Rosstat), in 2019 the share of poor people in Russia was 12.3% or 18.1 million. In these conditions, the absence of a personal tax-free allowance exacerbates the problem of poverty. Although the personal income tax design is not the ultimate solution to the problem of poverty, it can help narrow the gap between the rich and the poor.

3. The connection between the simplicity of the personal income tax's calculation and its collectability is far from being obvious. Economists cannot agree even regarding the success of the tax reform of 2001: some consider it to be a direct outcome of the transition to the flat tax rate [1], others point out that these results were achieved due to the overall individual income growth in Russia and reduction of social security contribution rates [2].

4. The rules of personal income taxation do not fit into the global trends. Tax systems of all developed countries with the largest economies in the world, including the USA, UK, Japan, Germany and Canada, have a personal allowance.

5. No inflation-related indexation of the existing tax deductions has been made and the transition to progressive taxation since 2021 is unlikely to bring any dramatic improvements to the lives of people from disadvantaged groups. The extra tax rate of 15% is aimed at enhancing income tax collection.

In Russia, where poverty is a serious social problem, the design of personal income tax has been a subject of consi-derable debate and no finality has been achieved up to date. The tax system is now entering a new stage in its development, which makes our study particularly relevant. The Russian government's decision to abolish the flat tax rate shows the willingness to apply more complex models of income taxation. And we're at a fork in the road. On one hand, the fiscal success Russia has enjoyed in recent years signifies the efficiency of its current taxation pattern and relevance to support it. On the other hand, taxpayers' abili-ty to pay the personal income tax is taken into account only in dealing with high incomes while low income, as before, is considered of little importance in determining the degree of tax immunity.

In the light of the above, it is obvious that there is a need for such tax mechanism for income redistribution and inequality reduction as a personal tax-free allowance. This, in turn, raises a question as to how such reform will influence the Russian budget system.

The aim of this study is to evaluate the possible budget implications of the introduction of a personal tax-free allowance by taking into account the Russian federative structure. Therefore, we are going to look at the reform's effect on the consolidated budget of Russia and the budgets of regional governments.

We are going to test the hypothesis that there is a connection between the amount of tax revenue losses of regional governments and these regions' reliance on the personal income tax for their tax revenues. We suppose that the regions that are going to be hit the hardest by the reform are most likely to be those with a high share of the personal income tax in the structure of their tax revenues.

The article is structured as follows. Section 2 provides an overview of the relevant research literature on the problem; Section 3 describes the data and methodology of the study; Section 4 discusses the results; and Section 5 summarizes our findings.

2. Literature review

In research literature, tax-free allowance is usually seen as one of the key elements of progressive income taxation, while the latter is compared to flat income taxation to identify the strengths and weaknesses of these taxation types. The choice of a tax scale is widely discussed in connection to fairness of taxation.

J. Head et al. contend that the selection of criteria of fairness in dealing with horizontal-equity (individuals with similar incomes) issues of taxation are related to the choice of income, consumption, or wealth as the tax base while vertical-equity issues (individuals with different incomes) are related to the choice of flat or more progressive rate structures [3].

D. Roberts and M. Sullivan observe that the classical argument given by the proponents of the flat scale is that the amount to be paid is differentiated regardless of the single tax rate as wealthier individuals are bound to pay more [4]. Such approach, however, ignores the distribution of the tax burden among individuals. B. Adhikari and J. Alm, for example, argue that the share of consumption expenditures is larger for the poor, which is why the real tax burden is higher for low-income households [5].

As a part of the progressive scale, tax-free allowance may be represented in the form of a zero tax rate. But the theory of taxation has described mechanisms to achieve progressivity even under the flat rate tax by using some other tax elements than the tax rate itself. In this context, tax-free allowance is seen as similar to the personal exemption or tax deduction. J. McNulty demonstrates that if the structure of a flat income tax includes personal tax exemptions, such tax is actually progressive even though officially it may be flat [6].

G. Nicodème argues that tax progressivity is primarily provided by the design of the tax, not by the transition to the progressive scale as such. The tax design is based on the combination of the marginal tax rate and tax-free allowance [7]. L. Chengjian and L. Shuanglin believe that a moderately progressive tax scheme is preferable since it distorts labour supply less and is more beneficial for the state. It also enables the government to expand the tax base that can be taxed at higher rates [8]. Their findings are supported by J. Davies and M. Hoy, who argue that an extremely high tax rate is not necessary for alleviating income inequality [9].

P. Doerrenberg et al. believe that budget losses incurred by the deviations from standard rules of personal income taxation are not pure losses of the state budget but should be seen as investment in the country's socio-economic policy [10]. G. Iyer et al. argue that the government can regulate the degree of the flat rate tax's progressivity by increasing or, on the contrary, reducing the amount of tax exemptions [11]. In their study, S. Barrios et al. explore the ways of such regulation. Basic tax allowances can in some instances be universal or be related only to employment income, be granted to all taxpayers or only to low-income earners, have a fixed amount or a sliding scale reducing the tax-free amount as the income rises [12].

Contemporary researchers pay much attention to tax exemptions, including the tax-free allowance, in the light of the administrative burden borne by taxpayers. M. Keen et al. explain some countries' decision not to introduce a tax-free allowance by their desire to simplify their personal income tax administration [13]. A. Evans and P. Aligica show the connection between the advantages of simple tax administration and tax evasion [14].

E. Luttmer and M. Singhal consider the phenomenon of tax morale, which they define as nonpecuniary motivations for tax compliance, and its potential to reduce tax evasion [15]. F. Schneider highlights the fact that on the macro-level, a heavy tax burden may affect labour supply in the shadow economy [16]. According to R. Cerqueti and R. Coppier, the shadow economy curbs economic growth due to the lack of funds in state budget for generating public goods [17].

T. Damjanovic and D. Ulph discuss the problem of the inefficient use of funds in economy due to the tax non-compliance. The government has to spend more on tax control trying to detect taxpayers' evasion schemes instead of using these funds more productively [18]. H. Cremer et al. emphasize that in the digital age, the simplicity of tax administration plays no crucial role in the choice of the right design of personal income tax [19].

Some economists focus on the fairness of the income and connect it to the problem of tax evasion. M. Roberts et al. show that the public preference for progressive taxation may be determined not by the desire to collect more tax but to eliminate the effect of tax minimization on the part of wealthy taxpayers [20]. Similarly, D. Nichols and W. Wempe interpret the 'ability to pay' principle as a condition under which the effective tax rate should not be lowered as the income increases [21].

Some studies approach progressive taxation from the perspective of tax burden redistribution. In this case, what comes to the forefront is the level of economic development of countries. For example, A. Paulus and A. Peichl contend that the idea to introduce a flat tax scale is less popular in societies where the middle class is in a strong position [22]. The preference for tax progressivity, according to B. Tarroux, is based on its ability to reduce inequality and poverty and improve social wellbeing [23].

V. Tanzi and H. Zee show the connection between the level of economic development of countries and efficiency of tax administration. They apply this approach to explain possible differences in the tax systems of developed and developing countries. In developing countries, a range of factors such as a large share of the informal sector, the limited capacity of tax administration, taxpayers' limited ability to keep accounts, the lack of reliable tax data, qualified staff and

necessary technical equipment for tax control can impede the implementation of progressive taxation [24].

Another aspect of the research on personal income taxation is the impact of tax design on work motivation. L. Osberg argues that the progressive income tax has a distorting effect on the taxpayer's optimal choice of hours of work and hours of leisure [25]. As S. Raei points out, the higher is the elasticity of labour supply, the stronger is taxpayers' reaction to changes in the tax code and vice versa [26]. J. Pántya et al. show that the introduction of a progressive tax scale can lead to a significant growth in work performance [27]. E. Saez et al. also demonstrate that taxpayers may react to certain characteristics of the personal income tax design by choosing to evade taxes or, for example, switching to another sphere of activity [28].

A separate group of studies deal with the absence of a personal tax-free allowance in the Russian tax system. These studies, in their turn, can be divided into two groups.

The first group comprises studies dating to the period when there existed a standard tax deduction of 400 roubles and soon after it was cancelled. These studies discuss the tax-free allowance in relation to this deduction. N. Solovieva argues that the cancellation of this deduction aggravates the financial situation of low-income individuals, which contradicts the principle of tax fairness. Therefore, she recommends to increase the standard tax deduction instead of cancelling it [29]. This approach is shared by S. Barulin and E. Barulina. Comparing the tax deduction with the tax-free allowance, they argue that the optimal solution would be to significantly increase the latter [30]. S. Sulyaeva demonstrates that the tax deduction should be replaced with a tax-free allowance equal to the minimum wage [31].

The second group of studies discuss the current state of the Russian tax system, which does not make exceptions for low-income taxpayers. Problems of personal income taxation are analyzed in connection to the absence of a tax-free allowance. T. Davletshin argues that it is necessary to introduce a tax-free allowance and apply a zero tax rate for incomes below the regional subsistence minimum [32]. N. Semenova shows the need to apply a tax-free allowance equal to the regionally differentiated amount [33]. V. Panskov and N. Melnikova see the tax-free allowance as an alternative to ineffective standard tax deductions [34]. M. Kosov and N. Bondarenko consider the tax-free allowance as a way to raise the income for the poor but warn that this measure will reduce tax revenues in the short term [35].

N. Malis calculates tax revenue losses suffered by the state budget if low-income taxpayers are exempted from income taxation. In her estimates she uses the data on the number of low-income earners and their average wages, concluding that the budget losses will be 2.6 billion roubles per month [36]. Her estimates, however, do not reflect the actual burden borne by the state budget since her calculations do not take into account the small business sector where millions of taxpayers are employed. Neither does she provide any estimates of how tax revenue losses are distributed among regional budgets.

Thus, in contemporary research literature the personal tax-free allowance is usually considered in connection with the impact of tax deductions and breaks on the progressivity of the personal income tax. The question of personal tax allowances is usually discussed together with that of tax fairness and is seen from the perspective of possibilities and risks of tax administration. Both earlier and contemporary research on this topic centres around the idea that the absence of a tax-free allowance or its small amount reduces progressivity and fairness of the personal income tax. Even though there is a large body of research on the problems of personal income taxation in Russia, the tax-free allowance still remains an underexplored topic. Therefore, when the recommendations concerning its introduction are given, no quantitative estimates of budget losses are provided.

3. Data and methodology

In our research, we are going to model the introduction of a personal tax-free allowance in the economic conditions of 2019 and to evaluate the possible consequences of this measure for the consolidated budget of Russia as well for budgets of regional governments. It is crucial to consider the regional aspect because the budget system of Russia is based on the principles of federalism. In accordance with the Russian budget legislation, the personal income tax is a source of tax revenues of regional governments. Therefore, it is primarily Russian regions that have to shoulder the burden of income tax exemptions and reliefs.

For fuller and more accurate results we need to be able not only to forecast the overall amount of tax revenue losses but also to predict the distribution of the burden among Russian regions. This will provide us with important insights into the stability of regional budgets and their ability to provide tax support to disadvantaged citizens. We will also be able to predict the number of regions where the introduction of the personal tax-free allowance would considerably diminish their tax revenues and the number of regions that would lose the least. Therefore, in this study we are particularly interested in regional statistics.

We use Rosstat data on the population in regions, the share of the working-age population and the number of poor people, on the average and median wages, and gross regional product (the size of regional economy). We also use the data of the Federal Tax Service of Russia, such as the number of taxpayers, regions' tax revenues, and revenues from the personal income tax. The data on the amount of subsistence minimum were acquired from the officially published legal acts of the Russian Ministry of Labour and Social Protection.

To evaluate the consequences of the tax reform in quantitative terms we need to specify the parameters of the personal tax-free allowance. These include the following: the maximum tax-exempt amount of income; the type of income exempt from the personal income tax; the perime-ter of beneficiaries entitled to a reduction of the tax base. We assume that the tax-free allowance should correspond to the standards of living, on the one hand, and, on the other, should not be extremely low.

In our calculations, the maximum amount of a personal tax-free allowance corresponds to the subsistence minimum for working-age population. This indicator accurately reflects the standards of living since it comprises the cost of the consumer basket and obligatory payments and fees. It reflects the income necessary to cover the costs of food and non-food essentials, in other words, the expenditures required to stay healthy and maintain basic life in a society. For the purpose of our study, among other types of income, the subsistence minimum should reduce the employment-related income. Depending on who will be the beneficiaries of the tax relief, we will identify and analyze budget implications according to two scenarios of the tax reform.

The first scenario is based on the model of the traditional progressive tax schedule where the tax-free allowance has the form of zero tax rate. Such approach is the closest to established world practices. According to the second scenario, only individuals with an income below the subsistence minimum will qualify for a tax-free allowance. In this case, it will be a targeted tax exemption and thus this measure will be able to reconcile the social policy goals and the needs of the budget system. Therefore, the key indicator used to evaluate the consequences of the reform is the number of beneficiaries in each scenario. For the zero tax rate scenario, we are going to use the data on the number of wage earners. For the second scenario, we are going to use only the number of low-income earners.

Our analysis will fall into the following three stages.

At the first stage, we will focus on regions' reliance on the personal income tax by using such indicator as the share

of this tax in the structure of regional tax revenues. For the purpose of our study, a region's reliance on the personal income tax will be deemed critical if such share accounts for more than 50% of the tax revenues.

At the second stage, we are going to estimate tax revenue losses of the consolidated budget of Russia and budgets of regional governments for the two above-described scenarios. We are also going to show how budget losses would be distributed among the regions, identifying the most resilient and the most vulnerable regions. We will calculate the amount and percentage of tax revenue losses. The amount per each beneficiary will be defined as tax-free amount multiplied by the main income tax rate of 13%. The percentage is based on the 'personal income tax to tax revenues' ratio mentioned above. To obtain aggregated estimates, we are going to use the data on the total number of beneficiaries and their distribution across the regions as well as the amount of the subsistence minimum we specified for each scenario. These estimates will then be compared with the levels of regions' reliance on the personal income tax and the results will be further specified by looking at socio-economic conditions in Russian regions.

At the third stage, we are going to systematize our findings concerning regions' fiscal abilities to compensate for their tax revenue losses. The stages of evaluation and scenarios of the tax reform are shown in Figure 1.

4. Results and discussion

4.1. Regions' reliance on the personal income tax

Many Russian regions strongly depend on the personal income tax for their revenues. The share of this tax in the total tax revenue of the consolidated budget of Russia is about 18% while in regional budgets this figure may reach 40%. There are, however, significant differences in the extent of regions' reliance on the personal income tax: in some of them, the share of this tax is considerably below average. For example, the Yamal-Nenets Autonomous Area has the minimum share of the personal income tax in its tax revenues – 19%. Comparatively small shares – 30% or lower – are characteristic of twelve other regions, including Khanty-Mansi Autonomous Area-Yugra, Krasnoyarsk Territory, Nenets Autonomous Area, Republic of Tatarstan and Sakhalin Region.

Nevertheless, the majority of regional governments are much more heavily dependent on the personal income tax: in 60 regions, this tax accounts for 30% to 50% of tax revenues. In 12 regions out of 85, the personal income tax is the main source of tax revenues, accounting for over 50%. The highest share of the personal income tax is 70% in Chechen Republic while in four other regions – Kamchatka Territory, Republic of Ingushetia, Republic of Tuva and Sevastopol city – it is over 60%. In other words, their reliance on the personal income tax reaches a critical level.

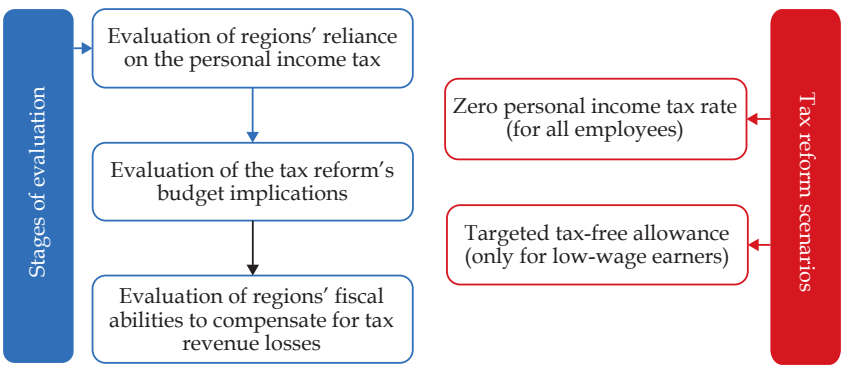

Fig. 1. **Stages of evaluation and tax reform scenarios**

A high share of the personal income tax does not necessarily imply high wages in one or another region. On the contrary, most of Russian regions are characterized by payments of low wages to employees. The lowest income levels are mainly feature of the regions that are heavily dependent on the personal income tax. Moreover, we found that a high share of the personal income tax in regional tax revenues usually goes together with high poverty rates. In the Russian economy, this indicator is 12.3% but may vary across regions and in some of them exceed 20%, for example, in Chechen Republic, Jewish Autonomous Region, Karachay-Cherkess Republic and Republic of Altay. In Republic of Ingushetia and Republic of Tuva, however, low-income individuals account for about a third of the total population. Therefore, personal income tax revenue collections in such weak, unstable regional economies are based on taxes paid by low-income taxpayers. Therefore, such regions will be hit harder by the reform than their more prosperous counterparts.

As our analysis has shown, such situation is not an accident. The share of the personal income tax in tax revenues of regional governments can be an indication of the degree of the regional economy's sensitivity to income tax exemptions or absence thereof, on the one hand, and, on the other, the size and state of the regional economy. The lar-ger and more developed is the economy, the higher is the share of the corporate income tax and the lower is the share of the personal income tax in the total tax revenues. Regions where the personal income tax accounts for less than 30% of their tax revenues tend to have the hig-hest GRP. Smaller economies are generally more reliant on the personal income tax. The economic performance of regions that are overly reliant on this tax is rather poor. A small regional economy is unable to generate sufficient economic activity to provide tax revenue from a variety of taxes and to raise people's income levels. Fewer economic transactions and business operations increase the role of the personal income tax despite the low average individual income. Therefore, the less reliant a region is on the personal income tax, the more stable is its economy and vice versa, if a region is heavily reliant on the personal income tax, it is a sign of economic problems and low living standards.

This conclusion is supported by the data provided by the Russian Ministry of Finance regarding regions' dependence on federal subsidies. This indicator shows how dependent the regions are on federal transfers and to what extent regions are capable of covering its own expenditures. We compared the data on the share of the personal income tax in regional tax revenues with this indicator and came to the conclusion that the regions that are overreliant on the personal income tax are struggling economically, typically less self-sufficient and dependent on federal subsidies.

A small number of regions that are less reliant on the personal income tax are also more self-sufficient in terms of federal transfers (subsidies). These are financially independent and economically prosperous regions that tend to rely more on the corporate income tax for their revenues. This situation is to a great extent determined by the regional industrial specialization: oil producing regions are usually more independent. Despite the low share of the personal income tax in their tax revenues, they maintain a higher wage level (Table 1). Regions with the largest economies have the lowest poverty rates. For example, in Yamal-Nenets Autonomous Area the share of poor people does not exceed 6%; in Republic of Tatarstan, 7%; and in Sakhalin Region, 9%.

The personal income level plays an important role for the formation of the tax base that will be available after personal allowances are granted to taxpayers. In other words, if there are high wages in the region, then it faces less risks of losing too much of tax revenues. What matters the most is the amount of the tax-free allowance and the number of beneficiaries. It should be noted at this point that the combination of a very large share of the personal income tax in tax revenues and high wages is a rare situation in Russian regions, with the only exception of Kamchatka Territory.

Thus, the structure of tax revenues of regional governments is determined by the socio-economic characteristics of Russian regions, including the level of wages as a tax base. Nevertheless, there are cases where a high share of the personal income tax in the tax revenues does not correlate with the region's weak economy and the generally low level of taxpayers' income. We mean the regions with a concentrated tax base that should be considered separately. These are primarily the cities of federal significance – Moscow and St. Petersburg – and, besides them, Moscow Region. Remarkably, in the structure of their tax revenues, the personal income tax accounts for 40–50% because these regions concentrate over one fourth of employees. Moreover, almost three-fourths of employees with wages over 1 million roubles per month work and pay their income tax in these three regions. This circumstance agrees with the fact that in these regions the share of poor people is one of the smallest in Russia – only 7% on average. Therefore, despite a large share of the personal income tax in their tax revenues, as we are going to show further, the regions

Table 1

Regions' reliance on the personal income tax

Regions	Personal income tax, % of tax revenues	Corporate income tax, % of tax revenues	Share of low-income earners, %	Median wage, rbs	Size of the economy, % of Moscow GRP
Regions that are critically dependent on the income tax (>50%)					
Chechen Republic	69.5	7.4	20.7	22 501	1.1
Republic of Ingushetia	65.8	11.2	30.5	19 954	0.3
Sevastopol city	64.5	13.4	11.6	29 563	0.4
Republic of Tuva	63.3	16.2	34.7	27 822	0.4
Kamchatka Territory	61.4	14.0	15.0	62 444	1.3
Republic of Crimea	55.6	16.7	17.2	25 901	2.2
Republic of Dagestan	55.5	14.3	14.6	20 015	3.5
Republic of Altay	54.5	21.3	24.2	24 872	0.3
Karachay-Cherkess Republic	53.9	16.3	23.2	20 788	0.4
Pskov Region	53.6	19.8	16.2	23 895	0.9
Republic of North Ossetia-Alania	53.5	11.7	13.5	21 061	0.7
Jewish Autonomous Region	51.0	15.1	23.9	34 538	0.3
Regions with a more resilient budget (<30%, no federal subsidies)					
Khanty-Mansi Autonomous Area-Yugra	28.4	41.3	8.9	60 570	24.9
Republic of Tatarstan	28.4	38.6	6.9	31 341	13.8
Sakhalin Region	24.8	62.3	8.5	62 647	6.6
Nenets Autonomous Area	20.1	47.9	9.5	71 303	1.7
Yamal-Nenets Autonomous Area	19.4	52.4	5.6	77 542	17.2
Regions with a concentrated tax base					
Moscow Region	42.2	26.6	7.3	45 201	23.5
St. Petersburg city	48.4	33.0	6.6	51 248	23.5
Moscow city	46.0	38.2	6.6	66 103	100.0
Russia	17.6	20.2	12.3	34 335	–

Source: author's calculations

Notes: 1) The economy of Moscow is the largest among Russian regions; for better data comparability we use their GRP in relation to GRP of Moscow; 2) low income refers to amounts being lower than subsistence minimum; 3) the data on the median wage are provided by Rosstat for medium-sized and large enterprises, and the values of this indicator would be lower if small businesses were also taken into account.

with a concentrated tax base are more resilient to tax base fluctuations. That way these regions enjoy an advantageous combination of high wages and low poverty rates, which leaves more room for a tax maneuver and for maintaining the necessary level of the income tax collectability when the tax reform comes into force.

4.2. Budget implications according to Scenario 1 (zero tax rate)

For all employees, a tax-free allowance means that the traditional progressive scale with the zero tax rate is applied. Low-income earners are not singled out as a separate category of be-neficiaries. An individual's right to a tax-free allowance does not depend on their income level. The subsistence minimum is taken as 12,130 roubles. The income below this threshold is non-taxable. The tax is levied on the income above the subsistence minimum. Progressivity is achieved because the share of the non-taxable amount is increased when the income is falling. In this case the number of beneficiaries will be maximal: in Scenario 1, it would be about 59 million. Tax expenditures of the Russian budget system would exceed 1 trillion roubles. This sum is equal to receipts from certain Russian taxes. The budget losses resul-ting from the tax reform in this scenario are comparable with those incurred by the cancellation of the regional tax on the assets of organizations. The losses caused by the cancellation of the personal property tax, transport tax and land tax would be more than twice lower.

In this regard the reform would create an extremely heavy burden on the state financial system. Tax revenues of the consolidated budget of Russia would be reduced by 5.0%. Taking into consideration the fact that the personal income tax is one of the key sources of revenue for regional governments, a more reliable indicator appears to be the ratio of their budget losses to regional tax revenues. In this case regions would lose 11.0% of their tax revenues – quite a substantial figure.

No less important is the distribution of losses among the regions, especially since regions differ considerably in terms of their reliance on the personal income tax. In absolute terms, the heaviest pressure will be borne by the cities of Moscow and St. Petersburg and Moscow Region – 256.6 billion roubles or one fourth of all the budget losses. For many other regions, the losses would be much lower, especially for those whose dependence on the personal income tax is critical. For instance, Republic of Ingushetia would lose 1.1 billion roubles.

This does not mean, however, that more prosperous regions are actually facing a more significant decrease in their revenues. The extent of revenue losses is determined by the number of taxpayers: the more taxpayers a region has, the bigger are the losses. Therefore, in absolute terms, larger economies will suffer more tax revenue losses. The real burden on the budget is determined by the share of the tax revenues lost due to the reform. In this case, the picture looks totally different. For instance, the city of Moscow would lose less than 6% of its revenue while St. Petersburg city and Moscow Region, 10–11%. As for Republic of Ingushetia, according to our forecast, it would lose about 28% of its tax revenue, which is the largest amount of losses among all Russian regions. As Figure 2 illustrates, losses of tax revenues of 70 regions would exceed 10%, with 47 regions losing from 10 to 20% of their tax revenues. Losses of such scale are likely to pose a serious challenge to the implementation of any regional expenditure budget.

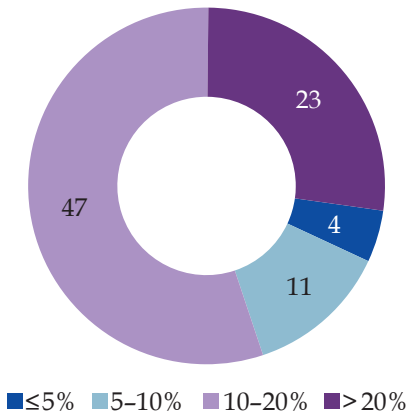

Fig. 2. **Number of regions according to the percentage of their tax revenue losses (Scenario 1 – zero tax rate)**

Oil-producing regions would lose the least: Nenets Autonomous Area, less than 2%; Sakhalin Region and Yamal-Nenets Autonomous Area, 2–3%. The tax revenues of Khanty-Mansi Autonomous Area-Yugra would drop by about 6%. These are the regions where the share of the personal income tax does not exceed 30% of the total tax revenues.

Interestingly, budget losses tend to grow together with the region's reliance on the personal income tax (see Fig. 3). The losses exceeding 20% are characteristic of the regions where the personal income tax is the main source of tax revenues. Therefore, the majority of Russian regions will suffer a 5–20% drop in their tax revenues – these are the regions where the personal income tax accounts for approximately 40% of tax revenues. This figure corresponds to the average figure for the whole economy.

Thus, the less dependent a region is on the personal income tax, the easier it will bear the burden of various tax breaks and tax exemptions. Unsurprisingly, the least vulnerable in this respect are the regions whose main source of revenues is the corporate income tax. They also enjoy a more stable budget and they are also more self-reliant and independent of federal grants. These regions, however, are only just a few. Apart from that, tax revenue losses still remain quite substantial even for their budgets.

One of the reasons behind more advantaged regions' resilience to the financial pressure is the above average wage level. Regions with low wages stand a small chance of coping with the zero tax rate. While the former would still have a sufficient tax base, the latter's tax base would be diminished by the tax reform. As a result, favourable economic conditions in some regions do not change the general situation: the zero tax rate scenario remains undesirable at large.

Our analysis of the tax reform's implications for regional budgets leads us to the conclusion that Scenario 1 goes beyond a reform of personal income taxation. To restore the level of tax revenues, the government would have to reconsider revenue sources both of the federal and regional budgets, in other words, create a new fiscal system. In the existing economic conditions and taxation model, such task turns into an unresolvable conundrum.

4.3. Budget implications according to Scenario 2 (targeted tax relief)

Shortcomings of the zero tax rate would require the government to change the conditions for granting personal tax-free allowance in order to reduce the pressure on the budget system. This can be achieved by reducing the number of taxpayers entitled to a tax-free amount of income. In other words, a more targeted tax relief is needed. It can be adopted for

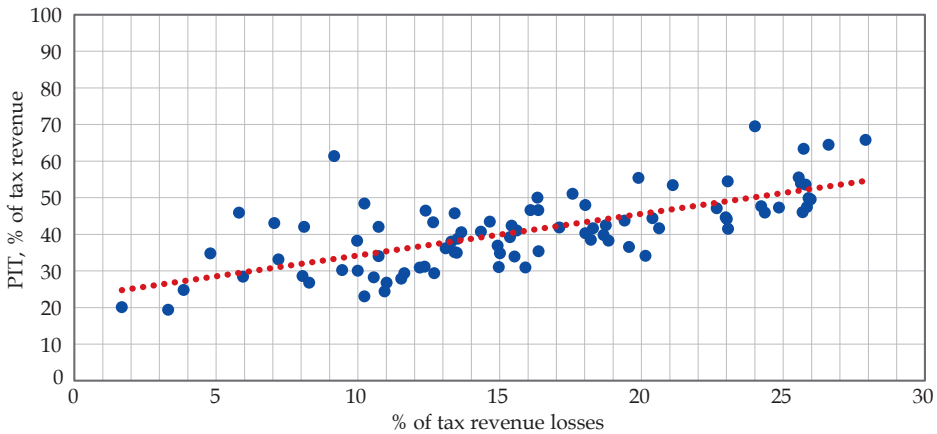

Fig. 3. **Distribution of regions according to the percentage of tax revenue losses and reliance on the personal income tax (Scenario 1 – zero tax rate)**

Note: PIT – Personal income tax

people with income below the subsistence minimum of their respective regions. In this scenario, the individual income level is taken into account for tax purposes. If a taxpayer's income is higher than the subsistence minimum, the tax base is not reduced. Thus, being of little means becomes a criterion for entitlement to a personal tax-free allowance. Therefore, a tax-free allowance turns into an instrument to support low-income earners.

The Federal Tax Service does not provide any data on the distribution of taxpayers regarding their earnings. However, we have access to the data on the number of people living in poverty. It should be noted that poverty is measured in relation to per capita income and household income, which means that the number of poor people may include individuals without income of their own (e.g. dependents) or those that have a non-taxable income (e.g. pension). It is important since a tax-free allowance can be granted only to individuals who are taxpayers and have a taxable income. So, using an aggregate poor people can create risks of overestimating the tax revenue losses, which is why we adjust the number of the poor in regions to the share of the working-age population. This way we can obtain the real number of beneficiaries: 10.1 million taxpayers, which is almost six times lower than in Scenario 1. Therefore, the pressure on the budget system is supposed to be much smaller.

In order to measure the tax revenue losses as accurately as possible, we should know the regional average wages within the bounds of non-taxable income brackets (i.e. regionally differentiated tax-free amount). The subsistence minimum only marks the income threshold for personal allowance but the actually used tax-free amount would be lower than this threshold. In other words, the losses of regional budgets depend on how much of the allowance would be applied by every taxpayer depending on income received. There is, however, no region-specific information on the average income of those workers who earn less than the subsistence minimum. For approximate estimates, we are going to use the federal average wage of a low-income taxpayer (Rosstat data on the distribution of the number of workers according to the wage levels in April 2019): 9,454.4 roubles.

The forecast revenue losses are 148.3 billion roubles, which is 7.5 times less than the revenue losses incurred by the tax reform in the first scenario. Our calculations show that the tax revenues of the consolidated budget of Russia would decrease by 0.7% while regional budgets would lose 1.5%. The amount of losses depends on the number and share of low-income taxpayers in regions.

Moscow's losses would be the largest, reaching 7.1 billion roubles. Although the share of the poor in this region is quite small, this region is densely populated, which means that the number of beneficiaries will be quite high in comparison with other regions. A large share of low-income earners combined with a large population obviously leads to an increase of regional tax revenue losses in absolute terms. Krasnodar Territory, Krasnoyarsk Territory and Rostov Region have over 1 million taxpayers each. In addition, all of these regions have a significant share of low-income earners. Therefore, in each of these regions tax revenue losses would exceed 4 billion roubles. Republic of Dagestan is particularly worthy of attention in this respect: in this region, the number of taxpayers is almost 20 times smaller than in Moscow city but three-fourths of the taxpayers are poor. Therefore, the number of beneficiaries in Republic of Dagestan is virtually the same as in Moscow city (the difference is less than two times). These regions together with Moscow Region would bear about 20% of tax revenue los-ses (see Table 2).

Losses are minimized if a region has a small number of taxpayers and an insignificant share of beneficiaries. For example, in Nenets Autonomous Area there are less than 20 thousand wage earners, and only 13 % of them would be entitled to a personal allowance. In Chukotka Autonomous Area, there are about 40 thousand wage earners but only 7% of them are beneficiaries. As a result, these regions' tax revenues would decline by not more than 40 million roubles.

Table 2

Distribution of the maximum and minimum amounts of tax revenue losses among the regions in Scenario 2

Regions	Employees, ths people	Beneficiaries		Tax revenue losses	
		ths, people	% of employees	mln rbs	% of total
Regions with maximum losses					
Moscow city	6,969.5	478.4	6.9	7,055.9	4.76
Krasnodar Territory	1,992.5	334.1	16.8	4,927.7	3.32
Moscow Region	3,504.4	320.9	9.2	4,733.5	3.19
Rostov Region	1,422.6	312.3	22.0	4,605.9	3.10
Krasnoyarsk Territory	1,248.2	286.8	23.0	4,230.1	2.85
Republic of Dagestan	366.2	272.4	74.4	4,018.0	2.71
Regions with minimal losses					
Sakhalin Region	269.0	23.7	8.8	349.8	0.24
Jewish Autonomous Regi on	61.3	21.3	34.8	314.8	0.21
Yamal-Nenets Autonomous Area	484.9	19.4	4.0	286.8	0.19
Magadan Region	95.9	7.9	8.2	116.2	0.08
Chukotka Autonomous Area	38.1	2.7	7.1	40.0	0.03
Nenets Autonomous Area	18.1	2.4	13.0	34.8	0.02
Russia	58,904.9	10,057.5	5.9	148,337.2	100

Source: author's calculations

Analysis of tax revenue losses in the ratio to tax revenues has shown that the second scenario of the tax reform would considerably reduce the budget losses of the vast majority of regional governments. If tax relief is granted only to low-income groups, tax revenues of 70 regions would fall by less than 5%. These are primarily the regions where the personal income tax accounts for no more than a half of their tax revenues. Moreover, in 12 regions, tax revenues would decrease by less than 1% (see Fig. 4). These are Chukotka Autonomous Area, Khanty-Mansi Autonomous Area-Yugra, Leningrad Region, Magadan Region, Moscow Region, Moscow city, Murmansk Region, Nenets Autonomous Area, Republic of Tatarstan, Sakhalin Region, St. Petersburg city and Yamal-Nenets Autonomous Area. In general, these are the regions with large economies and lower poverty rates. This group includes oil producing regions and regions with a concentrated tax base.

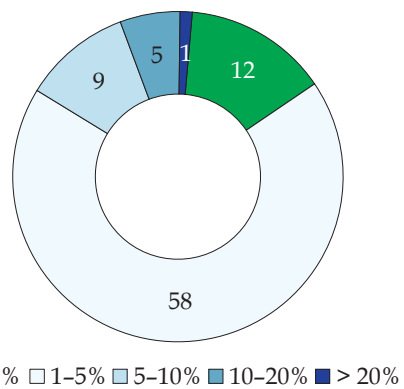

Fig. 4. **Number of regions according to the percentage of their tax revenue losses (Scenario 2 – tax-free allowance only for low-income taxpayers)**

In this scenario, a more than 10% decrease in tax revenues of regional governments appears exceptional: such regions perform poorly both in social and economic spheres due to a number of adverse factors. As a rule, these factors include a large share of the poor (higher

than the Russian average level), low per capita income, lack of business activities and resulting overreliance on the personal income tax. This group comprises regions of the North Caucasus, such as Chechen Republic, Karachay-Cherkess Republic, Republic of Dagestan, Republic of Ingushetia, and Republic of Tuva (Siberian Federal District). We could also include in this list Kabardino-Balkarian Republic but personal income tax makes up there slightly less than 50% of tax revenues while listed regions critically depend on receipts of this tax. However, three-fourths of taxpayers in this region are poor, which explains large tax revenue losses. With the exception of Republic of Ingushetia, tax revenue decline for the group would be 10–20%. In Republic of Ingushetia, this figure is still close to 30%, which is the maximum.

As we can see, the scenario of a more targeted tax relief facilitates the tax reform. However, regional governments' losses are distributed unevenly. Regions that are struggling both socially and economically would be hit the hardest while the fiscal interests of more prosperous regions would be affected much less. Thus, there may be a higher risk that the existing regional disparities would be exacerbated. Figure 5 illustrates the connection between tax revenue losses and regions' dependence on the personal income tax as well as significant regional disparities in the light of the tax reform.

The higher is the number of low-income earners in a region, the more this region will have to spend in order to implement the tax reform and, as a result, the less opportunities it will have to provide tax relief to low-income individuals. Taking into account the fact that poor regions are also the most dependent on federal funding, increasing financial pressure on their budgets will inevitably turn into the federal government's problem.

4.4. Fiscal limitations

We assume that the tax reform in question will be budget neutral. The principle of budget neutrality means that changes in the tax code will not be detrimental to state finance and will not go against the fiscal interests of regions. In other words, the introduction of the personal tax-free allowance should be associated with a shift of the tax burden to high incomes in order to compensate for tax revenue losses. Our analysis has shown that the government aiming at covering tax expenditures incurred by the expected reduction of tax receipts will have to deal with two major limitations.

Limitation 1 – The absence of middle class. According to the OECD methodology, the middle class consists of the households with income between 75%

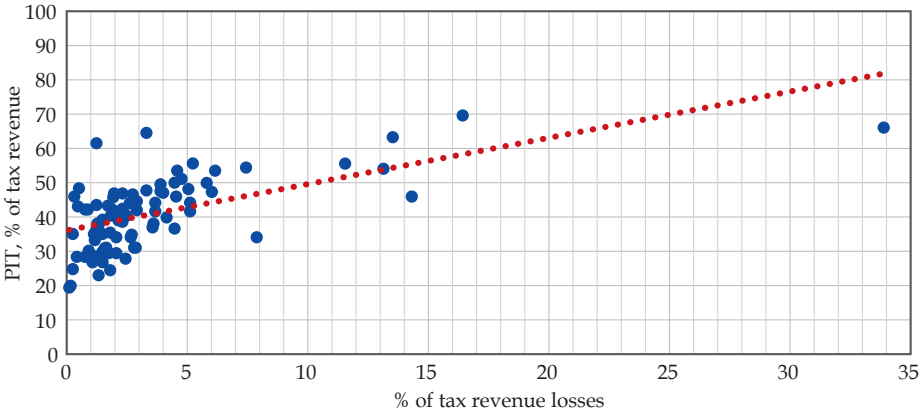

***Fig. 5.* Distribution of regions according to the percentage of tax revenue losses and reliance on the personal income tax (Scenario 2 – tax-free allowance only for low-income taxpayers)**

Note: PIT – Personal income tax

and 200% of the median national income[1]. The median wage in Russia is 34,335 roubles. Therefore, individuals with income 25,751–68,670 roubles can be referred to as middle class. Such approach, however, is purely formal and depends entirely on people's welfare. Therefore, it can be said that there is a middle class even if the general individual income level is low. For taxation, however, what matters more is taxpayers' ability to pay. Therefore, it should be noted that the interval of income specified above corresponds to a low ability to pay. The subsistence minimum in Russia is about one third of the median wage. The average wage of 47,867 roubles is equal to just four subsistence minimums.

If we look at the data on the distribution of per capita income, we will see that most Russian regions are low-income. As Figure 6 shows, three fourths of the Russian population have an income below the average wage level. In fact, this means that Russia has no middle class. Therefore, an increase in the tax burden on the main part of incomes (below 100 thousand roubles) does not make the personal income tax more fair. On the contrary, this measure will impoverish the population as additional tax revenues will be mainly transferred between poor taxpayers (i.e., from low-income earners to lowest-income earners).

The number of individuals with high and highest income is too small to eliminate the negative implications of the tax reform. Only 3.3% of taxpayers in Russia earn monthly wages above 100 thousand roubles. Such wage level cannot be considered a sign of financial wellbeing since it is only twice higher than average. At the same time only 0.08% of employees have an income above 500 thousand roubles a month; 0.02%, over 1 million roubles a month. It means that every wealthy taxpayer would have to finance tax exemption for 200 low-income earners in the first case and about 900 of them in the second case.

Limitation 2 – Extremely uneven distribution of the tax base among the regions. The problem of low income goes hand in hand with the fact that most high-income earners are concentrated in only a few of the regions. These are affluent and self-reliant regions with large economies, such as the cities of Moscow and St. Petersburg and Moscow Region. The pressure on these regions' budgets would be minimal. Moreover, they enjoy ample opportunities for restoring their tax revenues. If there is no viable mechanism for a redistribution of extra tax revenues among regional budgets, the tax reform will exacerbate the socio-economic disparities between the regions.

[1] OECD (2019), Under Pressure: The Squeezed Middle Class, OECD Publishing, Paris. https://doi.org/10.1787/689afed1-en.

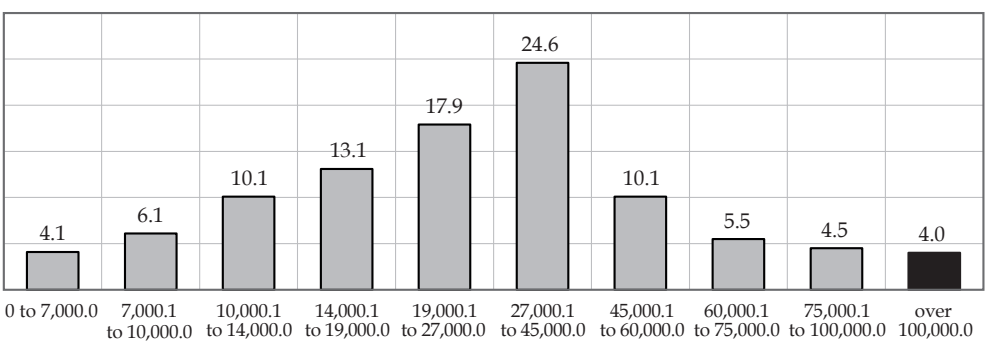

Fig. 6. **Distribution of the Russian population according to per capita income in 2019, rbs, %**

Notes: 1) income figures are given in roubles; 2) monetary income includes the wage. Apart from the wage, monetary income includes other sources, both taxable (e.g. earnings from business operations) and non-taxable (e.g. pensions, scholarships), as well as social transfers. Labour wages account for about 60% of the population's monetary income.

Table 3

Territorial concentration of high and highest wages

Regions	> 100 000 rbs			> 500 000 rbs			> 1 000 000 rbs		
	people	% of total	% of employees	people	% of total	% of employees	people	% of total	% of employees
Moscow city	718,763	36.9	1.220	27,412	56.3	0.047	6 791	60.2	0.012
St. Petersburg city	157,599	8.1	0.268	4,392	9.0	0.007	910	8.1	0.002
Moscow Region	119,848	6.1	0.203	3,801	7.8	0.006	650	5.8	0.001
Other regions	953,000	48.9	1.618	13,097	26.9	0.022	2 935	26.0	0.005
Russia	1,949,209	100	3.309	48,701	100	0.083	11 287	100	0.019

Source: author's calculations

Moreover, in Russia some regions have no taxpayers with wages above 1 million a month. These are the regions that rely most heavily on federal funding such as Chechen Republic, Jewish Autonomous Region, Kabardino-Balkarian Republic, Republic of Altay, Republic of Ingushetia, Republic of Kalmykia and Republic of North Ossetia-Alania. At that, in Republic of Altay there are even no taxpayers with wages above 500 thousand roubles. Regions of this group would not be able to independently redistribute tax revenues from wealthy taxpayers in favour of low-income taxpayers.

It should also be noted that the favourable economic situation in a region doesn't guarantee fiscal possibilities to cover the regional tax expenditures. This is especially true of the economically stable Nenets Autonomous Area, which does not have a large tax base, that is, it has a small number of high-income earners. As a result, even small tax revenue losses can pose a problem for the regional government if they cannot be compensated.

Table 3 illustrates the imbalance of the tax base distribution across Russian regions. Over a half of the employees with income above 100 thousand roubles a month are employed in just three Russian regions. Moscow city is a major centre of attraction for the tax base. This region is the leader in number of highest-income taxpayers. Most individuals with monthly wages above 500 thousand / 1 million roubles pay their income taxes only to the budget of Moscow city. Therefore, the compensation for tax revenue losses at large requires Moscow personal income tax receipts to be partly redistributed to poorer regions dependent on federal subsidies.

In most regions, a higher personal income tax rate would be all but useless as the necessary fiscal effect would not be achieved due to the deficiency of high salaried income. Therefore, the losses in tax revenues would lead to pure losses of those regions that are dependent on federal funding. The federal government would have to increase its subsidies to these regions.

5. Conclusion

In this study, we analyzed how the introduction of a personal tax-free allowance can influence the Russian budget system, in particular the reform's implications for the revenues of regional governments. First, we discussed the extent of regions' reliance on the personal income tax. Our analysis has shown that the majority of Russian regions are heavily dependent on this tax for their revenues. The share of the personal income tax in regional tax revenues mainly varies between 30 and 50%, which can be explained by the lack of economic activity and the prevalence of the full taxation of low incomes. This led us to identify three specific groups of regions. The first group comprises the regions with struggling economies that are critically dependent on the personal income tax. The second group, on the contrary, includes oil producing regions with high wage levels, which are less reliant on the personal income tax. The third group consists of regions located in the economic and political centre of Russia (the cities of

Moscow and St. Petersburg and Moscow Region). In these regions, there is a high share of the personal income tax in their tax revenues due to the concentration of the tax base.

Our analysis of the reform's implications for regional budgets has confirmed the hypothesis that there is a connection between regions' reliance on the personal income tax and their revenue losses. We have also found an interesting pattern: the stronger is a region's reliance on the personal income tax, the heavier will be the burden on the regional budget if the tax-free allowance is introduced. We tested this hypothesis and analyzed the tax reform's implications for regional governments by looking at two possible scenarios.

According to the first scenario, a personal tax-free allowance should be introduced in the form of a zero income tax rate. We found that the effect of tax reform would be similar to the cancellation of certain regional taxes. In this case the consolidated budget of Russia loses over 1 trillion roubles while tax revenues of regional governments are commonly reduced by more than 10%. The second scenario, with a tax exemption of low wages and narrower range of beneficiaries, changes the situation dramatically: the consolidated budget of Russia would lose 7.5 times less revenue; as a rule, regional tax revenues would be reduced by 1–5%. Remarkably, in both scenarios, the tax reform is likely to pressure more heavily on budgets of those regions that critically depend on the personal income tax receipts. The fiscal interests of more economically successful regions, less dependent on the personal income tax, would suffer much less.

There are certain barriers to redistribution of high and highest incomes to restore tax revenues through increased tax rate. These include the lack of middle class in Russia and the extremely uneven distribution of the large tax base. The share of rich taxpayers is very small and most of them pay their income taxes in the cities of Moscow and St. Petersburg and Moscow region. The introduction of the personal tax-free allowance under the prevalence of low-income taxpayers would lead to great amounts of uncovered tax expenditures of regional governments. Also considerable regional disparities create a risk that the tax reform will deepen regional inequality and be disruptive for the Russian budget system.

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Projected shortfall in personal income tax revenues of regional governments in Russia due to the COVID-19 pandemic

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ABSTRACT
The COVID-19 pandemic has put a great strain on the Russian economy and budget revenue. The study aims at furnishing an estimate of losses in personal income tax revenue in regional government budgets in 2020–2023 due to the COVID-19 pandemic. In order to investigate the shortfall in tax revenues, three factors were studied: the amount of damage caused by the COVID-19 outbreak to the whole economic system; the sensitivity of the state revenue base to the crisis; the sensitivity of regional tax revenue to the revenue base. The study was based on the annual reports of the Federal Tax Service of Russia, Rosstat data, Forecast of the Social and Economic Development of the Russian Federation, and data from the "National action plan to ensure the recovery of employment and incomes of population, economic growth and long-term structural changes in the economy". It was found that recession will lead to a significant reduction in people's income over the given period. As a result, personal income tax revenues will decrease. The budget losses will reach 416.6 billion rubles by the end of the 2020 fiscal year. This is equivalent to 0.4% of GDP and 9.7% of total income from personal income tax in an economic situation unmarred by the pandemic. The largest fall in public revenue is expected in the regions which stand out in regard to personal income tax revenues per capita. The research results confirm the initial hypothesis that the negative impact of the pandemic on personal income tax revenues depends on the share of income tax revenues of a particular region or municipality. The findings can be used by the regional and municipal financial authorities for developing draft budgets for 2022 and the planning period of 2023–2024.

KEYWORDS
personal income tax, budget losses, consolidated regional budget, forecast, COVID-19 pandemic

JEL H24, H30, H68, E62

Оригинальная статья

УДК 336.221.262

Прогноз потерь региональных бюджетов России от снижения поступлений подоходного налога в связи с пандемией COVID-19

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АННОТАЦИЯ
Пандемия COVID-19 нанесла серьезный ущерб российской экономике и доходам бюджета. Целью исследования является построение прогноза сокращения доходов по налогу на доходы физических лиц в консолидированные бюджеты субъектов Российской Федерации в период 2020–2023 гг. вследствие пандемии

COVID-19. Для прогнозирования снижения налоговых поступлений анализировались три фактора: размер ущерба, нанесенного пандемией COVID-19 экономической системе в целом; чувствительность доходной базы государства к кризису; чувствительность региональных налоговых поступлений к изменению доходной базы. Исследование проводилось на основе данных годовых отчетов Федеральной налоговой службы России, данных Росстата, Прогноза социально-экономического развития РФ, а также данных «Общенационального плана действий, обеспечивающих восстановление занятости и доходов населения, рост экономики и долгосрочные структурные изменения в экономике». Было определено, что рецессия приведет к существенному сокращению денежных доходов населения за анализируемый период, что отразится на снижении поступлений налога на доходы физических лиц в консолидированные бюджеты субъектов РФ. Бюджетные потери составят 416,6 млрд р. по итогам 2020 финансового года. Это эквивалентно 0,4% ВВП и 9,7% совокупных доходов от подоходного налога в экономической ситуации без учета пандемии. При этом наибольшее снижение ожидается в регионах лидирующих по объему поступлений налога на доходы физических лиц в расчете на душу населения. Таким образом, подтвердилась гипотеза о зависимости отрицательного воздействия пандемии COVID-19 на поступления налога на доходы физических лиц от объемов поступлений этого налога в бюджет конкретного региона или муниципалитета. Полученные результаты могут быть использованы Министерством финансов при разработке прогноза консолидированного бюджета РФ, проекта федерального бюджета РФ, а также финансовыми органами субъектов РФ и муниципальных образований в ходе разработки проектов бюджетов соответствующих территорий на 2022 г. и плановый период 2023–2024 гг.

КЛЮЧЕВЫЕ СЛОВА
налог на доходы физических лиц, консолидированный бюджет субъекта РФ, бюджетные потери, прогноз, пандемия COVID-19

1. Introduction

The COVID-19 pandemic has placed great strains on the state budget of the Russian Federation: the shocks incurred by the pandemic have led the federal, regional and local governments to struggle with staggering revenue losses and budget shortfalls. One of such shocks was brought about by the restrictions aimed at curbing the spread of the disease.

Although the effects of the pandemic can be found on all three levels of the budget system, regional and municipal budgets have turned out to be the most vulnerable in this situation. This can be explained by the fact that regional and municipal governments' authority to issue debt instruments is rigorously limited in Russia.

The personal income tax (PIT) provides one of the main sources of revenue for regional and local governments: over 40% of fiscal revenues of regional governments are generated by this tax. The major blow dealt by the 2020 pandemic to the national economy also had a massive effect on the taxation base – individual income of Russian citizens. In general, the situation on the labour market still remains precarious, which jeopardizes the efficient implementation of the consolidated federal budget regarding the collection of the personal income tax.

Unlike other similar studies, this research compares PIT receipts in 2020 not with the receipts of the previous period but with the receipts in the same year but according to the scenario where the pandemic had not occurred (non-COVID scenario).

Therefore, this study aims at developing projections of the losses in tax revenue of regional governments in 2020–2023 due to the COVID-19 pandemic.

The hypothesis of this study is that the pandemic had an asymmetrical negative effect on the receipts from the PIT to regional and local budgets: the larger are the tax receipts to the consolidated budget of a Russian region, the stronger is this effect.

The article is structured as follows.

Section 2 surveys the existing research literature on the problem. Section 3 describes the research methodology.

The first part of Section 4 analyzes the macro-economic data showing the scale of the crisis caused by the pandemic in 2020 and 2021 and estimates how the effects of the pandemic were reflected in the Forecast of Socio-Economic Development of the Russian Federation.

The second part of Section 4 addresses the question as to which taxes play the most significant role of Russian regions and municipalities.

The third part of Section 4 estimates how the changes in the Forecast of Socio-Economic Development may influence the general tax revenue and tax revenues of specific territories, with a special focus made on the personal income tax. In doing so, we are going to rely on the current international research data on the sensitivity of tax revenue to changes in the taxable income.

2. Literature review

Hua Xu and Huiyu Cui [1] suppose that the PIT is one of the major taxes widely used by both developed and less developed countries. They argue that PIT policy has gone through several rounds of revision as it has become an increasingly important source of revenue and a policy instrument in China's financial system over the past several decades.

Irena Szarowská [2] contends that importance of PIT is not only in their financial contribution to the public budgets (in average, personal income taxes are the second most important source of tax revenues in line with Eurostat tax classification), but also in their impact on other government policies and goals (e.g. an economic growth, a redistribution, country's competitiveness, a functioning of labour markets or fiscal federalism) at the same time.

Their viewpoint is shared by Desislava Stoilova [3], who argues that the PIT and social contributions have strong positive effects on growth. She also concludes that tax structure based on selective consumption taxes, taxes on personal income and property is more supporting to the economic growth.

J. Olejniczak [4] examines the significance of shares in the PIT constituting the revenues in all Polish urban municipalities in 1996–2014. His analysis has revealed significant differences between the urban municipalities in Poland in the scope of acquired shares in the PIT. This diversity stems from the differences in the tax bases of urban municipalities. Interestingly, the share of the PIT in the total revenue was found highly significant for all municipal budgets.

G. Dobrota et al. [5] consider the PIT as one of the fiscal tools that have a direct influence on public revenue. The authors analyze the receipts from the income tax and show the correlation between GDP, social security payments, level of employment, unemployment rates and the level of taxable income – the average nominal monthly wage in Romania.

M. Ibragimov et al. [6] argue that tax revenue to a great extent depends on the collection of the PIT, which, in its turn, is associated with the distribution of wages across industries. They also propose an approach to modelling and forecasting of PIT revenue in the absence of data on wages in different industries. This methodology can be applied if only industry-specific aggregate data and sampling observations for several industries are available.

A number of Russian and international studies investigate losses in tax revenues caused by various negative macroeconomic factors, such as illegal labour migration, 'shadowization' of economy, falling oil prices, crises of different kinds, early retirement because of illness or disability and so on. Tax reforms involving an increase in the tax rates are often associated with risks that this measure will be detrimental for tax revenue. Some studies describe methods for estimating tax revenue shortfall. These approaches are systematized in Table 1 below.

To estimate the shortfall in PIT revenue, studies analyze the sensitivity of total PIT revenue to changes in the tax base (individual income).

The first researcher to propose a comprehensive approach to the computation of tax revenue elasticity was Robinson [15]. In his article he describes what he refers to as the 'traditional' way of forecasting taxes, which consists of estimating an equation linking the receipts of each tax to model variables and using it to forecast tax receipts given the model forecast of the tax base. The growth in total revenue will, in this case, depend on two separately identifiable factors: how fast the relevant tax base grows in relation to nominal GDP, and how fast tax grows in relation to the tax base. The main strength of this approach lies in the fact that it allows information from many different sources to be assembled and used to provide a forecasting framework. As a result, it is calculated that the total tax base elasticity of PIT revenue in the UK is 1.6%.

There were earlier attempts to calculate the elasticity of tax revenue. For example, C.Y. Mansfield [16, p.434] estimated the automatic and discretionary changes in the revenues from specific types of taxes depending on the changes in GDP. Discretionary changes are understood as the legal changes in tax rates or in the tax base, the introduction of new taxes, and certain administrative efforts. Therefore, the indicator of elasticity that takes into

Table 1

Approaches to quantifying tax losses

Author	Methodology
M.O. Kakaulina [7]	The scale of the shortfall in additional PIT revenue due to international migration can be estimated by looking at the number of labour emigrants/ immigrants of a certain profession, the nominal wage payable in this profession in the Russian Federation, the standard child tax credit and the corresponding PIT rate for residents and non-residents.
M.O. Kakaulina [8]	The losses in PIT revenue from illegal labour migration are calculated as a difference between the potential and actual receipts from the income tax on earnings of foreign citizens.
M.E. Kosov [9]	Shortfalls in tax revenues can be estimated by building an econometric model which uses such factors as GDP, rouble exchange rate, the consumer price index and oil prices.
O.A. Tsepelev, O.S. Kolesnikova [10]	The amount of losses in PIT revenues caused by tax avoidance is calculated as a difference between the income tax revenue that theoretically should be received by the state budget in the absence of shadow economy and the actual sum of receipts.
M. Feldstein [11]	The deadweight loss of the income tax resulting from tax avoidance is calculated with the help of TAXSIM model by using the data from individual tax returns.
D. J. Schofield, R. N. Shrestha, R. Percival, M. E. Passey, S. J. Kelly, E. J. Callander [12]	Losses in PIT revenue caused by the early retirement of individuals due to bad health are measured by analyzing the output data of the microsimulation model Health & Wealth MOD. To analyze the differences in the income of people employed full-time, part-time and not in the labour force due to ill health, a multiple linear regression model is applied.
L. Calahorrano, L. Rebeggiani, S. Stöwhase, M. Teuber [13]	The possible long-term fiscal effects of demographic change (population ageing) are estimated by using microsimulation.
S.G. Belev, N.S. Moguchev, K.V. Vekerle [14]	To measure the shortfall in PIT revenue, it is proposed first to divide the tax base into the following two components: 1) The magnitude in labor intensity (intensive margin) associated with how many more or less individuals began to work; 2) The magnitude of participation in the labor force (extensive margin) associated with an individual's decision to work or not. Following this stage, an optimization model is built for an individual seeking to maximize their utility in accordance with the budget constraints, which implies a possibility of tax evasion.

account discretionary changes includes the positive effects of revenue administration, resulting from the changes in the legislation. By using the data on the economy of Paraguay, C.Y. Mansfield finds that the GDP elasticity of the individual income tax (with the account of discretionary changes) is 1.42%.

A.F. Friedlaender et al. [17] built LS models to measure the changes in the sales tax revenue in response to changes in per capita personal income and tax rates in specific US states. They found that the rate elasticity was on average 93%.

S.F. Gillani [18] conducted the decomposition of elasticities, arguing that the GDP elasticity of tax revenue can be divided into tax elasticity to base and base elasticity to GDP. She combined two methodologies for the estimation of the elasticity – the Divisia Index method and the proportional-adjustment method. The resulting values of the elasticities of the individual income tax for the Pakistani economy are 0.93, 1.12, and 0.72% respectively.

R.G. Holcombe and R.S. Sobel [19] provide evidence that income taxes are consistently more cyclically variable, and less predictable, than sales taxes. They used econometric modelling to identify the key factors that explain the differences in cyclical variability across US states. The average estimate of the total tax revenue elasticity of the individual income tax is 1.524%. The GNP elasticity of the tax base is 1.4%.

F. Mukkaram [20] examines the elasticity of major taxes in Pakistan by using the chain indexing method and finds that the estimates of elasticity are higher for direct taxes than for sales taxes. The long-run tax base elasticity of receipts from direct taxes is 1.3% while the short-run elasticity, 1.63%.

D. Bruce et al. [21] found that the long-run and short-run elasticity for income taxes is more than double that for sales taxes. To explain the variation in elasticities across different states of the US, cross-section regression methods are employed. The average long-run elasticity of the personal income tax revenue is 1.8% and the short-run elasticity, 2.7%.

T. Havranek [22] estimated the short-run and long-run tax base elasticity of tax revenue by using quarterly data adjusted for the effects of reforms and showed that the long-run elasticity in the Czech Republic is 1.4 % for wage tax.

J.E. Anderson et al. [23] use using panel time series methods to estimate the long-run and short-run income elasticity of property tax revenue in Nebraska. Long-term elasticity estimated with the help of an OLS-model varies between 0.57 and 0.67%. Interestingly, much higher estimates of elasticity were characteristic of fast growing urban districts while much lower ones, of cattle farming areas. Estimates obtained with the help of the Dynamic OLS-model demonstrated a slightly higher level of long-term elasticity of tax revenue – 0.86%, accompanied by significant variations across urban districts.

M. Gillman [24] shows that the elasticity of the income tax revenue with respect to the US tax rate is influenced by the degree of reported income – the higher is the reported income, the lower is the elasticity. An increase in the tax rate causes the tax elasticity to increase in magnitude due to rising tax evasion.

Table 2 shows different estimates of the tax base elasticity of PIT revenues calculated by various authors.

Summarizing all of the above, it should be noted that the tax base elasticity of tax revenue is the value derived from the GDP elasticity of the tax base. D. Bruce et al. [21] and Y.K. Kodrzycki [29] show a gradual increase in the tax base elasticity of the PIT in the USA over time. As for the UK, the evidence points to the fact that the sensitivity of the PIT remains more or less the same within the interval of 1.5–1.6% [26; 27].

We believe that the most accurate estimates are given by B. Robinson [15], whose study relied on large macro-economic models of the Centre for Economic Forecasting of London Business School (LBS).

Recently there has been a rise in publications estimating the impact of the COVID-19 pandemic on tax receipts of specific territories.

Table 2

Tax base elasticity of PIT revenues

Author/source	Elasticity
J.P. Hutton, P.J. Lambert [25]	Personal income elasticity varies between 1.72–1.91% (based on the UK data)
J.P. Hutton, P.J. Lambert [26]	Per capita income elasticity varies between 1.38–1.66% and is directly dependent on income inequality (based on the UK data)
J. Creedy N. Gemmell [27]	Aggregate revenue elasticity is 1.538% (based on the UK data)
J. Creedy, J. Felix Sanz-Sanz [28]	The per capita income elasticity is about 1.3% (based on the data on Spanish economy). There is a considerable variation among tax units in the revenue elasticity, with highly (positively) skewed distributions. The aggregate elasticities for each region display some variation associated with income distribution differences.
Y.K. Kodrzycki [29]	Real per capita personal income elasticity is 2.2% (based on the US data).

A. Auerbach et al. [30] argue that the total personal income tax revenue in US states will fall by 4.7% in 2020, by 7.5% in 2021 and by 7.7% in 2022.

E. Badger et al. [31] divided US states into two groups – those with 'rosier forecasts' that had managed to restore their tax revenue to the level of the previous year in 2020 and those whose revenue impact was much more severe.

L. Dadayan [32] considers the percentage changes of tax revenues of US states for different types of taxes. She points out that between 2014 and 2018, the growth in personal income tax revenues was volatile, largely due to federal policy changes. These changes created short-term tax windfalls for some states and shifted revenues between fiscal years. Interestingly, in 2015 and 2018 the growth in PIT revenues exceeded that of other taxes. However, the COVID-19 pandemic caused the job market to collapse resulting, in the first half of 2020, in the dramatic decline in income tax revenues in comparison with other taxes. There was also a drop in the per capita income tax revenues.

D. Belleville et al. [33] estimate the losses of US states caused by the postponement and possible cancellation of numerous events involving professional athletes, and thus leading to the loss of tax revenue resulting from state income taxes not being collected from professional sportsmen. They found that US states are likely to lose nearly 307 million US dollars in jock tax collections.

J. Karnon [34] discusses the possibility of introducing a temporary income tax levy in the USA as an optional policy aimed at minimizing the negative effects of the crisis on the state budget. He believes that an increase in tax revenue in the time of crisis is unlikely to reduce economic activity or to displace economic activity or reduce population wellbeing and longer-term government revenue.

It should be noted that, despite the vast number of research papers on this topic, there is still a perceived lack of comprehensive analysis that would provide a forecast of public revenue losses as a result of the pandemic's impact on economy.

3. Methodology

The shortfall in tax revenues of Russian regions can be analyzed by focusing on the following three factors: the first factor is the amount of damage caused by the COVID-19 outbreak to the whole economic system; the second is the sensitivity of the state revenue base to the crisis; and the third, is the sensitivity of regional tax revenue to the revenue base.

In other words, the first factor is associated with the increased risk of rising bankruptcy rates and the related increase in unemployment, fall in wages and general income. The second factor corresponds to the impact of these trends on the revenue base of regional and local govern-

ments while the third factor reflects the effect that the reduction in the revenue base has on tax revenues.

All of the above determined the structure of this study.

At the first stage, we estimated the reduction in the taxable base (income). The data were obtained from the official statistics published by Rosstat and the Forecasts of Socio-Economic Development of the Russian Federation. In our calculations we relied on the method of comparison.

It should be noted that the Ministry of Economic Development published its Forecast of Socio-Economic Development in September 2019 for the period until 2024 and in September 2020, it released a revised version of this forecast. The new version of the Forecast was based on the estimated potential effect of the COVID-19 pandemic on various macro-economic indicators.

The difference between the proposed approach to the calculation of percentage change and other approaches described in research literature lies in the fact that the planning value of a chosen indicator is compared not with its actual value in the previous period but with its planning value in the current period specified in the Forecast of Socio-Economic Development of the Russian Federation. Thus, we are going to compare the actual macro-economic situation in the country in 2020 with the no-outbreak scenario.

At the second stage we considered the shortfall in income tax revenue faced by different Russian regions. This indicator reflects the two factors that we take into account in our estimations. First, for some regions, the PIT is one of the main sources of tax receipts; second, some regions' total tax revenue exceeds that of other regions, such that a given percent decline generates a greater absolute decline. To make our data comparable, we recalculated PIT revenue per capita. At this stage we intend to use Rosstat data and the data from the annual reports issued by the Federal Tax Service of Russia. Methodologically, the analysis will rely on methods of comparative analysis and data visualization.

At the third stage it is estimated how the economic shocks affect PIT revenues of budgets of different levels. In order to answer this question, we combined three sets of data: first, the information about the scale and nature of macro-economic shocks (Section 4.1); second, the information about the main institutional characteristics of the tax base (Section 4.2); and third, the data from the research literature on the sensitivity of personal income tax revenue to changes in personal incomes.

It should be noted at this point that the economic aggregates discussed in Section 4.1 are approximate for the PIT base. Different types of income are taxed at different rates while some types of income are not taxed at all. Our calculations, for example, take into consideration the fact that all social welfare payments and benefits that help restore the level of employment and income, economic growth and long-term structural changes in the economy are not taxable.

In our estimations and forecasting of tax revenue losses, particular attention is given to the effects of the income tax reforms. Since the beginning of 2021, the Russian tax system has undergone a number of changes regarding the PIT. It is extremely difficult to estimate the effect that these reforms will have on the state budget, which is why we have chosen to rely on expert opinions in public media.

1) return to the progressive scale, which implies differentiated PIT rates for different income levels. For the personal income tax, the rate will be raised to 15% for those individuals who earn more than 5 million roubles a year. Moreover, it will not be applied to the entire tax base, but only to the sum of excess of 5 million roubles a year. Basic rate of 13% will be applicable for those taxpayers who earn 5 million roubles or less. It is expected that the introduction of the progressive scale will bring to the state budget extra 60 billion roubles in 2021; 64 billion in 2022 and 68.5 billion in 2023.

2) Interest income on deposits will be subject to the PIT rate of 13% in the part exceeding the non-taxable minimum. The latter equals the product of 1 billion rou-

bles and the key rate of the Bank of Russia as of the first day of the fiscal period. Assuming that the key rate remains 4.25%, the amount of non-taxable income will be 42.5 thousand roubles a year (1 mln rbs 4.25% = 42.5 ths rbs). It is expected that the introduction of a tax on income from large deposits will bolster public finances and provide the state budget with about 113 billion roubles a year.

3) An increase in the rate of the PIT on dividends transferred to overseas accounts to 15%. The estimated value of the tax base is about 5,014.4 billion roubles while the extra revenue generated by raising the tax rate is about 518.2 billion annually.

We calculated the total PIT revenue shortfall (Section 4.3) by following the methodology proposed by Clemens and S. Veuger [35]:

$$RS_{i,b} = CR_{i,b} \cdot BD_b \cdot RE_b, \qquad (1)$$

where $RS_{i,b}$ (*Revenue Shortfall*$_{i,b}$) is the total PIT revenue loss of the government of the i^{th} region for tax base b; $CR_{i,b}$ (*Counterfactual Revenue*$_{i,b}$) is the computed value of PIT revenue of the i^{th} region from tax base b under the hypothetical no-COVID-19 scenario. These estimates were obtained through forecasting by extrapolation based on the data of the Federal Tax Service on PIT revenues in 2019 and the growth in these revenues in the last decade; BD_b (*Base Decline*$_b$) is the reduction in the tax base (income level) caused by the COVID 19 outbreak, which is discussed in detail in Section 4.1; RE_b (*Revenue Elasticity*$_b$) is the estimate of the tax base elasticity of PIT revenue.

The relationship between PIT receipts and changes in the size of the applicable tax base depends on the progressivity of the tax scale. Progressive tax bases usually have income elasticity greater than 1. This means that the average tax rate will be lowered together with the shrinking tax base. Studies of the tax base elasticity of tax revenues have for a long time followed this logic.

We believe that on average in a given region PIT revenues will be falling by about 1.6% for every 1% decline in the personal income level. Such elasticity is based on the estimates of B. Robinson [15, p. 41] for the British economy. It should be noted that our estimates of the shortfall in PIT revenues will shift in proportion to changes in this estimated elasticity.

In our view, the application of this value of elasticity is justified since, starting from 2021, Russia has returned to the progressive income taxation scale.

4. Empirical research results

4.1. Impact of the COVID-19 Pandemic on the Russian economy

Tables 3–5 contain the data reflecting the shocks suffered by the country's economy due to the outbreak of COVID-19. The scale of these shocks is estimated by looking at the percentage point changes in several macro-economic indicators.

Table 3

Percentage point changes in the macro-economic indicators reflecting the economic shocks caused by the COVID-19 pandemic (baseline scenario)

Indicators	Δ2020	Δ2021
Unemployment, pp	1.1	0.7
Real wages, %	–0.8	–0.9
Real disposable household income, %	–4.5	–3.6
Total volume of production (works, services), %	–16.7	–15.5
Retail turnover, %	–4.3	–1.4
Volume of paid services provided to the population, %	–9.7	–6.1
Profit in all types of economic activity, %	–12.5	–9.8

Table 4

Percentage point changes in the macro-economic indicators reflecting the economic shocks caused by the COVID-19 pandemic (conservative scenario)

Indicators	Δ2020	Δ2021
Unemployment, percentage points	1.1	0.7
Real wages, %	–0.3	0.2
Real disposable household income, %	–4.1	–3.6
Total volume of production (works, services), %	–13.3	–13.1
Retail turnover, %	–4.3	–1.3
Volume of paid services provided to the population, %	–9.7	–.7
Profit in all types of economic activity, %	–7.5	–7.0

Table 5

Percentage point changes in the macro-economic indicators reflecting the economic shocks caused by the COVID-19 pandemic

Indicators	Δ2020	Δ2021
Household consumption expenditures, %	–6.2	3.1
Gross fixed capital formation, %	–6.0	2.5
Consolidated budget balance, % of GDP	–4.6	–3.0

According to the conservative scenario outlined in the Forecast of Socio-Economic Development of the Russian Federation (Table 4), in 2020, the rise in unemployment was about 1.1 pp in comparison with the previously projected value for this year. In 2021, this indicator is expected to increase – by 0.7 pp. In 2020, the real wages fell by slightly more than 0.3% and it is expected that this indicator will recover to 0.2% in comparison with the previously projected values. The fall in the real disposable income turned out to be more substantial – 4.1% in 2020 and 3.6% in 2021, which can be explained by this indicator's dependence not only on the national wage level but also on another important source of income – business income. Judging by the available data, we may conclude that there was an unprecedented slump in the real disposable income.

According to the baseline forecast, the situation appears to be even more alar-ming, with more severe effects of the economic shocks. Total household spending in 2020 fell by approximately 6.2%, which is the largest drop in the last 15 years. Although the general level of spending remained virtually the same, there were significant differences in the structure of consumption. For instance, the expenditures on eating out fell almost twice. Household expenditures on food grew dramatically in March and April and then the previous trend was restored. There was a considerable rise in consumption expenditures on durable goods and health care while spending on professional non-medical services (e.g. financial and legal services) remained relatively stable.

The above-described picture can be explained by the drop in income, objective decline in daily spending during the lockdown period as well as people's natural reaction to the crisis as they were trying to stash a financial cushion. It is expected that in 2021 there will be a 3.1% increase in total household spending in comparison with the data of the previous forecast published in 2019.

Figures 1 and 2 illustrate the changes in GDP forecasts of Russia's Ministry of Economic Development for 2020–2023.

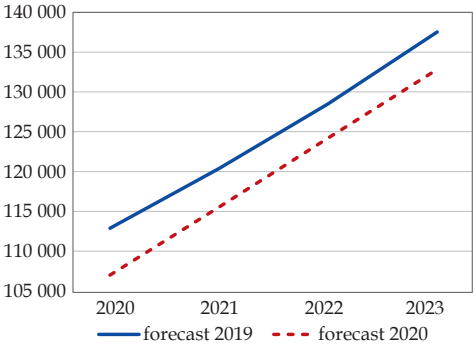

Fig. 1. **Projected GDP dynamics in 2020–2023, bln rbs (baseline scenario)**

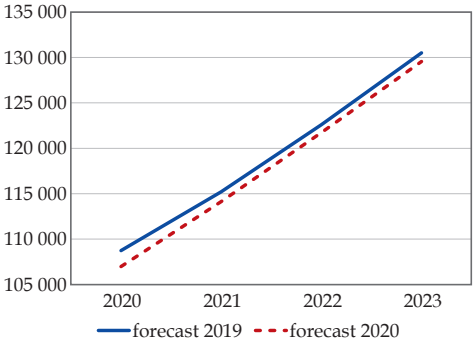

Fig. 2. **Projected GDP dynamics in 2020–2023, bln rbs (conservative scenario)**

The data show that a severe slump in GDP in all the given periods is expected, which will be followed by a recovery from the levels that are much lower than those specified by the previous forecasts.

Figures 3 and 4 illustrate the general income levels. These time series are directly related to the following estimations in the two dimensions: the first dimension is the main time series (according to the

Forecast of 2019) and the second, the additional time series (according to the Forecast of 2020). These aggregated data are necessary to estimate the scale of shocks suffered by the PIT base.

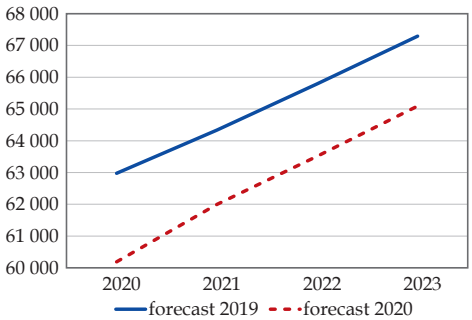

Fig. 3. **Projected dynamics of individual incomes in 2020–2023, bln rbs (baseline scenario)**

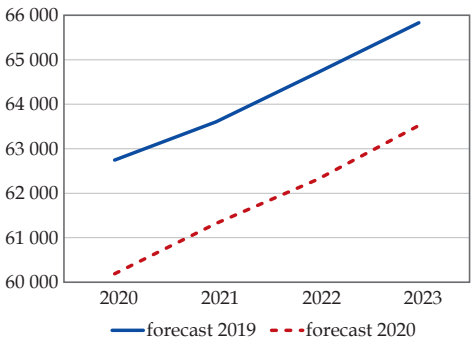

Fig. 4. **Projected dynamics of individual incomes in 2020–2023, bln rbs (conservative scenario)**

The data in Figures 3 and 4 demonstrate that, according to the new forecast, the income in the given period will 'stabilize' at the levels that are approximately 3–4% below the previous forecast values.

4.2. Analysis of regional and local governments' reliance on different types of taxes

To construct a sample, we need to rank the territories by their PIT revenues. To study the consequences of the pandemic, it seems most promising to choose for analysis those Russian regions that rank high in terms of PIT revenues per capita.

Figure 5 illustrates the distribution of PIT receipts across Russian regions in 2020.

11 regions with the highest PIT receipts are as follows: the Chukotka Autonomous District, Yamalo-Nenets Autonomous District, Nenets Autonomous District, Magadan region, Kamchatka region, Sakhalin region, Moscow (city), Khanty-Mansiysk Autonomous District – Yugra, Murmansk region, the Republic of Sakha (Yakutia), and St.Petersburg (city). In 2020, the PIT receipts of the country's state budget provided by these regions varied between 51 and 143 thousand roubles per capita.

The high revenues from the income tax collected in these regions can be ex-

Fig. 5. **Map of the distribution of PIT revenues in 2020, ths rbs per capita**

plained the following way: Moscow and St. Petersburg have the highest wages among other Russian regions while the other regions from this list are located in the Far North, which means that their inhabitants enjoy special benefits and compensations, including the multiplying 'district coefficient' applied to wages earned. In the above-mentioned northern regions such 'district coefficients' vary between 1.5 and 2. The population density in these regions is very low: in Russia's Far North, it is slightly above 11.5 million people (only 8% of the country's population). All of the above determines the high per capita tax receipts demonstrated by these regions.

Further we are going to analyze tax receipts of regional and municipal governments of these regions in order to gain a better understanding of how tax receipts in specific regions are distributed by tax type.

Table 6 summarize the statistical data on the given regions in 2020.

Table 6 shows that the revenues of different Russian regions are dominated by different tax types. For instance, regions' dependence on the corporate income tax (CIT) for their tax revenues varies between 31.9% of the general tax revenue in the 10th percentile to 60.5% in the 90th percentile. With regard to our data it means that at least in 10 out of 11 given regions (90% of the sample), the share of the CIT is over 31.9% while at least in 1 out of 11 given regions (10% of the sample), the share of this tax is over 60.5%. The same is true for the PIT: at least in 10 out of 11 given regions (90% of the sample), the PIT accounts for over 17.7% while at least in 1 out of 11 of the given regions (10% of the sample), it accounts for over 50.2%.

Thus, the PIT is one of the main revenue sources for Russian regions. A Russian region from the 10th percentile obtains over 17.7% of its general tax revenue from this tax while a region from the 90th percentile, over 50.2%. Property taxes demonstrate a somewhat different pattern: a region from the 90th percentile relies on this category of taxes to a lesser extent – 40.4% of tax revenue.

The last columns of Table 6 show how an increase in regional tax revenues corresponds to the size of the country's economy in general. In 2020, the given regions raised over 3.6 trillion roubles of tax. Overall, these revenues are equivalent to 3.5% of the country's GDP (17.9% of the state government's tax revenue). The PIT revenue to the consolidated state budget of the Russian Federation from these regions is 1.6 trillion roubles, which is slightly less than 1.5% of GDP (7.6% of tax revenue).

4.3. Impact of economic shocks on tax revenues of regional and municipal governments

Table 7 illustrates the forecast PIT revenue losses of the state government due to the COVID-19 pandemic in 2020–2024 according to the baseline and conservative scenarios and the input data for our calculations.

Table 6

Distribution of the total tax revenue of regions by tax category in 2020

Type of tax	Number of observations	Average value, %	Median value, %	10th percentile, %	90th percentile, %	Revenue, ths rbs	% of tax revenue
Total tax revenue	11	100	100	100	100	3,615,832,552	100
Personal income tax	11	31.1	22.1	17.7	50.2	1,506,482,830	41.7
Corporate income tax	11	43	40.3	31.9	60.5	1,390,104,956	38.4
Mineral extraction tax	11	4.6	0.5	0	15.8	26,705,464	0.7
Property taxes	11	18.3	11.6	6	40.4	461,730,385	12.8
Other taxes	11	3	1.5	0	7.4	230,808,917	6.4

It should be noted that the computed value of the total PIT revenue losses is determined by the chosen scenario. If the future changes in the macro-economic conditions follow the baseline scenario, the amount of losses in PIT revenues in 2020 will be 416.6 bln rbs. In the conservative scenario, this figure will be 392 bln rbs.

The projected losses in tax revenue take into account the income tax hike on super-high earners and the taxation of interest on bank deposits. We, however, did not take into account the extra revenue obtained from setting the 15% tax rate on the income from dividends transferred to foreign accounts. Businesses' responses to such changes in legislation are rather difficult to predict. If full transparency is ensured, this will bring about 518.2 billion of extra revenue annually.

If the measures aimed at counteracting the negative economic impact of the pandemic prove to be effective, in 2021 we can expect an increase in PIT revenue in absolute terms. The tax revenue in 2021 will increase by 381.7 billion roubles and by 407.5 billion in 2023 (according to the baseline scenario). The expectations, however, should not be overly optimistic. We are going to further consider the differences in the tax revenue trends in the regions from our sample (these regions are the leaders in terms of per capita PIT receipts).

Tables 8 and 9 show our estimates of per capita PIT losses in these regions. The estimates were calculated by using Formula 1.

Table 7

Forecast PIT losses in 2020–2024

Years	Counterfactual revenue from the PIT to budgets of different levels bln rbs*	Reduction in the tax base (baseline scenario), share	Reduction in the tax base (conservative scenario), share	Estimated elasticity	Projected PIT revenue losses (baseline scenario), bln rbs	Projected PIT revenue losses (conservative scenario), bln rbs
2020	4,313.8	–0.060	–0.057	1.6	–416.6	–392.1
2021	4,705.0	–0.041	–0.041	1.6	–136.5	–133.7
2022	5,131.6	–0.035	–0.037	1.6	–107.9	–127.7
2023	5,596.9	–0.033	–0.035	1.6	–110.7	–132.9

Source: author's calculations

Note: * Estimated tax revenue for a hypothetical non-COVID scenario forecast through the extrapolation method (based on the average growth rates in a 10-year period)

Table 8

Distribution of the forecast shortfall in PIT revenue per capita in 2020–2023 (baseline scenario)

Years	Number of observations	Average value, rbs per capita	Median value, rbs per capita	10th percentile, rbs per capita	90th percentile, rbs per capita
2020	11	–8,899	–8,398	–13,300	–5,385
2021	11	–6,661	–6,334	–10,002	–4,098
2022	11	–6,179	–5,917	–8,944	–3,864
2023	11	–6,393	–6,162	–8,903	–4,061

Table 9

Distribution of forecast shortfall in PIT revenue per capita in 2020–2023 (conservative forecast)

Years	Number of observations	Average value, rbs per capita	Median value, rbs per capita	10th percentile, rbs per capita	90th percentile, rbs per capita
2020	11	–8,374	–7,902	–12,514	–5,067
2021	11	–6,601	–6,277	–9,912	–4,061
2022	11	–6,610	–6,330	–9,567	–4,133
2023	11	–6,877	–6,629	–9,577	–4,368

The average PIT losses in the given regions, according to the baseline scenario, are 8,899 rbs per capita in 2020, falling to 6,393 rbs per capita by 2023. Since these are per capita figures, they may seem rather unimpressive but we should keep in mind that they are extrapolated to the overall decline of 416.6 and 110.7 billion roubles respectively (see Table 7).

It should be noted that the estimates of the projected losses in PIT revenue per capita differ significantly across the regions. These differences are explained by the following reasons: first, there is a considerable variation in the extent to which the given regions are reliant on PIT revenues; second, the larger is the per capita PIT revenue collected in a specific territory, the higher is the level of losses of this territory and vice versa. The leader in this respect is the Chukotka Autonomous District while the city of St.Petersburg is at the bottom of the list.

5. Discussion

Our analysis shows that with the help of the belt-tightening and tax-raising policy, the federal government has managed to mitigate the negative effects of the pandemic on tax revenues and to provide a stable influx of some extra PIT revenue in the mid-term, starting from 2021.

Regional and local authorities, however, will have to find other ways to deal with the shortage of funds since PIT payments on interest income from bank deposits and on income above 5 million roubles will first be directed to the federal budget.

Our analysis clearly demonstrates that in the institutional environment of Russia, it is the federal government that has to shoulder the burden of countercyclical policy. In practice, in the period of economic downturn, regions and municipalities receive financial grants from the federal government. Apart from increased equalization transfers and grants for maintaining balanced regional budgets, regional governments may count upon extra inter-budget transfers in the form of subsidies and other transfers.

In such circumstances, regional governments have nothing much to do but to rely on federal subsidies. The existing Methodology for Distribution of Equalization Transfers of Russian Regions is based on the computation of the so-called fiscal capacity index or the potential ability of a Russian region to raise tax revenue. The total fiscal capacity index of a Russian region is calculated by adding up all the values of fiscal capacity for each type of tax. Fiscal capacity for the PIT is calculated by using the formula that contains the taxable household income in this or that fiscal year. The projected PET receipts are calculated by the Federal Tax Service by using the following indicators of the Forecast of Socio-Economic Development: wages fund; the coefficient characterizing the dynamics of the wages fund; coefficient characterizing the dynamics of tax deductions depending on the changes in the country's legislation and other factors; and so on.

This means that when equalization transfers are distributed among Russian regions, what is taken into account is not only the revenue losses attributable to tax relief, tax exemptions and tax preferences granted under the current fiscal legislation but also the shocks such as those that resulted from lockdown restrictions.

6. Conclusions

One of the crucial tasks of state financial agencies in the current situation is to forecast the pandemic-driven revenue shortfalls and thus to provide a better understanding of the scale of damage to regional and local budgets. Fiscal forecasting is essential to inform governmental decision-making regarding the measures to counteract the negative effects of the pandemic and setting the amounts of inter-budget transfers.

Our study has shown that the COVID-19 pandemic had a severe negative effect on such macro-economic indicators as GDP, income of households, unemployment rates, and so on. The percentage changes of these indicators were brought to light by the comparative analysis of the two documents – the Forecast of Socio-Economic Development of the Russian Federation of 2019 and 2020.

As this study has shown, the majority of regional governments rely primarily on the CIT for their revenue, with the PIT ranking second in importance.

It was found that PIT revenue is highly sensitive to changes in the tax base, which is why, in all likelihood, the recession will lead to a considerable decline in PIT revenue due to the falling income in 2020 and in the three consecutive years.

There is a considerable regional variability regarding the shortfalls in PIT revenue. The most significant decline is to be expected in the regions that are the leaders in terms of per capita PIT revenue – Chukotka, Yamalo-Nenets and Nenets autonomous districts.

Thus, our hypothesis that the COVID-19 pandemic had a detrimental effect on the PIT receipts of regional and municipal budgets and that there is a dependency between the strength of the effect of the pandemic and the reliance of this or that territory on this tax.

The recent tax reforms were quite effective in mitigating the impacts of the pandemic on tax revenues and providing stable extra revenue in the mid-term, starting from 2021. Instead of going directly to regional and municipal budgets, however, these funds will be later redistributed in the form of inter-budget transfers as a part of the state counter-cyclical policy.

Our research findings can prove useful to the Ministry of Finance in developing forecasts of the state consolidated budget and the draft of the federal budget (for allocating equalization transfers to Russian regions). This research can also be of interest to state financial agencies of Russian regions and municipalities for the development of their draft budgets for 2022 and the planning period of 2023–2024.

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Long-run equilibrium between personal income tax and economic growth in Bulgaria

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ABSTRACT
The study analyzes the relationship of personal income tax and economic growth in the long and short runs to show which type of income tax (progressive or proportional) is more compatible with Bulgaria's economic growth. The methods of Vector Error Correction and Correlation are applied to determine the long-run and short-run impacts of the two types of income tax. The research covers the period from the first quarter of 1999 to the first quarter of 2020. Eurostat data (85 observations) were used. The empirical research has been divided into two periods. The long-run and short-run relationships between economic growth and tax revenue from progressive income tax in Bulgaria have first been studied, followed by the relationship between economic growth and the tax revenue from proportional income tax. The research results show that there is a long-run equilibrium relationship, but not a short-run relationship, between personal income tax and economic growth. The results imply that the progressive income tax is more compatible with economic growth than proportional income tax in Bulgaria in the long run. In the short run, the progressive income tax and proportional income tax have not shown statistically significant relationships with economic growth. Therefore, a progressive income tax leads to greater economic growth than a proportional income tax. From a long-run equilibrium standpoint, it is advisable that Bulgaria switch from proportional to progressive income taxation. It may be inferred that progressive taxation is more appropriate for economic growth than proportional taxation. The results are in conformity with the theory of endogenic growth and reject the neoclassical theory.

KEYWORDS
personal income tax, tax policy, long-run equilibrium, economic growth

JEL H21, H24, D50

Оригинальная статья

Долгосрочное равновесие между подоходным налогом с физических лиц и экономическим ростом в Болгарии

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АННОТАЦИЯ
В исследовании анализируется взаимосвязь подоходного налога с физических лиц с экономическим ростом в долгосрочной и краткосрочной перспективе, чтобы показать, какой тип подоходного налога (прогрессивный или пропорциональный) более совместим с экономическим ростом в Болгарии. Для определения долгосрочного и краткосрочного воздействия двух типов подоходного налога на экономический рост в Болгарии применялись методы кор-

рекции векторных ошибок и корреляции. Использовались данные Евростата (85 наблюдений) за период с первого квартала 1999 г. по первый квартал 2020 г. Эмпирическое исследование разделено на два периода. Сначала была изучена долгосрочная и краткосрочная взаимосвязь между экономическим ростом и налоговыми поступлениями от прогрессивного подоходного налога, а затем взаимосвязь между экономическим ростом и налоговыми поступлениями от пропорционального подоходного налога. Результаты исследования показывают, что между подоходным налогом с физических лиц и экономическим ростом существует не краткосрочное, а долгосрочное равновесное соотношение. В долгосрочной перспективе в Болгарии прогрессивный подоходный налог более совместим с экономическим ростом, чем пропорциональный. В краткосрочной перспективе нет статистически значимой связи между прогрессивным или пропорциональным подоходным налогом и экономическим ростом. Следовательно, прогрессивный подоходный налог в меньшей степени препятствует экономическому росту, чем пропорциональный. С точки зрения долгосрочного равновесия, Болгарии рекомендуется перейти от пропорционального подоходного налогообложения к прогрессивному. Можно сделать вывод, что прогрессивное налогообложение больше подходит для экономического роста, чем пропорциональное. Полученные результаты соответствуют положениям теории эндогенного роста и отвергают положения неоклассической теории.

КЛЮЧЕВЫЕ СЛОВА
налог на доходы физических лиц, налоговая политика, долгосрочное равновесие, экономический рост

1. Introduction

Income tax is a subject of a serious interest in the economic and political circles. It concerns the long-run and short-run growth of economy. The decrease of a tax rate brings to an increase of budget revenues, investments, employment rate and people's incomes. It has an impact on the business cycle, too.

In the course of the past thirty years, a trend has been observed, at which some developing countries replaced the progressive income tax with a proportional one. These are countries mainly of Central and East Europe, as well as some Asian and African countries. Their major objective is the increase of economic growth.

The first one to introduce income taxation with a proportional tax was the small British colony of Jersey in year 1940. In year 1947 while under British ruling, Hong Kong also adopted a proportional tax. Guernsey became the third British colony that started using a proportional tax in year 1960. In year 1986, Jamaica started taxing income with a proportional tax. The rising success was achieved at the end of the 1990s and at the beginning of the new millennium when a number of countries of Central and East Europe (CEE) adopted a proportional tax. Estonia became the first CEE country, which replaced the progressive tax with a proportional one in year 1994. Since then another fifteen countries of the CEE have introduced a proportional tax.

After the good results achieved by the countries of the CEE and within a period of a high economic growth in year 2008, Bulgaria, too, started taxing income with a proportional tax. The progressive tax rates of 20%, 22% and 24% were replaced by a proportional tax rate of 10%, no tax-free limit. The main goal of the government was to achieve an increase of the budget revenue and an improvement in the long-run growth of economy.

Figures 1 and 2 provide an illustration of the revenue from a progressive and from a proportional tax (in millions of BGN) in the budget of Bulgaria. 1999–2007 is the period with a progressive tax, and 2008–2019 – with a proportional one.

The budget revenue from progressive income tax (see Figure 1) showed an increase by 2.3 or a by a bit more than 230% during the studied period. The revenue increased in nominal values. A deceleration was only in 2001–2002. After this period the nominal value of the progressive income tax has shown an increase.

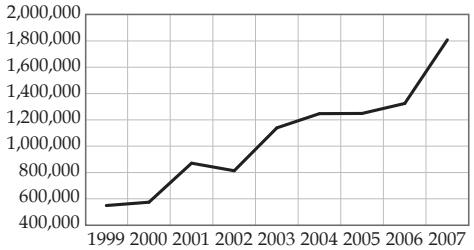

Fig. 1. **Revenue from progressive income tax (millions of BGN)**

Data: Eurostat

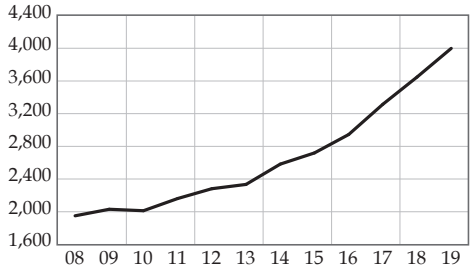

Fig. 2. **Revenue from proportional income tax (millions of BGN)**

Data: Eurostat

The revenue from proportional income tax (see Figure 2) showed an increase by 1.05 or a by a bit more than 100% during the studied period. After the implemented reform, the revenue increased in nominal values. A deceleration was only registered during the Global financial and economic crisis in 2008–2010. After that period the indicator has shown an increase.

Figure 3 shows the nominal values of GDP of Bulgaria in 1999–2019.

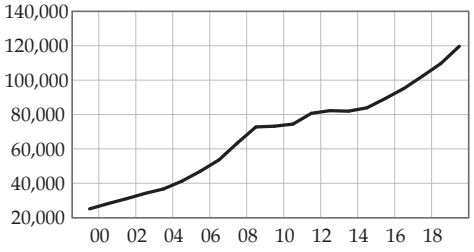

Fig. 3. **Nominal value of GDP (millions of BGN)**

Data: Eurostat

The nominal value of GDP (see Figure 3) showed an increase by 3.8 or a by a bit more than 380% during the studied period. Before the tax reform the increase was 1.5 and after the reform only 0.6. This means that the increase of GDP before the income tax reform is higher than after the reform.

In this study, an empirical analysis is made showing that the progressive income tax has a more favouable impact on the long-run growth of Bulgarian economy than the proportional income tax.

On the one hand, the economy of Bulgaria developed well during the period when a progressive tax was used, and on the other hand, the proportional tax did not succeed in stimulating the economic growth, which was the main aim for which it was adopted.

2. Theoretical background

The discussion of the advantages and disadvantages of a proportional income tax is a subject frequently encountered in empirical literature. In its essence, a proportional tax is of a simple structure at a rate of usually below 20%. The defenders of the proportional tax (liberal economists) claim that these features of its underlie its success. The proportional income tax has a stimulating effect on economy and features the following advantages [1]:

– increasing the budget revenue – the low-rate proportional tax increases the budget revenue as it becomes senseless to hide income;

– increasing the efficiency of the use of resources – a low-rate tax brings to increase of employment by not robbing taxpayers of the additionally earned income;

– increasing the growth of economy – the money remaining available due to the low-rate taxation increases savings and investments;

– providing a fair distribution of income – a flat rate does not rob the high income on the account of the low one.

Notwithstanding the patent arguments stated hereinabove, a proportional tax has still not been applied to the largest economy of the world – the US one. According to R. Hal and A. Rabushka [2] the proportional tax is fair to every taxpayer. They developed further the views of M. Friedman [1] adding the following advantages of a proportional tax:

– a low tax rate – the tax rate should be below 20%, taxation is even, income remains available and entrepreneurs' investments rise;

– double taxation is removed, income is taxed only once regardless of its source. For example, dividends and corporate tax;

– no income is hidden – the low tax rates do not stimulate income hiding;

– income from the same activity taxed by the same rate, equalize the marginal tax rate and remove the obstacles to demand and supply of labor and capital.

The difference between the views of M. Friedman and those of R. Hal and A. Rabushka concern the tax rate. M. Friedman considers that the tax rate should be near 40%, while R. Hal and A. Rabushka assume that the tax rate should be below 20%.

Therefore the Hal's and Rabushka's contributions prove that:

– a personal income taxation from higher to lower tax rates brings to an increase of savings and investments;

– the taxation of high income by lower rates has a stimulating effect on the higher return on investments;

– the same taxation brings to elimination of all the concessions and allowances in the different sectors – this way there is no redirection of businesses from one branch into another for tax reasons, and any movements of capital are lead only by purely market reasons;

– the tax base is expanded, and the tax system is simplified – the cost of administration and control are significantly lower for a proportional taxation;

– the lowered tax rates have a favourable impact on limitation of grey market business operations – the budget revenue increases and the competitiveness of economy rises.

Similar conclusions were published by A. Ambrus [3] who stated the following advantages: the entire tax system of the country is simplified, productivity is fostered, tax income hiding is decreased, employment is increased, income rises, bureaucracy is lowered, the economy growth is boosted, savings and investments increase, economy becomes more and more competitive. The fact that a proportional tax enhances inequality is stated as a disadvantage. In a study of L. Schiau et al. [4] it is confirmed that at proportional taxation the tax-payers are not stimulated to hide income and thus tax collection is increased.

It can be summarized that the benefits from a proportional tax are, as follows:

– significant simplification of procedures of administrating revenue and increased efficiency of tax authorities;

– the economy becomes less grey and the stimuli for income hiding are minimized;

– stimulation of business and increase of consumption;

– those working are stimulated to exert further efforts and to undertake further risk as they would not be "punished" for the extra income they will earn;

– the available income is increased thus bringing to an increase of consumption or increase of savings and investments;

– the direct foreign investments increase thus increasing the funds available for investments in business;

– a favourable impact on business because the motives for moving industry from one place to another resulting not from market signals but for tax purposes are removed.

– there is an easy opportunity to increase or decrease the tax rate depending of the economic cycle phase. When a state needs higher revenue, it just increases the tax rate, and when it needs smaller revenue, it decreases the tax rate.

According to R. Radonshiqi [5] a proportional tax, apart from advantages, features some disadvantages, too. They are, as follows:

1. Elimination of social justice and enhancement of inequality.

2. At keeping a tax-free limit, the medium-level income groups bear the greatest tax load.

3. The state spends more money on paying social benefits to people with low income who are affected by the tax changes.

4. There are no convincing evidence that a flat tax is a reason for the increase

of employment-rate, investments and growth.

5. Import rises owing to the higher available income of tax-payers with high income.

6. There are more stimuli for hiding income by the part of a large group of tax-payers with low and medium income, with regard to whom the tax load is increased.

Similar findings have been published in another empirical studies [6; 7].

Table 1 provides a summary of advantages and disadvantages of a proportional tax based on the studies published.

Table 1

Advantages and disadvantages of a proportional income tax

Advantages	Disadvantages
Easy administration	Enhances inequality
Increase of income	Increase of a state's social payments
No hiding of taxable income	Persons with low and medium income hide taxable income
Increase of savings and investments	The unit cost of income increases
Increase of employment rate	Increase of import
Increase of direct foreign investments	
No redirection of business from one branch to another for tax purposes	
Easily possible to increase or decrease the tax rate depending on the business cycle phase	
Stimulate economic growth	

Source: Prepared by the author

Certain conclusions can be drawn of the advantages and disadvantages of a proportional tax as listed in Table 1. Although it is believed that a proportional tax ensures a higher business activity, the one thing it cannot cope with is the enhancement of inequality. This advantage is recognized by the supporters of the proportional tax, too. Another substantial disadvantage of its concerns the unit cost of income. At a proportional tax the number of the taxable persons increases owing to the expanded taxation mass. Thus the expenditure of tax administration increases and the cost-effectiveness of revenue decreases. The groups earning smaller income would probably evade taxes, too. A proportional tax threatens their social existence and becomes a major motive for hiding income.

Another disadvantage can be related to the easy possibility of increasing or decreasing the tax rate depending on the business cycle phase. If a tax does not work properly throughout a business cycle (does not increase revenue during inflation and does not decrease it during deflation), it is considered ineffective. It does not secure a smooth passing through the phases of the cycle and brings to worsening of recession. Frequent changes of tax rates aimed at collecting revenue result in distrust for the government, disequilibrium of economy and increase of foreign debt.

It should be noted that a proportional tax generates convincing arguments of economic development, on the one hand, but one the other hand, many of them are rejected as unfounded.

Advantages and disadvantages of personal income tax are related with economic growth. Economic growth measures the percentage increase of the real gross domestic product (RGDP). It shows how a nation's wealth is changing. Taxes are considered to change the growth to the direction of decrease. There are two main macroeconomic models explaining the impact of taxes – the neoclassical growth model and the endogenous growth model. The neoclassical model is developed by R. Solow [8]. The endogenous model is related to the works of R. Barro [9] and R. King et al. [10].

According to the neoclassical model taxes do not influence the long-run growth rate. Their impact is only short-run [11]. For example, if the tax rate decreases, the savings and investment will increase. If it increases, it will bring to the opposite effect. That means that tax rates have only a short-run effect on the level of collective output. The main factors contributing to the long-run growth rate are savings,

population growth and technological progress. Hence, they are the ones bringing to a long-run increase of growth.

According to the endogenic model, taxes influence negatively the economic growth rate on a long-run basis. They change tax-payers behaviour at making decisions related to savings, expenses, labour and spare time in long-run [11; 12].

The main difference between the two models is that according to the neoclassical model a change in the tax rate affects economic growth only on a short-run basis, while according to the endogenic model an increase of the tax rate brings to a decrease of the growth.

According to I. Palic at al. [13] an empirical study between the economic growth and revenue from taxes proves a presence of a long-run relationship. The long-run relationship between taxes and growth is equilibrium [14]. Such a relationship can be disturbed in only two cases. First, upon a change of the tax rate. And second, upon economic shocks.

The link between taxes and economic growth can be studied in two directions: from taxes to economic growth and from growth to taxes. That means that this is a two-way relation. In the first case, it is checked whether there exists a short-run and a long-run state of equilibrium between the tax and the growth, and in the second – the efficiency (collection) of revenue. The two analyses differ in conceptual terms. They are calculated using different econometric methods, usually of the VAR group.

A positive relationship (short-run or long-run) means that taxes do not reduce growth. A negative relationship proves that taxes reduce growth.

3. Literature review

In a study of D. Canicio et al. [15] it is proven that there existed the long-run negative relationship for the economy of Zimbabwe between the tax revenue and growth.

G. Edewusi et al. [16] proved that there existed a long-run negative link between the revenue from income tax, profit tax and economic growth in Nigeria.

In a panel study for 79 countries conducted by J. Bakija et al. [17] using a co-integration analysis, it was established that there was no long-run relationship between the tax revenue and the GDP per capita. In another panel study for 27 countries conducted by N. Saidin et al. [18] results were published proving that the income tax influenced positively the GDP.

For economics of Nigeria and Ghana was established a positive impact between the tax revenue and economic growth [19]. Empirical is proved that the income tax influenced negatively on the growth in Croatia [20]. In a panel study for 32 countries conducted by A. Gbato [21], it was proven that in the long-run the tax revenue had a neutral effect on the economic growth.

In a panel study conducted by D. Stoilova et al. [22] for the countries of EU 27, it was stated that the tax systems structured on the basis of direct taxes are more compatible with economic growth. Abdon et al. [23] studied the tax revenues of 13 Asian countries. They proved that the taxes on high and medium income reduced growth. R. Iriqat et al. [24] proved that there was no relationship between the taxes and GDP for Palestine.

T. Wisdom [25] established a positive short-run and long-run relationship between the tax revenue and economic growth for Ghana. With regard to the economy of Turkey, S. Katircioglu [26] proved the existence of a positive link between tax revenue and economic growth.

Balatsky, E. et al. [27] confirm for economics of Russia that the flat income scale should be raised the rate from 13 to 15%. They concluded that at present Russia needs a balanced project which would include multi-step adjustments of the personal income tax over an extended period of time – ten years or more.

In conclusion, it can be stated that a larger part of empirical studies confirm the presence of a long-run relationship between taxes and growth. A smaller part of them prove the existence of a short-run link. A larger part of the studies confirm that such a relationship is negative and taxes reduce growth. A small part of empirical assess-

ments come to the opposite conclusions. A positive relationship between the taxes and economic growth means two things. First, the increase of taxes by the part of the government (in implementation of a discretionary policy) can be stood by the economic agents. Second, the growth of economy is not slowed down at a certain rate of a particular tax.

4. Empirical research results

The long-run relationship between two variables is researched with cointegration analysis and a vector autoregressive model. In this study Eurostat quarterly data for the period March 1999 – March 2020 with 85 observations are used. The data in the empirical analysis are in growth rates. They are seasonally smoothed using the Seasonal adjustment procedure. The empirical research is separated of two periods. The long-run relationship between economic growth and the tax revenue from progressive income tax of Bulgaria is first studied, and then its economic growth and the tax revenue from proportional income tax is studied. In the first period was included 36 observations. In the second period was included 49 observations. The number of observations in the two periods are difference because there are no quarterly data for previous years in the Eurostat database.

The use of an econometric method assumes that the variables are to be tested for stationary processes which are to be time-independent. If it is established that they are first-order integrated (I1), a series of tests are performed for an optimal number of lags. The optimal number of lags is applied at Johansen test for cointegration and thereafter at the construction of the vector autoregression. If Johansen test establishes a presence of a cointegration between the variables, restricted vector autoregression (VAR) is applied, also known as Vector Error Correction (VEC). If no cointegration is established between the variables, unrestricted vector autoregression (VAR) is applied. If the variables are of different orders (I0) and (I1), an ARDL is applied.

4.1. Empirical analysis of the long-run relationship between progressive income tax and economic growth

The group unit root tests (see Table 2) shows that as a group the revenue of the Progressive income tax and GDP were not stationary, but their first difference is are (see Table 3).

Table 2

Group stationarity tests of Progressive income tax and GDP

Method	Statistic	Probability	Cross-sections	Observations
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	4.59205	1.0000	2	65

Source: Prepared by the author

Table 3

Group stationarity tests of Progressive income tax and GDP (first difference)

Method	Statistic	Probability	Cross-sections	Observations
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	–1.64348	0.0501	2	64

Source: Prepared by the author

The test for the optimal number of lags, according to FPE, AIC, SC and HQ criteria, this number was one (see Table 4).

Table 4

Optimal lag length in the VEC model

Number of lags	FPE	AIC	SC	HQ
0	1.38e+11	31.32281	31.41350	31.35332
1	1.97e+08*	24.77322*	25.04531*	24.86477*
2	2.25e+08	24.90052	25.35401	25.05311
3	2.74e+08	25.09026	25.72514	25.30388
4	1.38e+11	31.32281	31.41350	31.35332

Source: Prepared by the author

* Shows the optimal number of lags according to the respective criterion

Johansen's cointegration test (see Table 5 and 6) shows that Progressive income tax and GDP are cointegrated according to the criteria of Trace and Max-eigenvalue.

Table 5

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.464923	23.72641	15.49471	0.0023
At most 1	0.089387	3.090036	3.841465	0.0788

Source: Prepared by the author

Note: Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

** MacKinnon-Haug-Michelis (1999) p-values

Table 6

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None*	0.464923	20.63637	14.26460	0.0043
At most 1	0.089387	3.090036	3.841465	0.0788

Source: Prepared by the author

Note: Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

** MacKinnon-Haug-Michelis (1999) p-values

According the above statistics, an restricted vector autoregressive model (VEC) with one lag was constructed. The statistically insignificant values are removed in ascending order. The vector autoregression was estimated with one lags.

The equation for the target variable in the VEC model GDP after the step-by-step removal of statistically insignificant variables is as follows:

(1) D(GDP) = C(1) ·(GDP(–1) – – 0.24228688236 ·PROGT(–1) + + 13514.2232898) + C(6)

The results from the evaluation of Equation (1) are shown in Table 7.

The variables in Equation (1) are statistically significant at a critical level of 5%. The first term of Equation (1) is named an error correction term and shows the long-run relationship between the variables of D(GDP) and progressive income tax (–1). The sign is negative and shows that the relationships long-run and equilibrium. Its absolute value (–0.24) indicates the rate of correction of deviations from the long-run equilibrium by 24% per period/quarter. The coefficient of error correction is negative (–0.041393) and confirms that the revenue from a progressive tax reduces growth in the long-run. The last term of Equation (1) is a constant and is also statistically significant. The coefficient shows that there is no short-run relationship between the growth rate of a progressive income tax and the growth. The VEC does not report statistically significant values in long-run.

The value of the coefficient of determination (R-squared = 0.48) proves that 48% of the change of the GDP in Bulgaria can be explained through the changes of the independent variable. The probability of the F-statistic (0,00) indicates that the alternative hypothesis of the adequacy of the model used is confirmed.

The correlation between progressive income tax and economic growth is positive whit value 0.56. It should be made clear that this does not mean that the

Table 7

Results from the econometric estimation of Equation (1)

Variable	Coefficient	Standard error	t-statistics	Probability
GDP(–1)	0.041393	0.007385	5.604675	0.0000
Constant	325.2932	27.22673	11.94757	0.0000
R-squared	0.487676	Mean dependent var	313.5404	
Adjusted R-squared	0.472151	S.D. dependent var	221.0461	
S.E. of regression	160.5970	Akaike info criterion	13.05112	
Sum squared resid	851116.5	Schwarz criterion	13.14000	
Log likelihood	–226.3946	Hannan-Quinn criter	13.08180	
F-statistic	31.41238	Durbin-Watson stat	2.455010	
Prob(F-statistic)	0.000003			

Source: Prepared by the author

Data: Eurostat

model is the best possible one but simply that it adequately reflects the relationship between the dependent and independent variables.

The results from the CUSUM test (Figure 4) prove that Equation (1) is steady in a dynamic time plan. The actual values of CUSUM are within the frames of the confidence interval at a 5% level of significance.

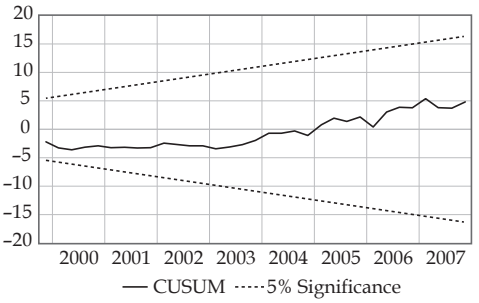

Fig. 4. **CUSUM test for dynamic stability of Equation (1)**

Source: Prepared by the author

The test for an absence of a serial correlation of disturbances shows that the null hypothesis is valid in Equation (1) (see Table 8). The results from the heteroscedasticity test on the residuals in the VEC model (see Table 9) is reason to accept the null hypothesis for lack of heteroscedasticity.

Table 8

Results from the serial correlation test of residuals in Equation (1)

F-statistic	1.276564	Probability F (2,37)	0.2933
Observations R2	2.663223	Probability Chi-square (2)	0.2641

Source: Prepared by the author

Table 9

Results from the heteroscedasticity test of residuals in Equation (1)

F-statistic	1.256221	Probability F F(6,37)	0.2984
Observations R2	2.547936	Probability Chi-square (3)	0.2797

Source: Prepared by the author

The probability of Jarque-Bera statistics is 0.57 (see Figure 5), which justifies the acceptance of the null hypothesis of normal distribution of the residuals in Equation (1).

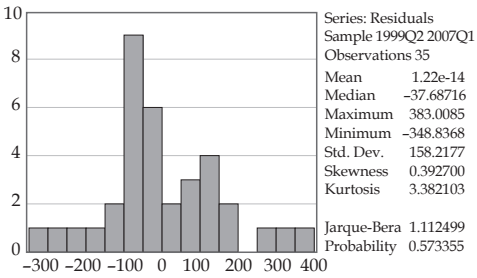

Fig. 5. **Test for normal distribution of residuals in Equation (1)**

Source: Prepared by the author

4.2. Empirical analysis of the long-run relationship between proportional income tax and economic growth

The group unit root tests shows that as a group the revenue of the Proportional income tax and GDP were not stationary, but their first difference is are. (see Tables 10 and 11).

Table 10

Group stationarity tests of Proportional income tax and GDP

Method	Statistic	Probability	Cross-sections	Observations
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	0.22189	0.5878	2	92

Source: Prepared by the author

Table 11

Group stationarity tests of Proportional income tax and GDP (first difference)

Method	Statistic	Probability	Cross-sections	Observations
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	–8.73997	0.0000	2	91

Source: Prepared by the author

The test for the optimal number of lags, according to FPE, AIC, SC and HQ criteria, this number was four (see Table 12).

Johansen's cointegration test (see Table 13 and 14) shows that Proportional income tax and GDP are cointegrated according to the criteria of Trace and Max-eigenvalue.

Table 12

Optimal lag length in the VEC model

Number of lags	FPE	AIC	SC	HQ
0	10.96299	8.070265	8.149771	8.100049
1	6.978559	7.618226	7.856744	7.707576
2	5.044863	7.292400	7.689931	7.441318
3	5.514408	7.378354	7.934897	7.586838
4	1.083587*	5.745809*	6.461364*	6.013860*

Source: Prepared by the author

Note: * Shows the optimal number of lags according to the respective criterion

Table 13

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.329348	20.08927	15.49471	0.0094
At most 1	0.055472	2.511072	3.841465	0.1130

Source: Prepared by the author

Note: Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

** MacKinnon-Haug-Michelis (1999) p-values

Table 14

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.329348	17.57820	14.26460	0.0144
At most 1	0.055472	2.511072	3.841465	0.1130

Source: Prepared by the author

Note: Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

** MacKinnon-Haug-Michelis (1999) p-values

According the above statistics, an restricted vector autoregressive model (VEC) with one lag was constructed. The statistically insignificant values are removed in ascending order. The vector autoregression was estimated with four lags.

The equation for the target variable in the VEC model GDP after the step-by-step removal of statistically insignificant variables is as follows:

$$\text{(2) } D(GDP) = C(1) \cdot (GDP(-1) - 0.15597128779 \cdot PT(-1) + 18.7618351218) + C(4) \cdot D(GDP(-2)) + C(6) \cdot D(GDP(-3)) + C(8) \cdot D(GDP(-4)) + C(10)$$

The results from the evaluation of Equation (2) are shown in Table 15.

The variables in Equation (2) are statistically significant at a critical level of 5%. The first term of the equation (error correction) shows the long-run relationship between the variables D(GDP), GDP(–1) and proportional income *t*(–1). The sign is negative thus indicating that the relationship is long-run and equilibrium. Its absolute value (–0.15) indicates that the rate of correction of deviations from the long-run equilibrium is 15% per period/quarter. The coefficient of error correction is negative (–0.258523) thus confirming that the revenue from a proportional tax on a long-run shall reduce growth. The se-cond, third and fourth terms of the equation show the short-run impact. The last member of Equation (2) is constant (a free term), and is also sta-

Table 15

Results from the econometric estimation of Equation (2)

Variable	Coefficient	Standard error	t-statistics	Probability
GDP(–1)	–0.258523	0.093363	–2.769000	0.0086
D(GDP(–2))	0.257372	0.090385	2.847497	0.0070
D(GDP(–3))	0.517572	0.093274	5.548953	0.0000
D(GDP(–4))	–0.247883	0.121901	–2.033486	0.0488
Constant	0.115262	0.112087	2.628323	0.0103

R-squared	0.639639	Mean dependent var	0.085798
Adjusted R-squared	0.602679	S.D. dependent var	1.236911
S.E. of regression	0.779667	Akaike info criterion	2.446745
Sum squared resid	23.70734	Schwarz criterion	2.649494
Log likelihood	–48.82838	Hannan-Quinn criter	2.521934
F-statistic	17.30621	Durbin-Watson stat	2.154472
Prob(F-statistic)	0.000000		

Source: Prepared by the author

Data: Eurostat

tistically significant. Coefficients prove that there is no short-run relationship between the growth rate of the revenue from a proportional tax and the growth. The VEC model does not establish any statistically significant values in the short-run by the part of the proportional tax, but only by the part of the GDP.

The value of the coefficient of determination (R-squared = 0.63) means that 63% of the change of the GDP in Bulgaria can be explained through the changes of the independent variable. The probability of the F-statistic (0.00) indicates that the alternative hypothesis of the adequacy of the model used is confirmed.

The correlation between proportional income tax and economic growth is weak with value 0.01. It should be made clear that this does not mean that the model is the best possible one but simply that it adequately reflects the relationship between the dependent and independent variables.

The results from the CUSUM test (Figure 6) prove that Equation (2) is steady in a dynamic time plan. The actual values of CUSUM are within the frames of the confidence interval at a 5% level of significance.

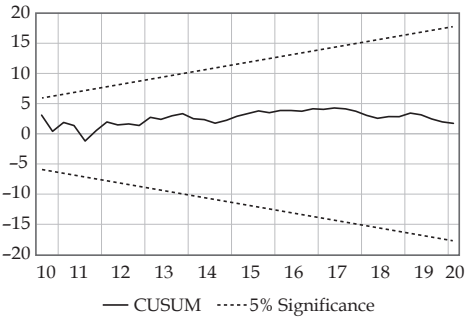

***Fig. 6.* CUSUM test for dynamic stability of Equation (2)**

Source: Prepared by the author

The test for an absence of a serial correlation of disturbances shows that the null hypothesis is valid in Equation (2) (see Table 16). The results from the heteroscedasticity test on the residuals in the VEC model (see Table 17) is reason to accept the null hypothesis for lack of heteroscedasticity.

Table 16

Results from the serial correlation test of residuals in Equation (2)

F-statistic	0.867208	Probability F (2,37)	0.4285
Observations R2	1.970195	Probability Chi-square (2)	0.3734

Source: Prepared by the author

Table 17

Results from the heteroscedasticity test of residuals in Equation (2)

F-statistic	0.377445	Probability F (6,37)	0.7697
Observations R2	1.205913	Probability Chi-square (3)	0.7516

Source: Prepared by the author

The probability of Jarque-Bera statistics is 0.1 (see Figure 7), which justifies the acceptance of the null hypothesis of normal distribution of the residuals in Equation (2).

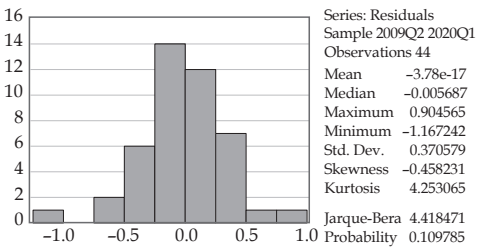

***Fig. 7.* Test for normal distribution of residuals in Equation (2)**

Source: Prepared by the author

5. Conclusions

Several important conclusions can be drawn from the empirical analysis.

First, there exists a long-run equilibrium relationship between the GDP growth rates and the revenue from a progressive tax. This link is negative, which means that income taxation with a progressive tax reduces growth. At an occurrence of shocks the restoration of the state of equilibrium shall take approximately a year. No short-run relationship is established between the economic growth and progressive tax in Bulgaria.

Second, there also exists a long-run relationship between the GDP growth rates and the revenue from a proportional tax. This link is negative, which means that

income taxation with a proportional tax reduces growth. No short-run impact is established by the part of the proportional tax on GDP growth rate. At the occurrence of shocks the restoration of the state of equilibrium shall take approximately two years.

Third, the progressive tax is more compatible with the economic growth than the proportional one. This is supported by the higher coefficient of error correction. Hence, the progressive tax in Bulgaria has a more favourable impact on the economic development.

Fourth, no short-run impact on the economic growth is established for both types of taxes. This result comes to confirm that the progressive and the proportional tax in Bulgaria are in conformity with the theory of endogenic growth and reject the neoclassical theory.

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Assessment of the effectiveness of anti-COVID tax support for innovation activities of small and medium-sized enterprises in OECD countries

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ABSTRACT
The global economy has rebounded from the lows of 2020, but its recovery will depend on innovations. Therefore, it is important to identify the most effective tax support instruments for the innovation activities of small and medium-sized enterprises (SMEs) that are used in the framework of anti-crisis economic policies in the OECD countries. It is suggested that tax incentives are the most effective tax instrument of all; the effectiveness of the profit tax benefit depends on the SME's profitability; as to the social insurance and pension contribution, there is an allowable minimum of the rate, determined by the level of wages, that will stimulate innovation. To assess the effectiveness of tax support tools, the study used the methods of linear multivariate regression and simulation in Simulink. The source of information for regression analysis was the data published by the World Bank and the Organization for Economic Cooperation and Development (OECD). It was concluded that the most effective measures of tax support are tax incentives, as well as deferred payment of social insurance and pension contributions. The 10% profit tax was shown to be optimal to stimulate innovation provided the company keeps the saved profit for development. For innovative SMEs, the minimum allowable contribution rate for social insurance and pension provision, which stimulates their innovative activities, is 12%. The results of modeling confirmed that the proposed threshold indicators for supporting SMEs' innovation activity can be an effective tool for overcoming the consequences of the global crisis caused by the COVID-19 pandemic.

KEYWORDS
tax incentives, tax support, income tax, social security and pension contributions, innovative activity, small and medium-sized enterprises, COVID-19

JEL H20, H21, H22, O38

Оригинальная статья
УДК 336.22

Оценка эффективности антиковидной налоговой поддержки инновационной деятельности малых и средних предприятий в странах ОЭСР

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АННОТАЦИЯ
Мировая экономика преодолела минимальные значения 2020 г., но ее будущее восстановление зависит от инноваций. Поэтому важно выяснить, какие инструменты налоговой поддержки инновационной деятельности малых и средних

предприятий (МСП), используемые в рамках антикризисной экономической политики в странах ОЭСР, являются наиболее эффективными. В исследовании выдвигаются следующие предположения: налоговые льготы являются наиболее эффективным налоговым инструментом из всех применяемых; эффективность льгот по налогу на прибыль зависит от прибыльности МСП; существует допустимый минимум ставки социального страхования и пенсионных взносов, определяемый уровнем заработной платы, который будет стимулировать участников к инновационной деятельности. Для оценки эффективности инструментов налоговой поддержки в исследовании использовались методы линейной многомерной регрессии и моделирования в Simulink. В качестве источника информации для регрессионного анализа использованы данные, публикуемые Всемирным банком и Организацией экономического сотрудничества и развития (ОЭСР). Сделан вывод, что наиболее эффективными мерами налоговой поддержки являются налоговые льготы, а также отсрочка выплаты взносов на социальное страхование и пенсионных взносов. Показано, что ставка налога на прибыль 10% является оптимальным вариантом для стимулирования инновационной деятельности, при условии, что компания оставляет сэкономленную прибыль на развитие. Для инновационных МСП минимально допустимая ставка взносов на социальное страхование и пенсионное обеспечение, которая стимулирует их инновационную деятельность, составляет 12%. Результаты моделирования подтвердили, что предложенные пороговые показатели поддержки инновационной активности МСП могут быть эффективным инструментом преодоления последствий глобального кризиса, вызванного пандемией COVID-19.

КЛЮЧЕВЫЕ СЛОВА
налоговые льготы, налоговая поддержка, подоходный налог, социальный взнос, инновационная деятельность, МСП, COVID-19

1. Introduction

Since the beginning of 2020, the COVID-19 pandemic has become not only a threat to the health of citizens, but also a serious challenge for the global economy. World countries continue to implement fiscal policy measures and support particularly vulnerable sectors of the economy, including small and medium-sized enterprises. As an example, in the EU countries, in order to minimize the negative impact on business, the European Commission has taken comprehensive economic measures aimed at easing fiscal rules, revised state aid programs and initiated an investment initiative to respond to coronavirus in the amount of 37 billion euros to provide liquidity to small and medium-sized businesses and the health sector[1].

Economic forecasts reflect negative trends in terms of the scale of the global economic recession caused by the pandemic. In its forecast, the OECD predicts a 6–7.6% drop in global GDP by the end of 2020. In the most affected countries, a double-digit decline is forecasted, followed by a moderate recovery of 2.8% in 2021(OECD, 2020[2]). The IMF forecast shows a decline in global GDP by 4.9% in 2020, which is 1.9% lower than the April forecast, followed by a partial recovery, with growth of 5.4% in 2021 (IMF, 2020[3]). UNCTAD predicts a decline in global foreign investment of up to 40% in 2020, followed by a decline of 5–10% in 2021 (UNCTAD, 2020[4]). ILO estimates the impact of COVID-19 on global unemployment growth by optimistic (5.3 million) and pessimistic (24.7 million) forecasts,

[1] European Coordinated Response on Coronavirus: Questions and Answers. Available at: https://ec.europa.eu/commission/presscorner/detail/en/qanda_20_458

[2] OECD Economic Outlook. OECD Publishing, 2020. Available at: https://dx.doi.org/10.1787/0d1d1e2e-en

[3] World Economic Outlook Update, June 2020: A Crisis Like No Other, An Uncertain Recovery. Available at: https://www.imf.org/en/Publications/WEO/Issues/2020/06/24/WEOUpdateJune2020?utm_medium=email&utm_source=govdelivery

[4] World Investment Report 2020: International Production beyond the Pandemic. Available at: https://unctad.org/system/files/official-document/wir2020_en.pdf

indicating that "maintaining business operations will be particularly difficult for small and medium-sized enterprises" (ILO, 2020[5]). Of course, these impacts affect both large and small businesses, but the impact on SMEs is particularly severe due to the high level of vulnerability and lower resilience associated with their size.

As for post-Soviet countries, they remain vulnerable to economic shocks, for example, in Ukraine, according to forecasts, GDP may decline by 4–8% compared to 2019. As a result, according to NBU forecasts, Ukraine in 2020 may face a drop in exports (–10%), imports (–14.5%), an expansion of the budget deficit (8% of GDP) and an increase in the unemployment rate (up to 9.5%)[6].

In these circumstances, innovative SMEs particularly need support, including tax support. It is these enterprises that are at high risk. On the one hand, the conditions of isolation have increased the risk for innovative enterprises, and on the other hand, they have proved that it is difficult to survive in such conditions without innovation. At the same time, innovations have a direct impact on the profitability indicators of enterprises, and they can reduce the time of economic recovery from the consequences of COVID-19. Therefore, now it is especially advisable for the state not only to support, but also to stimulate the development of innovative activities of small and medium-sized enterprises.

The purpose of this article was to identify the most effective tools for tax support of innovative activities of small and medium-sized enterprises, which continue to be used to overcome the consequences of coronavirus. For analysis, were collected and grouped statistics by 36 OECD countries as of 2019. OECD countries use a single methodology, which makes it possible to use it as a reliable tool for analyzing and predicting the development of economic processes.

We have formulated three hypotheses:

Hypothesis 1. Among the tax support tools used, tax incentives are the most effective.

Hypothesis 2. The effectiveness of the income tax benefit depends on the profitability of the enterprise.

Hypothesis 3. The minimum allowable contribution rate for social insurance and pension provision to encourage participants in innovation activities is determined by the level of wages.

The article is structured as follows. The second section provides an overview of the literature on the impact of tax support on the development of innovative SMEs. The third section describes the research methodology. Section 4.1 contains an analysis of the world practice of tax support for innovation activities of SMEs. Section 4.2 provides calculations and estimates of the effectiveness of tax support used in the COVID-19 context. The fifth section contains our conclusions, the limitations of the study and the practical significance of the results obtained

2. Literature review

In the context of the global economic crisis caused by the COVID-19 pandemic, the development of innovative small businesses is of particular interest. For example, Fairlie [1] presented an analysis of the negative impact of the pandemic on the number of active small businesses. Sufficient attention continues to be paid to the issue of developing tax support programs for innovative activities of SMEs. Boot et al. [2] proposes the provision of funds to firms in exchange for a temporary increase in the income tax rate after the crisis. Drechsel & Kalemli-Ozcan [3] recommend an immediate negative one-off tax for SMEs since a negative one-time tax will allow remittances that may exceed the deferral of existing tax liabilities.

Considering the policy of tax incentives for innovative SMEs, which was previously used during economic crises,

[5] ILO Monitor: COVID-19 and the world of work. Available at: https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6

[6] State program of stimulation of the economy to overcome the negative effects caused by restrictive measures to prevent the occurrence and spread of acute respiratory disease COVID-19 caused by coronavirus SARS-CoV-2, for 2020–2022. (Cabinet of Ministers of Ukraine). *Uryadoviy kur'er = Government courier*, 122. (In Ukrain.)

it is worth highlighting the work of Beca & Cozmei [4]. The authors studied that in order to mitigate the consequences of the 2008 crisis, the EU countries more often used a reduction in the established income tax rate; deductions for accelerated depreciation of capital expenditures; targeted investment tax incentives.

Most of the works of scientists are devoted to the question of the impact of tax incentives on the R&D of enterprises. Russo [5] concluded that tax incentives for R&D lead to a relatively significant increase in research and welfare, and lower rates of corporate income tax contribute to the development of innovative business. Kizim & Kasyanova [6] argue that R&D is sensitive to deferred payment of income tax and exemption from import VAT, as well as preferences for unified compulsory state social insurance.

Motivational impact on innovative business is expressed in an additional tax deduction, tax credit, and accelerated depreciation. Castellacci & Lie [7] note that the effect of additional tax credits on R&D is, on average, stronger for SMEs. Montmartin & Herrera [8] conclude that tax breaks increase business-funded R&D intensity. Freitas et al. [9] argue that firms in industries with a high R&D orientation, on average, have a higher propensity to use tax incentive schemes for R&D and more tangible effects of additionally in input and output. Cappelen et al. [10] found that projects that receive tax breaks lead to the development of new production processes and, to some extent, to the development of new products for the firm. Authors Foreman-Peck [11], Czarnitzki [12], Mitchell [13], Falk [14], Guceri & Liu [15], Acconcia & Cantabene [16] also argue that tax incentives for R&D have a significant and positive impact on firm performance.

Mohnen & Lokshin [17] investigated how the effectiveness of tax incentives for R&D was assessed in 2002–2009. Whether they are based on structural models that estimate the price elasticity of R&D or other valuation techniques, most studies estimate cost-effectiveness or complementarity.

Some scholars are analyzing the impact of the combined application of tax breaks and subsidies. Ples [18] found that higher tax credit rates significantly increase the impact of grants on R&D investment for small firms, especially those facing financial constraints, but lower it for larger firms. The author suggests that the complex of innovation policy should include both mechanisms for supporting small businesses. Busom [19] found that small and medium-sized enterprises with financial constraints were less likely to use tax incentives for R&D than subsidies. The authors suggest that subsidies may be more appropriate than tax breaks, at least for SMEs. In addition, in a joint work, Corchuelo & Martínez-Ros [20] found that tax incentives increase the innovation activity of large companies and high-tech enterprises, but can only be used randomly by small and medium-sized enterprises. Mitchell et al. [13], Dumont [21] in contrast, believe that R&D tax incentives targeting young companies tend to have a positive effect on R&D intensity and wages, but this impact is relatively reduced when combined with other instruments such as subsidies. Huergo & Moreno [22] found that the effects of subsidies and loans are mutually reinforcing when they are jointly provided to SMEs. However, for large firms, a crowding-out effect between subsidies and loans cannot be ruled out.

The positive impact of a tax credit on R&D is also common in the work of academics. Harris at al. [23] studied the effect of a regionally increased tax credit for R&D on "user costs" (or price) of R&D expenditures. The authors concluded that it is necessary to significantly increase the tax credit for R&D. Agrawal et al. [24] found that obtaining a tax credit for research and experimental development increases the overall volume of R&D among small private firms. The impact was more significant for firms that used tax credits as refunds because they had no current tax liability. Kasahara et al. [25] evaluating the equation of the linear R&D model using the GMM panel concluded that the effect of the tax credit

is significantly greater for firms with relatively large outstanding debts.

Considering the impact of tax cuts, it is worth highlighting the work of Zheng & Zhang [26]. The authors found a significant incentive effect of tax cuts. In addition, the incentive effect is greater in the service sector than in the manufacturing sector. Ghazinoory & Hashemi [27] found that for SMEs, tax exemption has a significant impact on investment in R&D, and financing has a significant impact on investment in R&D, employees in R&D, and new products. In addition, Rao [28] found that a 10% reduction in R&D costs for enterprises leads to the fact that the average firm increases the intensity of research – the ratio of R&D spending to sales – by 19.8% in the short term.

The effectiveness of tax incentives for innovation activities of SMEs is considered in many analytical studies of the OECD. The report titled "The effects of R&D tax incentives and their role in the innovation policy mix" notes the positive impact of tax incentives on both enterprises that take part in the R&D for the first time or enterprises repeatedly taking part in the R&D program (OECD, 2020)[7]. In the work of the European Commission (2015) "SME taxation in Europe", an assessment of tax incentives for the development of innovative SMEs was carried out[8]. It is noted that the tax incentive should provide enterprises with increased liquidity and provide additional investment and growth.

In the works of scientists, the topic of the effectiveness of tax incentives for innovative activities of SMEs is also often encountered. Guellec et al. [29] note that direct financing, as well as tax incentives, are more effective when they are stable over time: firms do not invest in additional R&D if they are not confident in the longevity of government support. Hall [30] presents the policy rationale for tax incentives, discusses potential effectiveness, and examines empirical evidence of their actual effectiveness. The focus is on two of the most important and most studied incentives: tax credits on R&D and super-deductibles and IP indexes (reducing corporate taxes on profits from patents and other intellectual property). Koga [31] studying the efficiency of tax incentives for R&D using data on Japanese manufacturing companies for 10 years (1989–1998), concluded that a tax credit for R&D is effective for increasing investment in R&D. Sokolovska & Rainova [32] identified the factors that affect the effectiveness of tax incentives for R & D, namely: 1) the type of tax benefits; 2) the effectiveness of the institutions that manage the national innovation system and tax administration; 3) the propensity of business to innovate and its response to tax benefits.

The authors Thomson [33], Cozmei & Rusu [34] emphasize the importance of further research on the effectiveness of tax incentives in R&D and emphasize the need to develop tax policies that will promote innovative development and enhance the strategy of transferring profits.

The literature review shows that the issue of assessing the effectiveness of tax support for innovative SMEs is insufficiently studied. It requires identifying the most effective tools for tax support of SME innovation activities, which are used in the framework of anti-covid economic policies.

3. Methodology

To confirm or refute hypothesis 1, based on the analysis of the world practice of tax support for SME innovation in previous years, it is proposed to identify the most effective tools for tax support for SME innovation that are used in the framework of anti-covid economic policy. To model and analyze the relationships between variables, as well as to see how

[7] The effects of R&D tax incentives and their role in the innovation policy mix: Findings from the OECD microBeRD project, 2016–19. OECD Science, Technology and Industry Policy Papers, 92. Available at: https://doi.org/10.1787/65234003-en

[8] SME taxation in Europe – An empirical study of applied corporate income taxation for SMEs compared to large enterprises. Internal Market, Industry, Entrepreneurship and SMEs. Available at: https://ec.europa.eu/growth/content/sme-taxation-europe-%E2%80%93-empirical-study-applied-corporate-income-taxation-smes-compared-0_en

these variables together affect the production of a certain result, we use regression analysis. Multiple linear regression involves establishing a linear relationship between a set of input independents and one output dependent variable.

One of the obstacles to effective application of regression analysis is the presence of multicollinearity. It arises when there are sufficiently close linear statistical relationships between the explanatory variables. In this regard, we use correlation analysis. Using this method it is possible to identify and eliminate multicollinearity. In addition, the main conceptual limitation of regression analysis methods is that they only detect numerical relationships, and not the underlying causal relationships.

For the construction and comprehensive analysis of multiple linear econometric models, statistics were collected and grouped by 36 OECD countries as of 2019. OECD countries use a single methodology, which makes it possible to use it as a reliable tool for analyzing and predicting the development of economic processes.

Under the dependent variable, we represent the rank value of the Global Innovation Index (Y). The advantage of this index is its wide coverage of all areas of innovation activity in 129 countries. The spectrum of sources of international statistics is: the World Bank, the Organizations for Economic Cooperation and Development (OECD), the International Telecommunications Union and the survey of managers' opinions, which is conducted annually by the Executive Opinion Survey. This index also evaluates innovation potential and infrastructure for innovation development.

The independent variables are: Income Tax Deferral (X_1), Value-Added Tax Deferral (X_2), social security and pension contributions (X_3), local tax deferral (X_4), and tax incentives (X_5). These tax support tools are currently used in the framework of anti-covid economic policies and are considered in the OECD reports.

Indicators for analyzing the impact of tax support forms on the innovative development of small and medium-sized enterprises are given in Table 1.

Table 1

Indicators for analyzing the impact of tax support forms on the innovative development of small and medium-sized enterprises

Symbol	Indicator	Unit of measurement
Y	Global Innovation Index	Rank value
X_1	Deferred income tax payment	Binary value
X_2	Deferred payment of Value Added Tax	Binary value
X_3	Deferral of social security and pension contributions	Binary value
X_4	Deferral of local taxes	Binary value
X_5	Tax incentives	Rank value

Source: compiled by the authors based on WIPO, OECD data.

These indicators were selected based on the results of research by scientists, in particular Drechsel & Kalemli-Ozcan [10], Fairlie [11] it is noted that tax deferral will allow businesses to delay the payment of outstanding tax liabilities, and the practical implementation of this tool can be fast. Kizim & Kasyanova [14], noted in the classification of tools for tax incentives for innovation the application of tax incentives, including a reduction in income tax and social insurance rates.

In order to take into account all available tools of tax support for innovation activities of SMEs that affect their development, we will conduct a correlation analysis of indicators to determine the density of the relationship between the performance feature and factor values and build an economic and mathematical model.

The analysis of the impact of these factors on the state of innovation activity of enterprises in the OECD countries allows us to assess the situation that has developed as a result of the use of tax support tools by states during 2000–2019.

Interaction of the resulting indicator (Y) with factor features (X_1, X_2, … X_n) is described by the equation of linear multivariate regression, determined by the formula [24, p. 54]:

$$\hat{Y} = \hat{a}_0 + \sum \hat{a}_i \cdot X_i. \quad (1)$$

Separately, we will evaluate the effectiveness of using income tax incentives and social security and pension contributions, since the use of incentives for these types of taxes is most popular for innovative small and medium-sized enterprises.

Income tax. A reduction in the income tax rate may affect R&D investments due to the expected higher future net income from productive R&D investments. To confirm or refute hypothesis 2 using the Simulink program, we will build a model that demonstrates the dependence of changes in budget revenues on the size of the preferential income tax rate (Table. 2).

Table 2

Indicators for building a model for using the income tax benefit of innovative small and medium-sized enterprises

Symbol	Indicator	Unit of measurement
Innovative SMEs	Equity of innovative SMEs	Monetary units
Rent	Profitability	%
Prof	Profit (calculated value)	Monetary units
Tax	Income tax rate	%
Budget	Tax revenues to the state (estimated value)	Monetary units
Prof2	Net profit (estimated value)	Monetary units

Source: compiled by the authors based on OECD data.

Indicators for building the model were selected according to the stages of forming and calculating tax revenues to the state. The object of income tax calculation is profit, which is calculated by multiplying the equity of innovative SMEs by profitability. The income tax rate is determined by the state. Tax revenues to the state are calculated as a multiplication of profits by the income tax rate. Net profit is the part of the balance sheet profit of an enterprise that remains at its disposal after taxes.

The initial value of the equity of innovative SMEs will be set at 1 money units, profitability from 0 to 100%, in 5% increments, income tax rate from 0 to 50%, in 5% increments. If the optimal tax rate is set, tax revenues to the state budget will reach their maximum value.

In the Matlab program, we will plot a graphical representation of the relationship between tax revenues and the dynamics of the income tax rate in the form of a Laffer curve (on the X-axis – the size of the tax rate, on the Y-axis – tax revenues to the budget).

Contribution to social security and pension contributions. A reduction in social security and pension contributions may affect the de-shadowing and wage increases of innovative SMEs. Let's put forward hypothesis 3 – the minimum allowable social security and pension contributions rate for stimulating participants in innovation activities is determined by the salary level. Using the Simulink program, we will build a model that will demonstrate the effectiveness of using a preferential regressive tax rate for social security and pension contributions (Table. 3).

Table 3

Indicators for building a model for using the preferential regressive tax rate for social security and pension contributions

Symbol	Indicator	Unit of measurement
Min_salary	Minimum wage	Monetary units
Step	Salary increase step	Monetary units
ESV	Social security and pension contributions	%
ESV1	Tax incentives	%

Source: compiled by the authors based on OECD data.

Indicators for constructing the model were selected depending on the calculation of social security and pension contributions for different salary amounts (from the minimum to the maximum, with the setting of the increase step) using the tax incentives.

At the same time, the minimum wage value will be set at 200 USD (rounded minimum wage rate in OECD countries), the step by which the tax will be reduced by 2% will be 200 USD, the maximum salary is 2,500 USD. If the optimal tax rate is set, tax revenues to the state budget will reach their maximum value.

In the Matlab program, we will plot a graphical representation of the relationship between the amount of wages and the dynamics of the social security and pension contributions (on the *X*-axis – the amount of wages, on the *Y*-axis – tax revenues to the budget at a regressive tax rate).

4. Empirical research results

4.1. Analysis of the world practice of tax support for innovation activities of SMEs

The assessment of the innovative development of the OECD countries in 2019 according to the GII index showed the best results in Switzerland (67.2), Sweden (63.7) and the United States (61.7). The lowest level of innovation development among the analyzed countries is in Turkey (36.9), Chile (36.6) and Mexico (36.1) (Fig. 1).

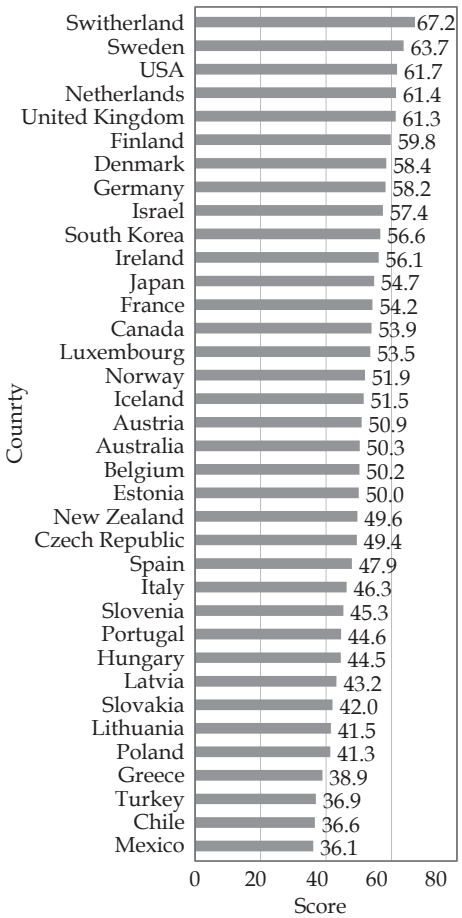

***Fig. 1.* Global Innovation Index (GII) of OECD countries for 2019**

Source: compiled by the authors based on WIPO data

The OECD countries that had the highest rating in terms of innovation development in 2019 – Switzerland (66.1), Sweden (62.5) and the United States (60.6) – did not all use tax support for SME Innovation equally. For example, Switzerland did not provide tax incentives or other tax support for R&D for businesses during 2000–2018. However, in the context of COVID-19, Switzerland granted a deferral of social insurance contributions and reduced the 0% rate on VAT, customs duties and special excise taxes from March 21, 2020 to December 31, 2020. In turn, Sweden and the United States provided R&D tax incentives for businesses in the amount of 0.01% and 0.08% of GDP, respectively, for the period 2000–2018. To overcome the consequences of the coronavirus, these countries also introduced deferral and tax reductions.

An analysis of tax support for innovative development in 2019 showed that 33 OECD countries provided preferential tax treatment for R&D expenses compared to 19 OECD countries in 2000 [25]. In 2018, the largest total government support for R&D expenses as a percentage of GDP was provided in the France and United Kingdom (Fig. 2). Other countries have provided significant tax assistance – Australia, Belgium, Italy, Japan, Lithuania, the Netherlands and Portugal.

Some countries that provide little support solely on a direct funding basis provide significant assistance through the tax system. For example, Australia, Ireland, Japan and the Netherlands, where tax incentives account for more than 80% of total government support. In OECD countries, the share of tax incentives in total government support increased from an average of 36% in 2006 to 46% in 2018. This trend was fairly uniform among the OECD countries, with only a few exceptions, such as Canada and Hungary, which abandoned a high share of tax support in 2006 and balanced it with public funding [25].

In 2019, the largest amount of tax incentives for profitable innovative SMEs was in France, Portugal and Chile (Fig. 3).

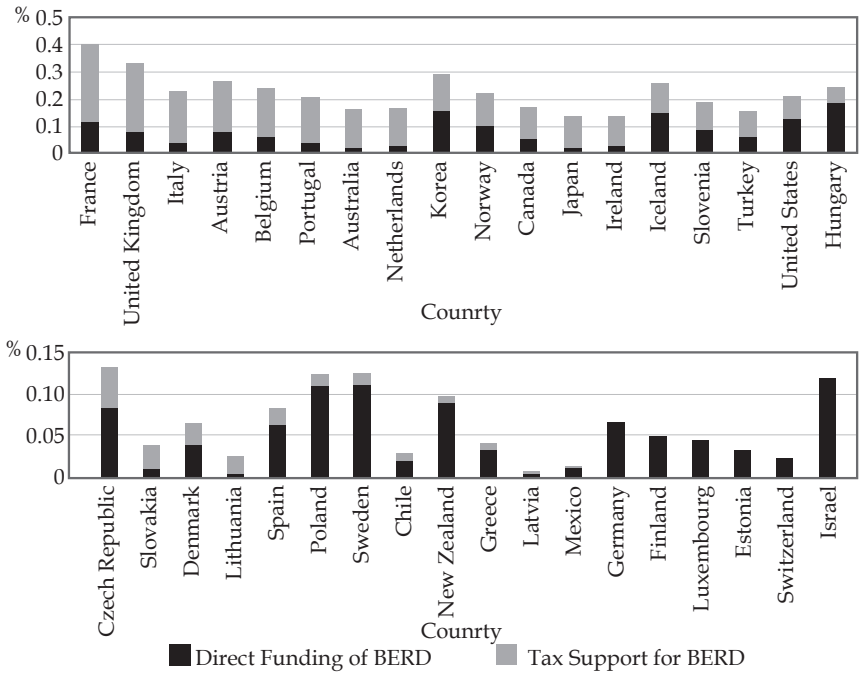

Fig. 2. **Government funding and tax support for business research and development, 2018**

Source: compiled by the authors based on OECD data

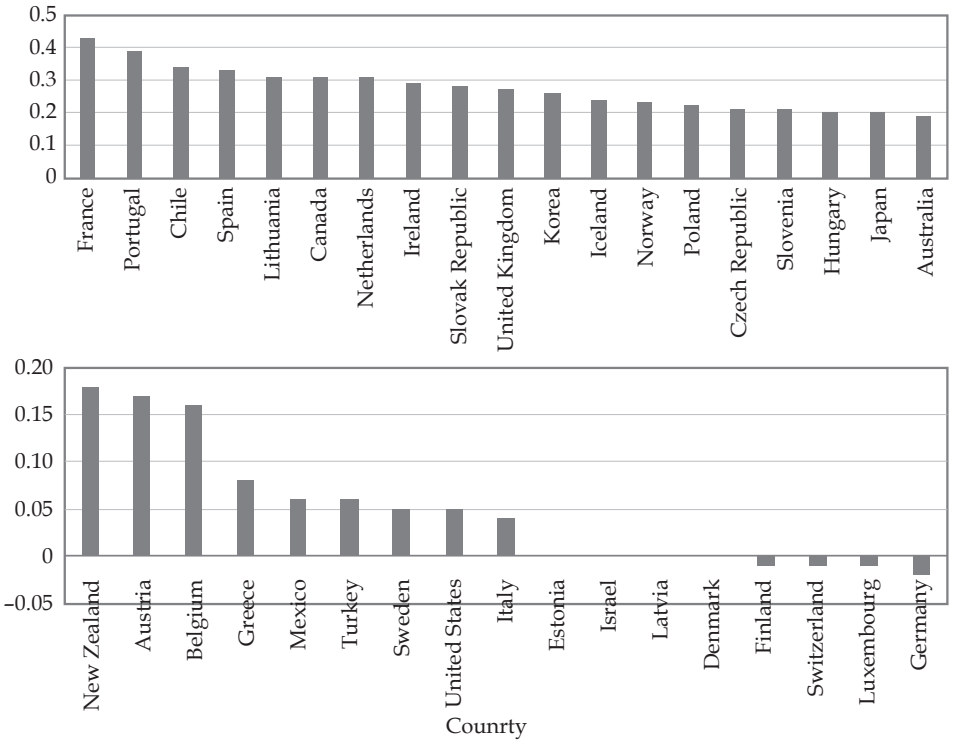

Fig. 3. **Tax subsidy rates for R&D expenses for profitable SMEs, 2019**

Source: compiled by the authors based on OECD data

To facilitate research work in firms that cannot otherwise use their loans or benefits, countries around the world offer refunds (payable) or equivalent incentives. Such provisions tend to be more generous for SMEs and young firms compared to large enterprises, as in the case of Australia, Canada and France. In contrast, R&D tax subsidy rates for SMEs may be lower than those of large firms, where countries offer R&D tax incentives and enterprise income tax incentives for SMEs (such as China and Croatia), with the amount of tax deductions related to the corporate income tax rate. In general, there are large differences in the rates of R&D tax subsidies in different countries.

Data from the World Bank show that tax support ranks third among all measures to support SMEs in the context of coronavirus (out of 1,149 SME policy instruments used worldwide, 439 relate to debt financing (loans and guarantees), 280 to employment support and 217 to tax support) [26].

Analysis of the global experience of tax support for innovative SMEs in the context of COVID-19 (Table 4).

Table 4

Forms of tax support for innovation activities of small and medium-sized enterprises in the context of COVID-19

Country	Deferral of Income / corporate tax	Deferral of Value Added Tax	Deferral of Social security and pension	Deferral of Rent / local tax
Switzerland	✓	✓	✓	
Sweden	✓	✓	✓	✓
USA	✓		✓	
Netherlands	✓	✓		
United Kingdom	✓	✓		✓
Finland	✓	✓		
Denmark	✓	✓		
Germany	✓			
Israel		✓	✓	✓
Korea				
Ireland	✓	✓		
Japan	✓			✓
France	✓		✓	✓
Canada	✓	✓		✓
Luxembourg	✓	✓		
Norway	✓	✓	✓	
Iceland	✓	✓		
Austria	✓		✓	✓
Australia	✓			
Belgium	✓	✓	✓	✓
Estonia	✓		✓	
New Zealand	✓			✓
Czech Republic	✓			✓
Spain	✓		✓	✓
Italy	✓	✓	✓	✓
Slovenia	✓			✓
Portugal	✓	✓	✓	
Hungary	✓		✓	✓
Latvia	✓			
Slovakia	✓			
Lithuania	✓			✓
Poland	✓		✓	
Greece	✓	✓	✓	
Turkey	✓	✓	✓	✓
Chile	✓	✓		✓
Mexico				

Source: compiled by the authors based on World Bank data.

In order to ease liquidity restrictions, OECD countries have introduced measures to defer income taxes, VAT, social payments, local taxes and tax reliefs. In some cases tax incentives or a moratorium on debt repayment are applied. One of the most common types of tax preferences for innovative businesses is income tax exemption. The following forms of tax support (Fig. 4) may have direct or indirect significance for businesses. In the first case, the tax burden is reduced in various ways, and in the second case, the general conditions for conducting economic activities are improved.

In order to avoid further decline in the liquidity of innovative SMEs, most countries have introduced measures to defer tax payments. Deferral is more often used when paying corporate income tax, less often countries provide deferral of Value-Added Tax (VAT), social security and pension contributions. In addition, in some countries, utility bills, mortgages, and rentals for small businesses and citizens have been temporarily suspended. Local authorities also postponed the payment of property taxes. The scope and duration of deferral measures vary by country. In some countries, along

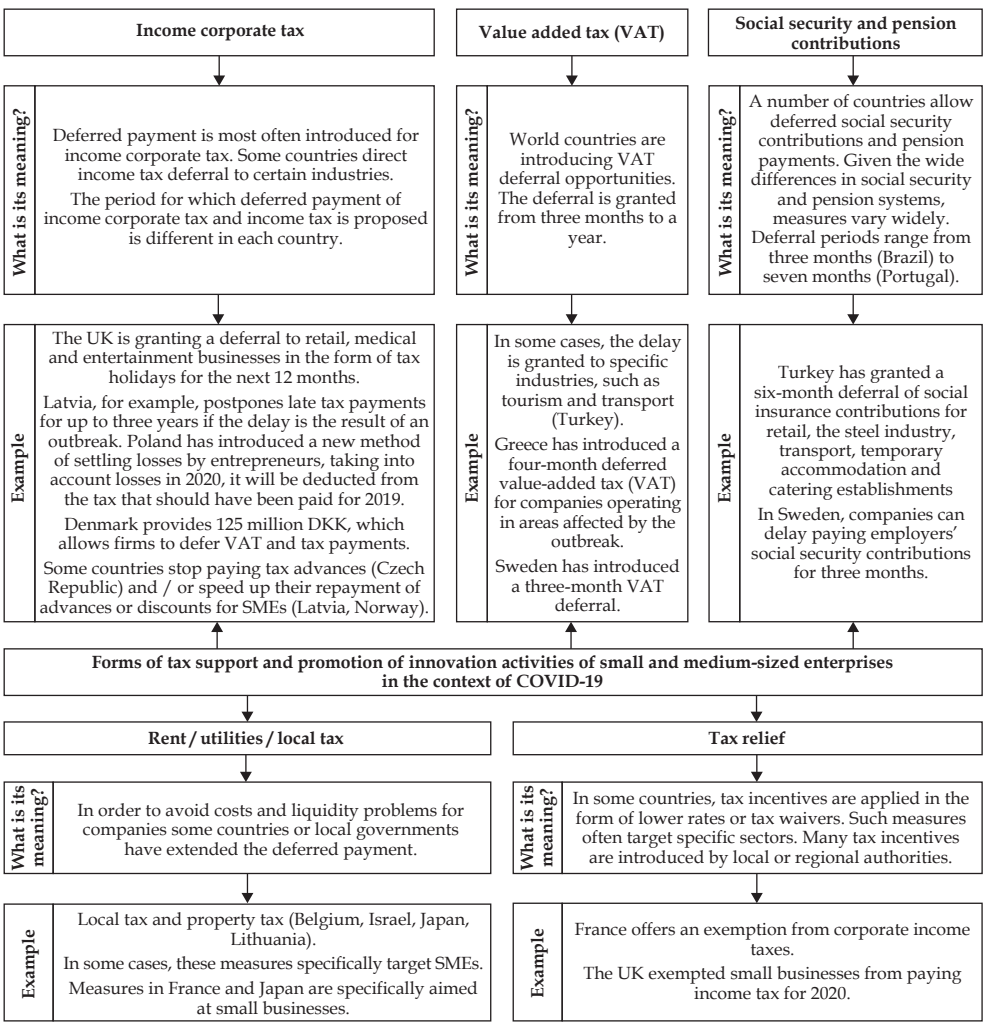

Fig. 4. **Forms of tax support and incentives for the development of innovative activities of small and medium-sized enterprises in the context of COVID-19**

Source: compiled by the authors based on World Bank data

with tax deferral, a tax incentive is also granted (Fig. 5).

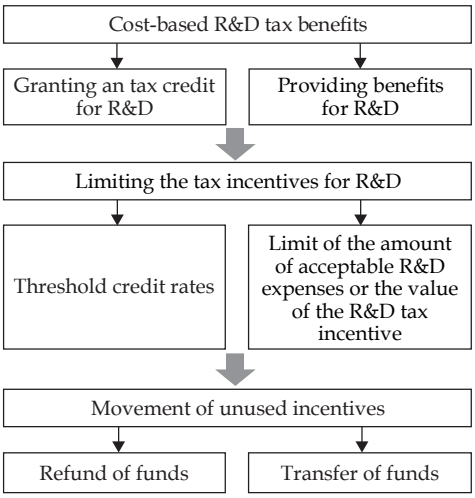

***Fig. 5.* Main features of R&D tax incentives for SMEs in the context of COVID-19**

Source: compiled by the authors based on World Bank data

Tax incentives are provided by reducing rates or refusing to pay tax. Such measures often target specific sectors. Many tax incentives are introduced by local or regional authorities.

4.2. Assessment of the effectiveness of tax support for innovative SMEs

The correlation matrix shown in Table 5 does not show a strong relationship (>0.6) between the variables. This means that there are no problems with the collinearity of variables.

Table 5

Correlation matrix of the variables described in the model

Variable	X_1	X_2	X_3	X_4	X_5	Y
X_1	1.00	–0.28	–0.24	–0.12	0.10	0.18
X_2	–0.28	1.00	0.02	0.36	0.27	0.26
X_3	–0.24	0.02	1.00	0.26	0.04	0.32
X_4	–0.12	0.36	0.26	1.00	0.27	0.15
X_5	0.10	0.27	0.04	0.27	1.00	0.50
Y	0.18	0.26	0.32	0.15	0.50	1.00

Note: X_1, Deferred income tax payment; X_2, Deferred payment of Value Added Tax; X_3, Deferral of social security and pension contributions; X_4, Deferral of local taxes; X_5, Tax incentives *Y*, Global Innovation Index.

Source: authors' own calculations.

To assess the importance of tax support tools for SME innovation activities used in the framework of anti-covid economic policy, we use a linear regression model. The basic model is as follows:

$$Y = \hat{a}_0 + \hat{a}_1 \cdot X_1 + \hat{a}_2 \cdot X_2 + \\ + \hat{a}_3 \cdot X_3 + \hat{a}_4 \cdot X_4 + \hat{a}_5 \cdot X_5. \quad (2)$$

Using the least squares method, we will estimate the value of the tools of tax support for innovation activities of SMEs used in the framework of anti-covid economic policy, which are presented in the form of coefficients X_1–X_5 for regression variables. The study was conducted in the Statistica program, starting with the basic form of the model, we consistently rejected the variables with the highest *P*-values. The results of the regression analysis are shown in Table 6.

Table 6

Regression results for the dependent variable Y

Variable	Dependant variable	
	Y	
	(1)	(2)
X_1	0.29	
	0.15	
X_2	0.26	
	0.15	
X_3	0.40***	0.29**
	0.15	0.14
X_4	–0.11	
	0.15	
X_5	0.41***	0.49***
	0.14	0.14
Observations	36	36
R_2	0.44	0.35
Adjusted R_2	0.35	0.3
F-statistic	4.7 (5.3)	8.51 (2.33)

Note: X_1, Deferred income tax payment; X_2, Deferred payment of Value Added Tax; X_3, Deferral of social security and pension contributions; X_4, Deferral of local taxes; X_5, Tax incentives *Y*, Global Innovation Index.

Source: authors' own calculations

During the analysis, negative values were obtained for deferred payment of local taxes (X_4), which indicates the opposite relationship. This may be due to the fact that in the case of the deferral of local taxes is used very rarely.

The largest values for X_3 – deferred social security and pension contributions – countries with a high level of innovative development use this tax incentive quite often; X_6 – tax benefits.

So, the model has the form:

$$Y = 0,29 \cdot X_3 + 0,49 \cdot X_5. \quad (3)$$

Regression analysis revealed that the use of tax incentives for innovative SMEs is a powerful public policy tool that provides not only solutions to private economic problems, but also increases the competitiveness of the national economy, which is important in times of crisis. The hypothesis about the effectiveness of applying tax incentives among other tax support tools is confirmed.

Tax incentives that contribute to technological progress are most relevant for taxpayers and for the implementation of state economic policy. The chosen innovative vector of economic development requires the mobilization and investment of significant financial resources in the national economy. Tax incentives can play a significant role in this case, as they increase the financial potential of investors by reducing payments to the budget and stimulate its use in the direction necessary for the state.

Let us consider the feasibility of using income tax incentives and social security and pension contributions incentives for the state and innovative small and medium-sized businesses. Since an innovative business is considered more profitable, this allows you to reduce the tax rate without losing budget revenues. Also, the amount of wages for innovative small and medium-sized businesses is higher, so it will be advisable to reduce the amount of social security and pension contributions in order to de-shadow high wages and stimulate the development of innovation activities.

The model for determining the preferential income tax rate is shown in Fig. 6.

At the entrance of the model, the "innovative SMEs" block is presented, which accumulates equity at the expense of saved profits as a result of receiving a tax incentive. Next, profit is generated by multiplying equity by profitability, from which budget revenues are subtracted (multiplying by the tax rate). The "budget" block is also presented as a storage of budget revenues.

The results of modeling the model at different levels of profitability are shown in Fig. 7.

A graphical representation of the relationship between tax revenues and the dynamics of the income tax rate at profitability levels from 0 to 100% shows that reducing the income tax rate is appropriate at high levels of profitability (90% and above) and the optimal value of the income tax rate is 10%, provided that the company leaves the saved profit from the provision of tax incentives for its development. Hypothesis 2 about the

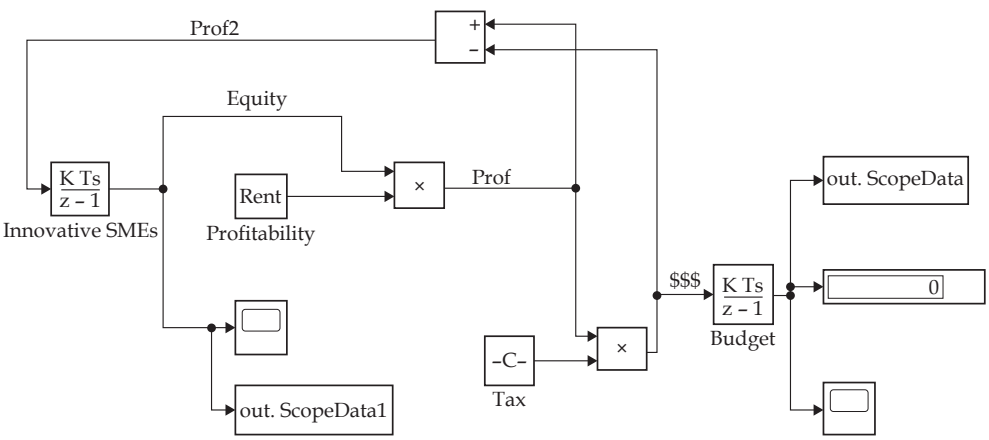

***Fig. 6.* Model for determining the preferential income tax rate**

Source: authors' own calculations

dependence of an enterprise's profitability on the effectiveness of a tax incentive is confirmed.

Regression model for calculating social security and pension contributions for innovative small and medium-sized businesses (Fig. 8).

The "Min_salary" block specifies the minimum wage, which will be increased by the value of the "Step" block. The "ESV" block is the existing social security and pension tax rate, which will decrease by the value of the "ESV1" block with each step of increasing wages.

The graph of the simulation model of tax revenues and wages shows that when using a regressive tax rate on social security and pension contributions, budget revenues continue to increase until the rate is reduced to 12% (Fig. 9).

Let us consider the model of the regression rate of the social security and pension contributions from 22% to 12%, with similar salary amounts (Fig. 10).

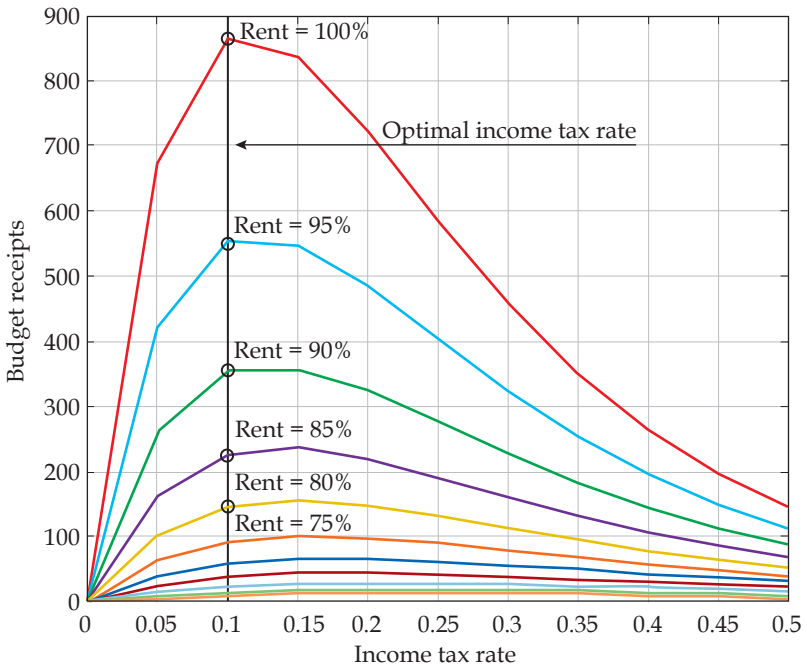

***Fig. 7.* Dependence of changes in budget revenues on the preferential income tax rate**

Source: authors' own calculations

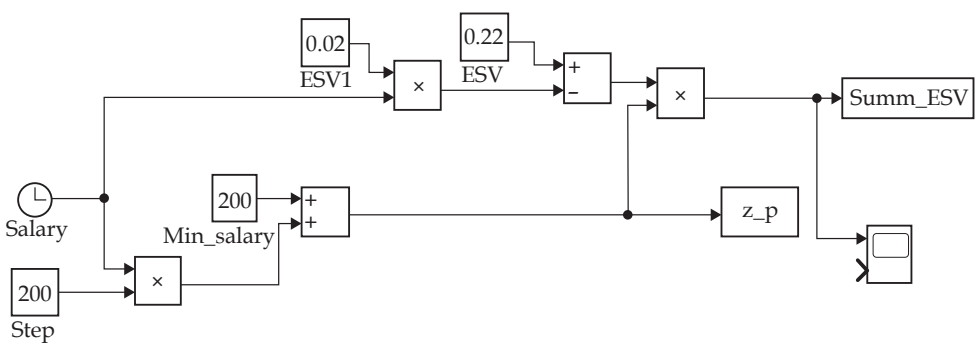

***Fig. 8.* Model for determining the preferential tax rate on social security and pension contributions**

Source: authors' own calculations

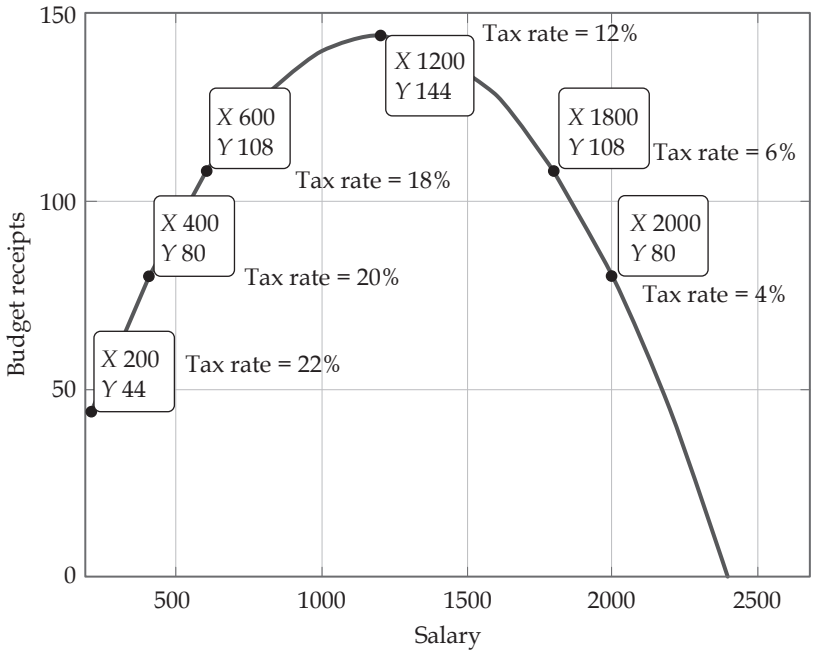

Fig. 9. **Dependence of changes in budget revenues on the preferential regressive tax rate on social security and pension contributions provision with a tax rate from 22% to 0%**

Source: authors' own calculations

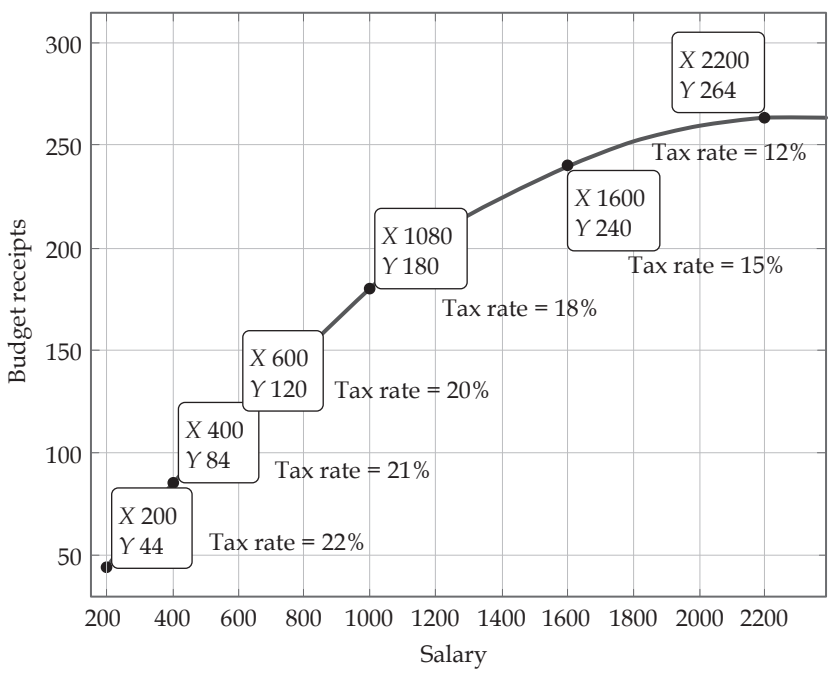

Fig. 10. **Dependence of changes in budget revenues on the preferential regressive tax rate on social security and pension contributions with a tax rate from 22% to 12%**

Source: authors' own calculations

For innovative SMEs, the minimum allowable reduction in the social security and pension contributions is up to 12%. It is at this value that budget revenues will increase. So, the minimum allowable social security and pension contributions rate for stimulating participants in innovation activities is determined by the salary level, which confirms hypothesis 3.

5. Conclusions

As part of the anti-covid economic policy, deferral of income tax, VAT, social insurance payments, rent payments/utility bills/local taxes is most widely used. In some cases, tax incentives or a moratorium on debt repayment are applied. The stage of the outbreak varies greatly from country to country, and political responses are very specific to the economic and social situation, respectively. The analysis showed that the issue of assessing the effectiveness of tax support for innovative small and medium-sized enterprises is insufficiently studied, and in the context of the COVID-19 pandemic, this issue is particularly relevant, because these enterprises are at high risk.

Analysis of the global practice of tax support for innovative small and medium-sized enterprises and the general innovation state of world countries in previous years confirmed hypothesis 1 – that the most effective tool for tax support is tax incentives. It was also found that the most popular tax to which a deferred or preferential rate is applied, income tax, is effective for innovative small and medium-sized enterprises with high profitability, which was reflected in the testing of hypothesis 2. As for the social security and pension contributions, the minimum allowable social security and pension contributions rate for stimulating innovation participants is determined by the salary level, which confirms hypothesis 3.

A limitation of the current study was that it focused on some countries using tax support for innovative small and medium-sized enterprises, and the expansion of the sample could significantly clarify the picture. The study did not use information about the financial condition of enterprises that received tax incentives.

Theoretical provisions have been brought to the level of practical recommendations for substantiating proposals for tax support for innovative activities of small and medium-sized enterprises.

Due to the COVID-19 pandemic, the global economy continues to suffer losses. Small and medium-sized businesses are particularly sensitive to changes in their operations. This requires further study of this topic, given the international experience of supporting innovative small and medium-sized enterprises and the rapidly changing economic conditions that continue to be caused by measures to counter COVID-19.

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Underground economy and GDP growth: Evidence from China's tax reforms

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ABSTRACT
Since 1991, China has implemented two significant tax reforms. The first reform, in 1994, was a large-scale adjustment of the tax distribution system between the central and local governments, and the second reform, in 2012, replaced business tax with value-added tax. Also, the size of China's underground economy decreased from 13.55% in 1995 to 12.30% in 2016. The paper presents an evaluation of the effect of the two tax reforms and the existing underground economy on GDP growth in China. GDP is defined as explained variable, the explanatory variables include: the ratio of declared income to actual income, the change of concealed income, and the influence of tax rate change on declared income and concealed income. According to the tax reform in 1994 and 2012, two dummy variables are set respectively. In methodology, this paper uses Simultaneous equations model, SUR-OLSs and Slutsky identity. Our estimation is based on the official statistics of China National Bureau of Statistics in the period from 1991 to 2019. In empirical analysis, we decomposed tax changes into tax rate effect (change of budget constraint slope) and income effect (change of tax liability), then analyzed the impact of tax elasticity on GDP growth. The empirical results demonstrate that both the 1994 tax reform and 2012 tax reform have had a positive impact on GDP, with high statistical significance respectively. The results also confirm that the increase of tax rate leads to the increase of hidden income, which eventually leads to the decrease of GDP. The offered methodology can also be applied to most countries for time series analyses.

KEYWORDS
underground economy; tax evasion; cash deposit ratio; elasticity of taxable income; currency demand; currency transaction

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Теневая экономика и рост ВВП: опыт налоговых реформ в Китае

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АННОТАЦИЯ
За период с 1991 г. в Китае были проведены две важные налоговые реформы. Первая реформа, проведенная в 1994 г. существенно изменила систему распределения налогов между центральным и местными уровнями власти. В ходе второй налоговой реформы, проведенной в 2012 г., налог на добавленную стоимость введен вместо налога на бизнес. В рассатриваемый период, размер тене-

вой экономики Китая сократился с 13,55% в 1995 г. до 12,30% в 2016 г. В данной статье представлена оценка влияния двух налоговых реформ и теневой экономики на рост ВВП в Китае. ВВП является зависимой переменной, к независимым переменным относятся: отношение декларированного дохода к фактическому доходу, изменение скрытого дохода, а также влияние изменения налоговой ставки на декларированный доход и скрытый доход. Налоговые реформы 1994 и 2012 гг. введены в модель как две фиктивные переменные. В качестве методологии исследования использованы модель одновременных уравнений, SUR-OLS и идентичность Слуцкого. Оценки основаны на официальной статистике Национального статистического бюро Китая за период с 1991 по 2019 г. В ходе эмпирического анализа была проведена декомпозиция влияния изменения налогов на эффект налоговой ставки (изменение наклона бюджетного ограничения) и эффект дохода (изменение налоговых обязательств), а затем было проанализировано влияние эластичности налога на рост ВВП. Эмпирические результаты с высокой статистической значимостью показали, что и налоговая реформа 1994 г., и налоговая реформа 2012 г. оказали положительное влияние на ВВП. Результаты исследования также подтверждают, что повышение налоговой ставки ведет к росту сокрытых доходов, что в конечном итоге приводит к снижению ВВП. Предложенная методология может также быть использована для анализа временных рядов в других странах.

КЛЮЧЕВЫЕ СЛОВА
теневая экономика; уклонение от уплаты налогов; коэффициент внесения наличных денег; эластичность налогооблагаемого дохода; спрос на валюту; валютная операция

1. Introduction

Tax system provides many incentives for people to change their taxation behavior, which means that people may decide not to declare part or all of their income and evade some taxes. However, the avoidance fees can be actual resource costs (e.g., requiring lawyers or accountants to help people evade taxes or open Swiss bank accounts to cover up income). Moreover, it may be that tax evaders know that they may go to prison and lead to the reduction of personal utility, or the tax evaders may be morally condemned because they know that they have not complied with the legal obligations, resulting in the reduction of personal utility. The research from Mirus and Smith [1] define the underground economy as unreported rental incomes, skimming by owners of businesses, barter activities, off-the-books employment, and unreported income from home-produced goods. Indeed, it is difficult to accurately measure the size of the underground economy, because the conspiracy of tax evaders is not easily detected. For example, Kolm and Nielsen [2] find that employers and employees may agree to underreport business income in exchange for employees paying less personal income tax (PIT).

Nevertheless, a survey from Buehn and Schneider [3] estimate that the proportion of South Korea's underground economy in GDP decreased from 28.3% in 1999 to 24.7% in 2010, which is related to the rapid growth of e-payment in South Korea during the past 20 years, resulting in the slowdown of underground economy. A research from Dreher and Schneider [4] point out that in low-income countries, the efficiency of public goods provided by the government is lower than that in high-income countries, which is one of the reasons that drives individuals or manufacturers to engage in underground economic activities. Considering that literature on China's underground economic assessment, Schneider [5] shows that China's underground economy accounted for 13.1, 14.4 and 15.6% of GDP in 1999, 2001 and 2002, respectively. Medina and Schneider [6] demonstrate that over the period 1991–2015, China's shadow economy accounts for a minimum of 8.3 and a maximum of 14.1 of GDP. Besides that, Chen et al. [7] use the MIMIC method for measuring the size of China's

underground economy from 1995 to 2016, revealing the average size of the UE increased from 13.55% in 1995 to 14.39% in 2009, and then fell to 12.30% in 2016.

2. Background

The reform of China's tax sharing system in 1994 was initiated by the Chinese government in 1992 and finally implemented in 1994. As one can see, before China's fiscal and tax reform in 1994, the central government discussed with local governments over the share of locally collected taxes that would be paid into the central budget. This reform is a large-scale adjustment of tax distribution system and tax structure between central and local governments. The main purpose of tax sharing reform is to reduce China's budget deficit since the end of 1980s. Therefore, tax sharing reform is regarded as the key tax reform. On the other hand, since 2012, Shanghai has carried out pilot projects to replace business tax with value-added tax, including transportation industry and some modern service industries. Furthermore, By 2016, China has fully implemented value-added tax (VAT) instead of business tax.

In order to evaluate the impact of these two key tax reforms on economic growth, this paper takes these two tax reforms into the model as dummy variables.

The rest of this paper is arranged as follows. Section 2 briefly reviews the relevant theoretical and empirical literature. Section 3, we demonstrate the research design and methodology. This paper reports the construction of SUR-OLS regression diagnosis using ETI and Slutsky equation. In Section 4 and section 5, we check the key parameters of the model by SUR-OLS regression, which provides a explicit explanation for our findings. A brief conclusion is discussed in Section 6.

3. Review of literature

3.1. Theoretical literature review

In the 1950s, Lewis [8], Kaldor [9] and Cagan [10] mark the beginnings of preliminary research into hidden economic activities. Since then, more and more literatures have focused on the analyses between undeclared income and tax erosion. Considering the formal economic theory of tax evasion can be traced back to Allingham & Sandmo [11]. It is worth noting that Gutmann [12] proposes that recessive economy is not included in the calculation of the gross national product, he adopts the ratio of money and deposit to estimate the underground economy of the United States and illustrates currency and demand deposits as the core indicators of changes in the size of the underground economy (see also Bodemann et al. [13]).

In this paper, we first review some theories about the tax elasticity and underground economy. According to the quantitative theory of money, Feige [14] demonstrates that the relationship between the volume of transactions and official GDP is constant over time, he uses the value of total transactions as an estimate of nominal GNP and measures the informal economy as the difference between nominal GNP and the official GNP, proving that reducing income tax elasticity means that with the growth of GDP, income will not be converted into the expected tax base. In addition, Hutton & Lambert [15] derived tax elasticity and applied it to UK data to replace existing estimation techniques. In their view, in addition to the total tax data, all that needs to be done is to classify taxpayers according to the highest marginal tax rate. Obviously, compared with other methods is advantage is that it does not need to collect real information about personal income. In terms of the theory or concept between underground economy and economic growth, Adam & Ginsburgh [16] pointed out that the relationship between the growth of underground economy and the official economy is positive.

In addition, La Porta & Shleifer [17] claim that economic growth mainly comes from the contribution of efficient legal enterprises above the ground, rather than from the inefficient private enterprises underground. However, Schneider & Enste [18] show that two thirds of the income from underground economic activities will eventually flow into the official eco-

nomic sector through consumption and investment, which will have a positive impact on the official economy.

While research into the elasticity of taxable income (ETI), which measures the responsiveness of reported taxable income to changes in tax rates, dates back to at least Lindsey [19]. The ETI can capture this wide array of behavioral responses and can then be used to calculate both the efficiency and revenue implications from a change in tax rates. The intuition behind the standard ETI model is that individuals increase taxable wages until its marginal cost equals the tax rate (Feldstein [20]). Brewer et al. [21] define ETI as "percentage change in taxable income" relative to "percentage change in net income" (Carroll & Hrung [22]). Similarly, Saez et al. [23] emphasized the fact that ETI is not a constant parameter, but will be affected by government policies. In other words, since the parameters of these models are not structural, that is, they are not invariable policies, they will inevitably change whenever policies change. Therefore, adhering to the policy conclusions of these models may lead to deviation. Apparent-ly, in a more general model, Laffer [24] concerns that changes in tax rates have two effects on income, including the arithmetic and economic effects. The arithmetic effect is that if the government reduces the tax rate, tax revenues will be lowered by the amount of the decrease in the rate. Conversely, the economic effect involves the impact of lower tax rates on employment and investment, so as to stimulate people to increase these activities. Therefore, the combined effects of economic and arithmetic effects of tax rate changes lead to the uncertainty of the impact of tax rate changes on total tax.

3.2. Empirical literature review

The primary methodological objective in the empirical literature is to devise a method for separating the response of taxable income to changes in tax rates from responses to the many other factors that also affect taxable income. Especially referring to the elasticity of taxable income (ETI) takes place in a changing economic environment, and the changes to that environment affect income growth. Therefore, adequately controlling for those non-tax-induced trends in taxable income poses a major challenge to estimating elasticities. Feldstein [25] uses panel data to assess taxpayers' behavioral response to the 1986 US income tax reform. He estimates that the ETI is large, ranging from 1–3. After Feldstein [20; 25], the literature on ETI has increased greatly. Many subsequent researches focus on improving the elasticity estimation by paying more attention to the net-of-tax rate instrument and non-tax-related changes in the income distribution. It is worth noting that along with these modifications, the ETI estimates decreased markedly compared with those in Feldstein [25]. Research conducted by Gruber & Saez [26] report an ETI of 0.2 for middle-income earners and 0.6 for high-income earners in the US.

On the other side, Blomquist & Selin [27] estimate an ETI of around 0.20 for males and 1 for females in Sweden, this study focuses directly on the response of hourly wage rate to the change of marginal tax rate, however the model can not distinguish effort response from the change of compensation form, that is, how to distinguish the transformation of fringe benefits into full cash payment. Study by Matikka [28] shows that the average the elasticity of taxable income (ETI) estimate in Finland is 0.35–0.60. Earlier literature has shown that the income impact is either insignificant or small (see Saez, Slemrod & Giertz [23]). Hence, Matikka [28] assumes that income impact is not considered, but it is not easy to observe the income response to tax rate changes. Likewise the research results from Thoresen & Vattø (2015) [29] demonstrate elasticities below 0.1 for Norway. It is worth noting that Creedy (2009) [30] considers there is no reason to expect the elasticity to remain unchanged over time, or to be similar across countries having different tax structures and regulations (see also Giertz [31]).

Further, Creedy & Gemmell [32] provide estimates of individual and aggregate revenue elasticities of income and consumption taxes in the UK over the period 1989–2000. They find income tax revenue

elasticity estimates, of around 1.3 to 1.4 in the early 1990s, are lower than middle 1980s, reflecting in part flattening of the income tax structure since the time, which reveals that discretionary tax changes have considerably reduced tax revenues. Other countries, Pirttila & Uusitalo [33] measure the ETI in Finland, their tentative analysis shows that the average ETI is around 0.3. Mattos & Terra [34] estimate ETI in Brazil, which were derived through the use of pooled cross-sectional data with the difference-in-differences approach, the result declares cash transfers seem to have a negative association with reported income elasticity close to −0.05, suggesting that leisure and cash transfers are complements, whereas in-kind transfers have a positive association elasticity coefficient close to 0.05, illustrating that they serve as leisure substitutes, the study found that physical (cash) transfer is positively correlated (negatively correlated) with the "declared taxable income". However, for most countries, it is not easy to obtain the complete and accurate time series data of the above two items.

4. Research Design

4.1. Methodology

As mentioned earlier in the above sections, our research is arranged and follows the processes in associative quantitative research, starting from the determination of research topics, discussing historical background, conducting literature reviews, putting forward theoretical model to formulate several testable propositions. Furthermore, we define research variab-les and explain the source of empirical data on the underground economy (UE), elasticity of taxable income (ETI) and tax system issue in China since 1991 to discuss about their impact on GDP growth. Finally, we implement empirical testing and draw conclusions based on the results of the empirical analysis.

Referring to the important literature on underground economy and tax base erosion in recent years. Different from the analysis of the existing literature, this article uses the following methods to investigate the impact of shadow economy on GDP in current social science research. We uses Simultaneous equations model, Slutsky identity and SUR-OLS approach (see Zellner [35]; Griffiths et al. [36]) to directly derive income compensation elasticity coefficient and income effect coefficient. In general, the SUR-OLS estimates are consistently better than the OLS (equation-by-equation) estimates, since the SUR-OLS method estimates the parameters of all equations simultaneously, so that the parameters of each single equation also take the information provided by the other equations into account. This results in greater efficiency of the parameter estimates (Cadavez & Henningsen [37]).

Also, the SUR-OLS estimator takes the correlation between the error terms into account, therefore, SUR-OLS is a robust methodology for predicting. As is well known, although China's inland provinces have convenient transportation links. Taxpayers are in the same environment of tax laws and regulations. Therefore, it has the heterogeneity of variance, and the residual has the characteristics of contemporaneous correlation. In view of this, in order to reduce the standard error, this paper uses "seemingly unrelated regression" (SUR-OLS) to test and analyze.

Also, Slutsky equation has two parts: substitution effect and income effect. Generally, the substitution effect is negative. A merit of this approach used here is that the elastic estimation can be calculated directly from our model. In addition, in order to measure the size of China's underground economy. In this paper, we use the cash deposit ratio (CDR) hypothesis, currency demand (CD) hypothesis and currency transaction (CT) hypothesis.

Without loss of generality , in this paper, our research is designed and follows the processes in associative quantitative research, starting from determining problems, formulating objectives, conducting literature reviews, both theoretical and empirical approach, formulating research hypotheses, define research variables, determine data collection methods, implement empirical testing and draw conclusions based on the results of the empirical analysis.

As is well known, simultaneous equations models are a type of statistical model in which the dependent variables are functions of other dependent variables, rather than just independent variables (Martin et al. [38]), which means that some of the explanatory variables are jointly determined with the dependent variable. In economic society, this is usually the result of some potential equilibrium mechanism.

Nevertheless, simultaneity poses challenges for the estimation of the statistical parameters of interest, because the Gauss–Markov assumption of strict exogeneity of the regressors is violated, whilst it would be natural to estimate all simultaneous equations at once, this often leads to a computationally costly non-linear optimization problem even for the simplest system of linear equations (Quandt [39]). As is well known , Use of SEM is commonly justified in the social sciences because of its ability to impute relationships between unobserved constructs and observable variables (Hancock [40]). SEM invokes a measurement model that defines latent variables using one or more observed variables, the links between constructs of a structural equation model can be estimated with independent regression equations(see Kaplan [41]). That is, SEM involves sequential decision-making under uncertainty or strategic environments where beliefs about other agents' actions matter.

According to the literature review of taxable income elasticity (ETI) theory, whether from an efficiency or tax perspective, taxable income elasticity (ETI) is a key parameter in revenue analysis. Moreover, in recent years, the extended version of the ETI- the behavioral elasticity of taxable revenue (BETR) has taken over the field of public economics and be used to analyze the tax base and tax administrative and compliance choices, Hemel & Weisbach [42] demonstrates the government has to pay for audit fees, which reduces resources. Finally, the government may recover tax evasion from the audit-the mechanical revenue effect, on the whole, they are just transfers and do not affect the total resources.

However, how the above important variables play an important role in the decision-making of tax evaders is worth studying. In this article, we seek to establish the framework of the research concept and show the resulting measure – the joint elasticity of taxable revenue (JETR) to capture the change in GDP caused by any marginal change in tax rates, the tax base, and tax enforcement. Following the previous literature, Gruber & Saez [26] shows there are two sources of difference here, the first is mechanical; broad income has a larger base, so that a given dollar response will result in a smaller 10 elasticity, the second is behavioral; taxable income includes itemized deductions, which might respond to changes in taxes. Following the same discussion, Doerrenberg et al. [43] exploit several tax reforms that were implemented in Germany between 2001 and 2008, the estimates show that the total ETI is between 0.54 and 0.68, and the total income elasticity (EGI) is between 0.16 and 0.28. They believe that the difference between ETI and EGI is caused by the change of tax rate caused by the deduction amount. Since the deduction amount of China's official statistics is not available for the time being, this paper will not discuss the impact of the deduction on economic growth.

4.2. Model

Before proceeding further, regarding the effects that underground economic activity has on tax base erosion and the maximization of individual utility. We start by performing a simplicial model assuming that the representative taxpayer with a linear utility function of the following properties for above ground economy income y_g and underground economy income y_u, the total real income $\Sigma y = y_g + y_u$. As is known, linear utilities functions are a small subset of quasilinear utility functions, where above ground economy income and underground economy income with linear utilities are a special case of substitute goods, in which the preferences are strictly monotone and weakly convex, and the marginal rate of substitution of y_g and y_u is constant. In this section, our models accord with the ap-

proach of random utility maximization models (RUM) and additive in income. In the other words, the systematic utility is fixed and the individual choices are static (see McFadden [44]).

$$U(y_g, y_u) = \ln y_g^a + \ln y_u^b; \quad (1)$$

$$U_{y_g y_g} = \frac{a(a-1)(y_g^a + y_u^b)y_g^{a-2} - a^2 y_g^{2a-2}}{(y_g^a + y_u^b)^2} < 0; \quad (2)$$

$$U_{y_u y_u} = \frac{b(b-1)(y_g^a + y_u^b)y_u^{b-2} - b^2 y_u^{2b-2}}{(y_g^a + y_u^b)^2} < 0; \quad (3)$$

$$U_{y_g y_u} = \frac{-ab(y_g^{a-1})y_u^{b-1}}{(y_g^a + y_u^b)^2}; \quad (4)$$

$$\Delta = \det(A) = \begin{bmatrix} U_{y_g y_g} & U_{y_g y_u} \\ U_{y_u y_g} & U_{y_u y_u} \end{bmatrix} > 0.$$

In the above formula, a represents the coefficient value of the ratio of "above ground income" to "actual income" of the representative taxpayers, b is the coefficient value of the ratio of "underground income" to "actual income" of the representative taxpayers, and $0 < a$, $0 < b$, y_g^a denotes the representative taxpayer's above ground income, and y_u^b denotes the representative taxpayer's underground income. Clearly,it can be seen from the above formula, if the determinant $det(A)$ is positive, it means that there exists an extreme value, where $U_{y_g y_g} < 0$, which denotes that there exists a relative maximum. Moreover, $U_{y_u y_u} < 0$, ensuring the consistency of concavity. Eq.(4) shows that $U_{y_g y_u} < 0$. In essence, tax evaders should transfer a dollar from ground economy y_g to underground economy y_u at an concealed cost H, only so long as

$$\frac{\partial U / \partial y_u}{\partial U / \partial y_g} > \frac{1}{(1-H)}. \quad (5)$$

4.3. An application: decomposing the composition effects

Next we exploit Gutmann_UE [12] approach combined with National Bureau of Statistics of China and China Statistical Yearbook to check the changes of China's underground economy over the period 1991–2019. The CDR method of Gutmann [12] implies that: (1) all the UE activities are completed in the form of cash transactions; (2) the ratio of cash to deposits demand held in the above-ground economic activities at any time should be the same as the base period; (3) the velocity of money circulation of the above ground economy is the same as that of the underground economy.

However, Pickhardt & Sardà [45] thinks that the ratio of cash to deposits demand cannot be fixed in the long term, so two hypotheses are added to Gutmann's original hypothesis: (1) in the above ground economic activities, the currency held by the people remains unchanged; (2) the economic activities of all additional legal transactions are completed through demand deposits.

In contrast with Pickhardt & Sardà [45], Gutmann [12] thinks that cash may also be used in the above ground economic transactions. Based on the above viewpoints, this paper estimates the ratio of China's "underground economy" to "above ground economy" based on 2017, the reason for choosing 2017 as the base period include:

1) as we calculate the size of China's underground economy from 1991 to 2019, the ratio of "cash transaction" to "deposit currency" is the lowest in 2017, which is 0.1493. As is known,bank deposit include: (a) deposits demand, (b) fixed deposits, (c) savings deposits, (d) other deposits.

2) according to the data of China National Bureau of Statistics, China's cash account in 2017 is 7,064 billion yuan, M1 is 54,379 billion yuan, the tax-free cash account is 7,175 billion yuan. The cash circulated in the underground activity is 110 billion yuan, M1 deducted the cash circulated in the underground activity is 54,268 billion yuan, demonstrating the amount of cash required by the formal market. The ratio of "cash circulated in the underground market" to "cash circulated in ground market" is 0.00203, which is lowest during the period of 1991–2019.

Based on the results of data analysis, we show the ratio of "underground economic income" to "above ground economic income" is 0.27 for China in 1991,

and that ratio in 2019 is 0.004. In comparing with the changing trend of the ratio of "underground economic income" to "above ground economic income" in 1991 and 2019, we show that China's underground economy has ameliorated significantly during the past 20 years (see also Schneider et al. [46]; Elgin & Öztunali [47]). Note that ETI is a measure of how taxable income changes when we make a change to the tax system, that statistic, moreover, can be summarized by a single "sufficient" statistic: the elasticity of ta-xable income. (see Feldstein, 1995 [25]). As is well known, in a progressive income tax rate schedule, the marginal tax rate increases as taxable income increases. Hence, a change in taxable income endo-genously defines the change in the net-of-tax rate, and thus a valid instrumental variable for $(1 - m)$ is required (Saez et al. [23], Matikka [28]).

Considering the joint role of the elasticity of taxable income (the effect on taxable income of a tax rise) and the revenue elasticity (the effect on revenue of a change in taxable income) in influencing the revenue effects of tax rate changes and GDP. In Eq. (7), we illustrate the correlation between aggregate income, the elasticity of taxable income and the revenue elasticity as follows:

$$dY = \frac{-\partial Z}{\partial(1-m)}dm + \frac{\partial Y}{\partial R}dR - \frac{\partial H}{\partial R}dR;$$

$$\xi^u = \frac{(1-m)}{z}\frac{\partial Z}{\partial(1-m)}; \qquad (6)$$

$$\eta = (1-m)\frac{\partial Y}{\partial R}.$$

In this case, we further describe this expression as follows:

$$dY = -\left[\frac{(1-m)}{Z}\frac{\partial Z}{\partial(1-m)}\right]\frac{Zdm}{(1-m)} + \\ + \eta\frac{\partial R}{(1-m)} - \left[\frac{\partial H}{\partial R}dR\right]. \qquad (7)$$

Using the Slutsky compensation equation approach, we get

$$\xi^c = \xi^u - \eta;$$

$$\xi^c = \left[\frac{(1-m)}{Z}\right]\frac{\partial Z}{\partial(1-m)}\bigg|_u. \qquad (8)$$

Hence, we have

$$\frac{dY}{Y} = -\left[\frac{(1-m)}{Z}\frac{\partial Z}{\partial(1-m)}\right]\frac{Zdm}{Y(1-m)} + \\ + \frac{\partial Y}{\partial R}(1-m)\left(\frac{dR - Zdm}{(1-m)Y}\right) - \frac{H'}{Y}dR \qquad (9)$$

which can be rewritten as

$$\frac{dY}{Y} = -\xi^c\frac{dm}{(1-m)}\frac{Z}{Y} + \\ + \eta\left(\frac{dR - Zdm}{(1-m)Y}\right) - \frac{H'(1-m)}{(1-m)Y}dR.$$

Further, Eq. (9) can be further simplified as

$$\frac{dY}{Y} = -\xi^c\frac{dm}{(1-m)}\sigma + \\ + \frac{\eta dR - \eta Zdm \rfloor H'(1-m)dR}{(1-m)Y}, \qquad (10)$$

where Y denotes the aggregate income, Z is the declared income, R is the concealed income, ξ^c and ξ^u are the compensated and uncompensated elasticity of income relative to the net-of-tax rate $(1 - m)$, respectively, the income effect parameter η represents the change in after-tax GDP caused by the change in hidden income, $(dR - Zdm)$ is the change in after-tax income due to the tax change for a given before declared income Z, which means that delinquent taxpayers may not honestly declare the whole amounts of their evaded tax. Let taxpayer's declared income be taxed at the marginal tax rate m. Thus, it can be expressed as (some example see Cebula & Feige [48])

$$Z_t = \left(1 - \frac{Y_t^U}{Y_t^g}\right)Y_t = \frac{M1_t}{M1_t - \Delta C_t}GDP_t;$$

$$R_t = \left(\frac{Y_t^U}{Y_t^g}\right)Y_t = \frac{\Delta C_t}{M1_t - \Delta C_t}GDP_t; \qquad (11)$$

$$\Delta R_t = \left(\frac{Y_t^U}{Y_t^g}\right)Y_t - \left(\frac{Y_{t-1}^U}{Y_{t-1}^g}\right)Y_{t-1}.$$

The biggest discrepancy between this paper and the current literature is that the coefficient ξ^c and coefficient η can be derived through SUR-OLS regression directly, where ξ^c denotes the compensated elasticity of taxable income coefficient, η is

the income effects coefficient. Considering the costs of evasion are real resource costs and not just transfers (Chetty [49]; Balafoutas et al. [50]), variable H represents the hidden cost of tax evasion, H'/Y is the marginal cost of "hidden cost", m_t is the average income tax rate applicable to the taxpayers (some example see Wang et al. [51]). Using the compensated elasticity of taxable income

$$\xi^c = \left[\frac{(1-m)}{Z}\right]\frac{\partial Z}{\partial(1-m)}\bigg|_u$$

and the income effect parameter

$$\eta = (1-m)\frac{\partial Y}{\partial R}.$$

Change in

$$\frac{dm}{(1-m)}\frac{Z}{Y}, \quad \frac{dR - Zdm}{(1-m)Y}$$

and R affect aggregate income as follows,

$$\frac{dY}{Y} = -\xi^c \frac{dm}{(1-m)}\frac{Z}{Y} + \\ +\eta\left(\frac{dR - Zdm}{(1-m)Y}\right) - \frac{H'}{Y}dR + \varepsilon_t. \quad (12)$$

Furthermore, Eq. (12) can be analyzed as follows:

(a) Suppose the hidden cost of tax evasion for the tax evaders is ignored, which means the hidden cost is 0, thus we have

$$\frac{dY}{Y} = -\xi^c \frac{dm}{(1-m)}\frac{Z}{Y} + \eta\left(\frac{dR - Zdm}{(1-m)Y}\right) + \varepsilon_t; \quad (13)$$

(b) Consider the tax evaders' s hidden cost is greater than zero, thus we have

$$\frac{dY}{Y} = -\xi^c \frac{dm}{(1-m)}\frac{Z}{Y} + \\ +\eta\left(\frac{dR - Zdm}{(1-m)Y}\right) - \frac{H'}{Y}dR + \varepsilon_t. \quad (14)$$

In fact, concerning the change of tax policy is likely to affect the income elasticity of income tax (see Creedy & Gemmell [32]), for example, Singer [52] uses dummy variables in estimating the income elasticity of state income-tax revenues. In this paper, we take the impact of two dummy variables D_{1994}, D_{2012_t} into consideration, where D_{1994} is dummy variable that equals 1 after 1994, denoting the reform of China's tax sharing system, and D_{2012} is dummy variable that equals 1 after 2012, depicting the implementation of replacing business tax with value-added tax since 2012. However, as is known, because the regression analysis of more than two dummy variables are inclined to appear "dummy variable trap" and linear combination of dummy variables, the intercept term of one dummy variable can be omitted to avoid singular phenomenon (Kennedy [53]). So that Eq. (13) is represented as follows:

$$\frac{dY}{Y} = -\xi^c \frac{dm}{(1-m)}\frac{Z}{Y} + \eta\left(\frac{dR - Zdm}{(1-m)Y}\right) - \\ -\frac{H'}{Y}dR + \beta_4 D_{1994} + \beta_5 D_{2012} + \varepsilon_t, \quad (15)$$

where $\varepsilon_t = \varphi_1\varepsilon_{t-1} + \varphi_2\varepsilon_{t-2} + \sigma_t$.

As shown in Eq. (15), instead of calculating ETI directly, Eq. (15) obtains an average elasticity through regressions explicitly.

Obviously, in comparing with exis-ting relevant literature on underground economy, our result has the advantage of allowing simple tests of significance of the estimated average elasticities as well as the option of including relative explanatory variables. On the other hand, it has the advantage of being applicable to countries and applications in time series analysis. In this section, we demonstrate, at the aggregate income level, how the revenue elasticity and the elasticity of taxable income are combined to generate the elasticity of tax with respect to the marginal rate. Furthermore, considering the joint role of the elasticity of taxable income (the effect on taxable income of a tax rise) and the revenue elasticity (the effect on revenue of a change in taxable income) in influencing the aggregate income and revenue effects of tax rate changes. Clearly, an appealing feature of this article is that, in the traditional literature, when calculating the value of the two coefficients, ξ^c and η, the statistical data must be brought into ξ^c and η to seize the results. However, instead of calculating, in this paper, we use the SUR-OLS regression approach and Slutsky identity directly obtain the coefficient values of the time serial composite structures model. Namely, this is the main discrepancy between our article and current relative literature.

5. Empirical Research results

5.1. Methodology

As is well known, there are a number of ways to measure aggregate income, but GDP is one of the best known and most widely used.To explore the impact of China's underground economy and tax arrears on GDP, our estimates are from official statistics complied annually by China National Bureau of Statistics since 1991. It is well known, the basic hypothesis, intercept term, regression coefficient and error term of the model will vary with various assumptions In this paper, we assume that all independent variable coefficients (including intercept and slope) are different due to different tax rates and tax policies, but the error term dependent. Although traditional regression analysis assumes that the residual items are independent of each other, in fact it may be dependent. In fact, the overall environment faced by taxpayers in all regions of China is roughly the same. Except for various explanatory variables, other factors not included in the regression model may have the same impact on taxpayers in all regions.

Therefore, in this case, seemingly unrelated regression (SUR-OLS) can be used for analysis (see Zellner [35], Griffiths et al. [36]). As mentioned above, even though China has a vast territory, but the transportation in China is very convenient. Taxpayers are in the same environment of tax laws and regulations, which affects the environment of taxpayers' income declaration and tax arrears. Therefore, the residual items are not independent but related. In view of this, in order to reduce the standard error, this paper uses "seemingly unrelated regression" (SUR-OLS) to test and analyze . In order to explore the influence of underground economy and tax rate on GDP growth, firstly, GDP is defined as "explained variable". The explanatory variables include: the ratio of declared income to actual income, the change of concealed income, and the influence of tax rate change on declared income and concealed income. According to the tax reform in 1994 and 2012, two dummy variables are set respectively.

5.2. Unit Root Test

Next we use Simultaneous equations model and SUR-OLS approach to exploit China as a case study, using the cointegration approach among the GDP, variables Z, R, m for China over a time period ranging from 1991 to 2019, determining whether the stochastic component contains a unit root or not.

The results of unit root tests are presented in Table 1, which demonstrates that all the variables appeared stationary at the first – differenced form under 5% significant level, depicting the logged variables are I(1). We next utilize the SUR-OLS regression method evaluating the residual term and estimate whether the residual term conforms to no sequence autocorrelation.

Owing to the Q-statistic proposed by Box and Pierce (1970) is rather weak in large samples, Ljung-Box [54] proposes another modified Q-statistic suitable for small samples. However, Box & Jenkins [55] consider that it is necessary to diagnose whether the parameters have overfitting and also confirm whether the residuals have serial correlation. Below, the results of Ljung-Box Q test are shown in Figure 1, which reveals the probability values of Q-statistics from the first period

Table 1

Performance of unit root test 1991–2019

Variable	*N*-st difference	(*C*, *T*, *K*)	*DW*	*ADF*	5%	1%	Result
Y	1	(*C*, *n*, 8)	1.54	–4.04	–3.67	–4.53	*I*(1)**
Z	1	(*C*, *n*, 6)	2.04	–4.22	–3.61	–4.39	*I*(1)**
R	1	(*C*, *n*, 5)	1.83	–6.05	–3.67	–4.53	*I*(1)***
m	1	(*C*, *n*, 1)	1.87	–5.20	–3.59	–4.35	*I*(1)***

Note: (*C*, *T*, *K*) indicates whether the test formula contains constant term, time trend and number of lag periods using AIC. Standard errors in parentheses: *** means the first-order difference passes the stability test at 1% significance level, ** means the first-order difference passes the stability test at 5% significance level.

Sample: 1991 2019
Included observations: 13
Q-statistic probabilities adjusted for 2 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Prob...
		1	0.333	0.333	1.7991	0.180
		2	-0.03...	-0.16...	1.8188	0.403
		3	-0.22...	-0.18...	2.8223	0.420
		4	-0.22...	-0.10...	3.9421	0.414
		5	-0.30...	-0.26...	6.2272	0.285
		6	-0.10...	0.016	6.5058	0.369
		7	-0.10...	-0.22...	6.8637	0.443
		8	-0.14...	-0.26...	7.7184	0.461
		9	0.011	-0.00...	7.7245	0.562
		1...	0.200	-0.00...	10.316	0.413
		1...	0.150	-0.08...	12.516	0.326
		1...	0.170	0.056	18.182	0.110

*Probabilities may not be valid for this equation specification.

(a)

Sample: 1991 2019
Included observations: 13
Q-statistic probabilities adjusted for 2 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Prob...
		1	-0.01...	-0.01...	0.0021	0.964
		2	0.137	0.137	0.3371	0.845
		3	-0.17...	-0.17...	0.9133	0.822
		4	0.117	0.104	1.2117	0.876
		5	-0.49...	-0.47...	7.0829	0.215
		6	0.068	0.084	7.2105	0.302
		7	-0.24...	-0.19...	9.1393	0.243
		8	-0.05...	-0.23...	9.2474	0.322
		9	-0.09...	0.101	9.6793	0.377
		1...	0.220	-0.13...	12.835	0.233
		1...	-0.13...	-0.10...	14.518	0.206
		1...	0.105	-0.06...	16.670	0.162

*Probabilities may not be valid for this equation specification.

(b)

Sample: 1991 2019
Included observations: 13
Q-statistic probabilities adjusted for 2 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Prob...
		1	0.352	0.352	2.0159	0.156
		2	0.005	-0.13...	2.0165	0.365
		3	-0.26...	-0.25...	3.3550	0.340
		4	-0.28...	-0.12...	5.1293	0.274
		5	-0.29...	-0.20...	7.2114	0.205
		6	-0.12...	-0.05...	7.6394	0.266
		7	-0.04...	-0.11...	7.6966	0.360
		8	-0.10...	-0.28...	8.1331	0.421
		9	-0.03...	-0.10...	8.1929	0.515
		1...	0.244	0.195	12.075	0.280
		1...	0.119	-0.22...	13.453	0.265
		1...	0.180	0.109	19.763	0.072

*Probabilities may not be valid for this equation specification.

(c)

Sample: 1991 2019
Included observations: 13
Q-statistic probabilities adjusted for 2 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Prob...
		1	-0.06...	-0.06...	0.0621	0.803
		2	0.163	0.160	0.5320	0.766
		3	-0.22...	-0.21...	1.5462	0.672
		4	0.153	0.120	2.0531	0.726
		5	-0.45...	-0.42...	7.0782	0.215
		6	0.058	-0.00...	7.1709	0.305
		7	-0.25...	-0.15...	9.2708	0.234
		8	-0.06...	-0.31...	9.4391	0.307
		9	-0.07...	0.097	9.7313	0.373
		1...	0.315	0.073	16.172	0.095
		1...	-0.08...	-0.15...	16.888	0.111
		1...	0.101	-0.01...	18.870	0.092

*Probabilities may not be valid for this equation specification.

(d)

Sample: 1991 2019
Included observations: 13
Q-statistic probabilities adjusted for 2 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Prob...
		1	0.376	0.376	2.3016	0.129
		2	-0.01...	-0.18...	2.3074	0.315
		3	-0.27...	-0.23...	3.7509	0.290
		4	-0.29...	-0.12...	5.6220	0.229
		5	-0.22...	-0.12...	6.8719	0.230
		6	-0.13...	-0.12...	7.3727	0.288
		7	-0.02...	-0.07...	7.3939	0.389
		8	-0.08...	-0.23...	7.6600	0.467
		9	-0.01...	-0.05...	7.6664	0.568
		1...	0.178	0.120	9.7144	0.466
		1...	0.099	-0.17...	10.675	0.471
		1...	0.149	0.107	14.979	0.243

*Probabilities may not be valid for this equation specification.

(e)

Sample: 1991 2019
Included observations: 13
Q-statistic probabilities adjusted for 2 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Prob...
		1	-0.17...	-0.17...	0.4922	0.483
		2	0.200	0.175	1.2005	0.549
		3	-0.31...	-0.26...	3.0738	0.380
		4	0.129	0.028	3.4317	0.488
		5	-0.31...	-0.23...	5.8501	0.321
		6	0.011	-0.16...	5.8534	0.440
		7	-0.19...	-0.13...	7.0476	0.424
		8	-0.05...	-0.28...	7.1468	0.521
		9	-0.03...	-0.10...	7.2103	0.615
		1...	0.355	0.269	15.421	0.117
		1...	0.014	-0.02...	15.441	0.163
		1...	0.072	-0.08...	16.459	0.171

*Probabilities may not be valid for this equation specification.

(f)

Sample: 1991 2019
Included observations: 13
Q-statistic probabilities adjusted for 2 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Prob...
		1	0.098	0.098	0.1549	0.694
		2	-0.01...	-0.02...	0.1571	0.924
		3	-0.15...	-0.15...	0.6338	0.889
		4	-0.03...	-0.00...	0.6600	0.956
		5	-0.23...	-0.24...	2.0017	0.849
		6	-0.16...	-0.15...	2.7355	0.841
		7	-0.15...	-0.16...	3.5123	0.834
		8	-0.04...	-0.13...	3.6012	0.891
		9	0.091	0.019	4.0086	0.911
		1...	0.009	-0.14...	4.0141	0.947
		1...	0.136	0.036	5.8301	0.884
		1...	0.209	0.130	14.320	0.281

*Probabilities may not be valid for this equation specification.

(g)

Sample: 1991 2019
Included observations: 13
Q-statistic probabilities adjusted for 2 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Prob...
		1	-0.00...	-0.00...	0.0006	0.981
		2	0.127	0.127	0.2859	0.867
		3	-0.19...	-0.19...	0.9881	0.804
		4	0.082	0.072	1.1327	0.889
		5	-0.45...	-0.43...	6.0774	0.299
		6	0.065	0.066	6.1956	0.402
		7	-0.24...	-0.20...	8.2016	0.315
		8	-0.01...	-0.18...	8.2109	0.413
		9	-0.07...	0.038	8.5152	0.483
		1...	0.138	-0.18...	9.7493	0.463
		1...	-0.10...	-0.07...	10.818	0.459
		1...	0.132	-0.08...	14.207	0.288

*Probabilities may not be valid for this equation specification.

(h)

***Fig. 1.* Performance of residual autocorrelation diagnosis, 1991–2019**

Note: 1. (*a*) to (*h*) in Fig. 1 correspond to the model 1 to model 8 in Table 2 . 2. *p*-value from (*a*) to (*h*) are all significantly greater than the 5% significance level, which reveals the residuals estimates of model 1 to model 8 have no sequence autocorrelation.

to the twelfth period are all significantly greater than the 5% significance level. On the other words, the residuals estimates of model 1 to model 8 have no sequence autocorrelation.

We next exploit the Histogram-Normality test and Heteroscedasticity test. In Table 2, we use Breusch-Pagan-Godfrey to diagnose residual heterogeneity, which show the p-values of *F*-statistic, OBS * *R*-squared and Scaled explained SS of all models are all significantly greater than 5%, denoting that the residuals from model 1 to model 8, in Table 2, do not exist residual heterogeneity.

5.3. Correlation coefficient analysis

In order to avoid the problem of collinearity among explanatory variables, which will affect the empirical results, this paper intends to test the correlation degree of each explanatory variable before the empirical study. From the Pearson correlation coefficient analysis results in Table 3, it is known that the

$$\frac{dm}{(1-m)}\frac{Z}{Y}$$

and

$$\left(\frac{dR-Zdm}{(1-m)Y}\right)$$

are negatively correlated with variable Dummy1994 at − 0.781 and − 0.601, respectively.

The correlation coefficients of other explanatory variables ranged from −0.056 to 0.558, which means that the correlation coefficients of independent variables are not high, and the problem of regression collinearity is not serious, among which the tax system reform in 1994 and 2012 are discussed by using the dummy variables.

In Table 4, we show that from model 1 to model 8, the p-values of Jarque-Bera

Table 2

Implementation of the residual heterogeneity test, 1991–2019

Breusch-Pagan-Godfrey test	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
F-statistic	3.584627 (0.0587)	1.239100 (0.4006)	1.450325 (0.3154)	1.515248 (0.3345)	2.140653 (0.1745)	2.277715 (0.1909)	1.276058 (0.3704)	0.876338 (0.5794)
OBS* R-squared	8.344362 (0.0797)	7.194095 (0.3033)	6.614762 (0.2509)	8.835131 (0.2647)	7.859705 (0.1641)	9.896486 (0.1945)	6.198952 (0.2873)	7.162217 (0.4122)
Scaled explained SS	1.390470 (0.8458)	1.224072 (0.9757)	0.736053 (0.9809)	0.717364 (0.9982)	1.080067 (0.9559)	0.527859 (0.9993)	1.130833 (0.9513)	0.872182 (0.9966)

Note: 1.In this table, the p-values of F-statistic, OBS * R-squared and Scaled explained SS of model 1 to model 8 are significantly greater than 5%. 2. In this Table, model 1 to model 8 correspond to the eight models in Table 4 in an orderly way. 3. Standard errors in parentheses: *** means the first-order difference passes the stability test at 1% significance level, ** means the first-order difference passes the stability test at 5% significance level.

Table 3

Correlation coefficient analysis results

Explanatory variable	$\frac{dm}{(1-m)}\frac{Z}{Y}$	$\left(\frac{dR-Zdm}{(1-m)Y}\right)$	$R_t=\left(\frac{Y_t^u}{Y_t^g}\right)Y_t=\frac{\Delta C_t}{M1_t-\Delta C_t}GDP_t$	Dummy 1994	Dummy 2012
$\frac{dm}{(1-m)}\frac{Z}{Y}$	1	0.558** (0.002)	–0.359*** (0.056)	–0.781** (0.000)	–0.180 (0.351)
$\left(\frac{dR-Zdm}{(1-m)Y}\right)$		1	–0.061 (0.755)	–0.601** (0.001)	–0.271 (0.155)
$R_t=\left(\frac{Y_t^u}{Y_t^g}\right)Y_t=\frac{\Delta C_t}{M1_t-\Delta C_t}GDP_t$			1	0.391* (0.036)	–0.056 (0.772)
Dummy 1994				1	0.192 (0.319)
Dummy 2012					1

Note: The upper right corner of this table is the Pearson correlation coefficient (*p*-value in brackets).

test are greater than 5%, depicting that all models in Table 4 can not reject the null hypothesis that the residual term conforms to normal distribution. This above mentioned research design demonstrates, at the aggregate income level, how the revenue elasticity and the elasticity of taxable income are combined to generate the elasticity of tax with respect to the change of marginal rate. Next, on the basis of the the joint elasticity of taxable revenue (JETR), three indicators (the cash deposit ratio (CDR) approach, currency demand (CD) approach and currency transaction (CT)) are added separately to evaluate the relationships among elasticities, underground economy(UE) and GDP growth. For controlling the contemporaneous correlation between the heterogeneity and the residual in the models, we use SUR-OLS and Rolle's approach to evaluate the interdependence and correlation between those parameters.

In model 1 of Table 4, we only analyze the impact of above ground income variables

$$\left(1-\frac{Y_t^U}{Y_t^g}\right)Y_t$$

on GDP growth. As noted in Table 4, D_{1994} is dummy variable that equals 1 after 1994, denoting the reform of China's tax sharing system, and D_{2012} is dummy variable that equals 1 after 2012, depicting the implementation of replacing business tax with value-added tax since 2012. Due to the regression analysis of more than two dummy variables are inclined to appear "dummy variable trap" and linear combination of dummy variables, the intercept term of one dummy variable can be omitted to avoid singular phenomenon [53]. To show how these two important tax reforms influence the GDP growth over time, in model 2 of Table 4, the dummy variables D_{1994} and D_{2012} are added concurrently.

5.4. GMM test

The Sargan-Hansen test (Sargan [56]; Hansen [57]) is computed from residuals from instrumental variables regression by constructing a quadratic form based on the cross-product of the residuals and exogenous variables. Under the null hypothesis that the over-identifying restrictions are valid. In Table 4, we use Sargan-Hansen test to prove the post estimation of GMM (generalized method of moments), the null hypothesis shows that the instrumental variable is effective.

According to the estimation results, the *p*-values of model 1–8 are all less than 0.05.

Therefore, we agree with the null hypothesis of "instrumental variables are effective" in Eq. (16) regression model.

5.5. Regression analysis and results

Eq. (15) displays the behavioral response in income induced by the small tax change and tax reform. However, for large tax changes, it is perhaps more suitable to use a log–log specification. Hence, excluding dummy variables, we obtain the following specification.

$$\begin{aligned}\log\frac{dY}{Y} = &-\xi^c \log\left(\frac{dm}{(1-m)}\frac{Z}{Y}\right)+\\ &+\eta\log\left(\frac{dR-Zdm}{(1-m)Y}\right)+\\ &+\beta_1\log Gutmann\_UE_t+\\ &+\beta_2\log Tanzi\_UE_t+\\ &+\beta_3\log Feige\_UE_t-\frac{H'}{Y}\log(dR)+\\ &+\beta_4 D_{1994}+\beta_5 D_{2012}+\varepsilon_t,\end{aligned} \tag{16}$$

where $\varepsilon_t = \varphi_1\varepsilon_{t-1} + \varphi_2\varepsilon_{t-2} + \sigma_t$.

Further, we incorporate three kinds of underground economic parameters respectively, including *logGutmann_UE*, *logTanzi_UE* and *logFeige_UE*, into Eq. (16) in pursuit of measuring their influence on GDP growth. For the underground economy parameter, it can be seen that research conducted by Tanzi [58] calculates only those underground activities that are solely the result of taxes. That is to say, in general, the estimates are obviously higher for the Gutmann approach than for the Tanzi approach (see Cebula & Feige [48]). Based on the empirical results in Table 4, we draw the following results:

Case 1: Model 1 in Table 4 indicates the independent variable

$$\frac{dm}{(1-m)}\frac{Z}{Y}$$

has a negative correlation with $^{dY}/_{Y}$, and its coefficient value ξ^{c} is –0.442, reaching 1% significance.

It means that the increase of tax rate will lead to the decrease of taxpayer's income and willingness to declare. Likewise, the independent variable

$$\frac{dR-Zdm}{(1-m)Y}$$

has a negative correlation with $^{dY}/_{Y}$, and its coefficient value η is –0.139616, which means that the increase of tax rate leads to the increase of concealed income, which eventually leads to the decrease of GDP, but it does not pass the 10% significance test.

Case 2: We add two dummy variables D_{1994} and D_{2012} into model 1 in Table 4, and get model 2 in Table 4. The result shows that ξ^{c} is –0.28407, which passes the significance test of 1%. It means that the increase of tax rate will lead to the decrease of taxpayer's income. The coefficient η is –0.0275, it means that the increase of tax rate leads to the increase of concealed income, which eventually leads to the decrease of GDP, but it fails to pass the 10% significance test. This shows that the increase of tax rate leads to the prevalence of underground economy, but the income holders of underground economy may eventually drive part of GDP growth through consumption expenditure, which can be regarded as partially offsetting the strength of the above ground economic slowdown (see Schneider & Enste [18]). In addition, two dummy variables D_{1994} and D_{2012} are added to model 1 in Table 4, Model 2 in Table 4 can be obtained, and the corresponding regression coefficient is positive, which has passed the significance test of 1%. It shows that the impact of the two tax reform on GDP is positively correlated.

Case 3: Model 3 in Table 4 adds the variable Gutmann_UE

$$\frac{Y_{ut}}{Y_{gt}}=\frac{\frac{C_t}{D_t}-\theta_{gt}}{\theta_{gt}+1}$$

to model 1 of Table 4 From the results of model 3 in Table 4, we can see that the variable *Gutmann_UE* is negatively correlated with GDP, reaching a significant level of 1%.

The test of the cash deposit ratio (CDR) method shows that the higher the proportion of currency to current deposit, the more underground economic activities, leading to the decline of GDP. Likewise, Model 4 in Table 4 shows that the two dummy variables, D_{1994} and D_{2012} both have a positive effect on GDP , which pass the 10% and 5% significant test, respectively. Meanwhile, Model 3 in Table 4 is based on model 1, adding the variable *Gutmann_UE*, which indicates the independent variable

$$\frac{dm}{(1-m)}\frac{Z}{Y}$$

has a negative correlation with $^{dY}/_{Y}$, and its coefficient value ξ^{c} is –0.2430, reaching 1% significance. It means that the increase of tax rate will lead to the decrease of taxpayer's income and willingness to declare. Likewise, the independent variable

$$\frac{dR-Zdm}{(1-m)Y}$$

has a negative correlation with $^{dY}/_{Y}$, and its coefficient value η is –0.2075, reaching 5% significance, it means that the increase of tax rate leads to the increase of concealed income, which eventually leads to the decrease of GDP.

Based on Model 3 in Table 4, two dummy variables are added to form Model 4 in Table 4. Similarly, the independent variable

$$\frac{dR-Zdm}{(1-m)Y}$$

has a negative correlation with $^{dY}/_{Y}$, and its coefficient value η is –0.2248, reaching 1% significance, it means that the increase of tax rate leads to the increase of concealed income, which eventually leads to the decrease of GDP. The coefficient η is –0.1051, which fails to pass the 10% significance test. Similar to the result of case 2, this shows that the increase of tax rate leads to the prevalence of underground economy, but tax evaders in underground

Table 4

Implementation of elasticities and Underground Economy on GDP (1991–2019)

Explanatory variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
$\ln\frac{dm}{(1-m)}\frac{Z}{Y}$	−0.442453*** (−6.492946)	−0.284076*** (−5.620377)	−0.243030*** (−4.942176)	−0.224828*** (−5.411377)	−0.426308*** (−6.494772)	−0.284170*** (−5.669070)	−0.245071*** (−5.638118)	−0.249913*** (−0.035226)
$\ln\frac{dR-Zdm}{(1-m)Y}$	−0.139616 (−0.960369)	−0.027502 (−0.287149)	−0.207544** (−2.662932)	−0.105175 (−1.116855)	−0.154027 (−1.116855)	−0.032271 (−0.337934)	−0.012269 (−0.170422)	−0.027686 (−0.367612)
Gutmann $\frac{Y_{ut}}{Y_{gt}}=\ln\frac{\left(\frac{C_t}{D_t}-\theta_{gt}\right)}{(\theta_{gt}+1)}$			−0.518864*** (−5.980597)	−0.326234*** (−3.358242)				
Tanzi $\ln\frac{C_{ut}}{(C_t+D_{gt}-C_{ut})}$					−0.234889 (−1.288345)	−0.054636 (−0.484154)		
Feige $\frac{Y_t^U}{Y_t^g}=\ln\frac{\Delta C_t}{M1_t-\Delta C_t}$							−0.741244*** (−6.866686)	−0.536203** (−2.939628)
Dummy1994		0.703433** (2.318284)		0.478658* (2.032305)		0.693949* (2.301224)		0.131317 (0.6810)
Dummy2012		1.145828*** (5.085711)		0.594083** (2.530717)		1.109889** (4.713955)		0.455214 (1.547051)
AR(1)	1.663166*** (5.603642)	1.401265*** (6.576107)	1.625625*** (5.258483)	1.393153*** (6.063799)	1.601428*** (4.962446)	1.601428*** (4.962446)	1.303156*** (6.451232)	1.460350*** (5.458498)
AR(2)	−0.689095 (−2.417058)*	−0.408583* (−1.960289)	−0.681564* (−2.324137)	−0.413000 (−1.841833)	−0.634416* (−2.060193)	−0.634416* (−2.060193)	−0.314920 (−1.597541)	−0.456024 (−1.823403)
W	1.654753	2.377389	2.198092	2.173955	2.104868	2.581169	3.034119	2.576688
Jarque-Bera	1.100422 (0.576828)	0.216076 (0.897593)	1.362569 (0.505967)	0.443695 (0.801038)	0.990879 (0.609303)	1.012386 (0.602786)	0.682764 (0.710787)	0.101850 (0.950350)
TSLS J-statistic (Prob)	5.37E-40	4.77E-37	0.000000	2.40E-36	0.000000	3.13E-38	0.000000	0.000000
Adjusted-R^2	0.750498	0.904652	0.922794	0.940591	0.754637	0.894500	0.937167	0.933673

Note: 1. In brackets is the t-statistic of the estimated parameter. 2. Robust standard errors in parentheses. $p^* < 0.10$, $p^{**} < 0.05$, $p^{***} < 0.01$. 3. suppose $H'/Y \approx 0$. 4.The table is based on the historical data of the National Bureau of statistics of China. 5. Endogeneity Test: the *p*-value of all the models is greater than 0.05, which accepts the null hypothesis that there is no endogenous variable.

economy may eventually pull part of GDP growth through consumption expenditure, partially offsetting the above ground economic recession.

Case 4: Model 5 in Table 4 is based on Model 1, adding the variable *Tanzi_UE*,

$$\frac{C_{ut}}{(C_t + D_{gt} - C_{ut})},$$

and the corresponding regression coefficient is –0.234, indicating that the effect of the variable Tanzi_UE on GDP is negative, but it fails the 10% significance test. The analysis results of model 5 in Table 4 can be explained by Becker's crime and penalty theory [58], the cost of using cash seems to be less than that of electronic payment, so the increase of using electronic payment may not necessarily lead to the decrease of cash use. Our empirical result is similar to the research by Visa Europe et al. (2013), illustrating the anonymity of cash makes it difficult to trace cash transactions, resulting in the prevalence of underground economy. Nevertheless, we add two dummy variables to model 1 of Table 4 to obtain model 6 of Table 4. The results show that two dummy variables D_{1994} and D_{2012}, both of them have a positive impact on GDP, reaching 10% and 5% respectively. Meanwhile, Model 5 in Table 4 is based on Model 1, adding the variable *Tanzi_UE*, which indicates the independent variable

$$\frac{dR - Zdm}{(1-m)Y}$$

has a negative correlation with $^{dY}/_{Y}$, and its coefficient value ξ^c is –0.4263, reaching 1% significance. The empirical result is the same as that of case 1 to case 3, which means that the increase of tax rate leads to the increase of concealed income, which eventually leads to the decrease of GDP.

Case 5: Further, we include the variable *Feige_UE*,

$$\frac{Y_t^U}{Y_t^g} = \frac{\Delta C_t}{M1_t - \Delta C_t}$$

into Model 1 in Table 4, and get Model 7 in Table 4. The corresponding regression coefficient is –0.741, which shows that the influence of variable *Feige_UE* on GDP is negative, reaching the significance level of 1%. Even if we include the two dummy variables, D_{1994} and D_{2012} into Model 8 in Table 4. The results show that the impact of *Feige_UE* on GDP is negative and reaches the significance level of 5%. Obviously, the above empirical results are consistent with Farrell's (2004), that is, tax evasion will lead to a decline in GDP. Likewise, Model 7 and Model 8 in Table 4 both indicate the independent variable

$$\frac{dR - Zdm}{(1-m)Y}$$

has a negative correlation with $^{dY}/_{Y}$, and its coefficient value ξ^c is –0.2450 and –0.2499, respectively, reaching 1% significance.

The result of our analysis confirming the increase of tax rate leads to the increase of concealed income, which eventually leads to the decrease of GDP.

5.6. Summary

Further, based on the results of empirical analysis, the above research results can be further summarized, with the following key points:

1) Using *Tanzi_UE* [59] approach, the impact of cash transactions on GDP is negatively correlated, implying that the increase in cash transactions led to an increase in the underground economy. Our findings are consistent with Cagan's [10] view that cash is the main medium for people to engage in underground economic activities.In underground economic activities, cash transactions can avoid being recorded and tracked by monetary authorities (see Gutmann [12], Tanzi [60]). As is well known, in recent years, electronic payment transaction has been widely used to replace traditional cash payment in China. In this paper, we find that the use of cash in the market is negatively correlated with GDP, but this relationship does not pass the 10% significance test. The empirical results of this paper are consistent with Schneider and Enste [18]. The increase of tax rate leads to the prevalence of underground economy, but some of the income from underground economy may eventually flow into the consumption market to drive the growth of GDP.

Table 5

Slutsky identity estimation from SUR-OLS

Slutsky coefficient	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
$\xi^c = \left[\frac{(1-m)}{Z}\right]\frac{\partial Z}{\partial(1-m)}\Big\vert_u$	–0.4424	–0.2840	–0.2430	–0.2248	–0.4263	–0.2841	–0.2450	–0.2499
$\eta = (1-m)\frac{\partial Y}{\partial R}$	–0.1396	–0.0275	–0.2075	–0.1051	–0.1540	–0.0322	–0.0122	–0.0276
$\xi^u = \frac{(1-m)}{z}\frac{\partial Z}{\partial(1-m)}$	–0.582	–0.3115	–0.4505	–0.3299	–0.5803	–0.3163	–0.2572	–0.2775

Note: Table 5 is the result derived from formula (8) based on Table 4.

2) All models in Table 4 show that ξ^c is negatively correlated with GDP and pass the 1% significance test. Obviously, this proves that Slutsky compensation price elasticity (including income effect and substitution effect) is negative, that is, an increase in the marginal tax rate will lead to a decrease in taxpayers' declared income. This article further derives the relationship between uncompensated price elasticity, $\xi^c = \xi^u - \eta$ and GDP, and the two also show a negative correlation, as shown in Table 5. It can be found that, generally speaking, the fluctuation range of tax rate is smaller than that of commodity price, so the coefficient difference between ξ^c and ξ^u is not obvious. However, since ξ^u includes the income effect, the "income" is normal goods rather than inferior goods, so $\xi^u > \xi^c$.

3) In Table 4, almost all models reveal two dummy variables, D_{1994} and D_{2012}, which are positively correlated with GDP and pass the significance test of 10%. Obviously, our results are consistent with those of Fugazza and Jacques [61], who believe that higher tax rates and government regulation are the key factors affecting the underground economy.

6. Conclusion

In this paper, we exploit GDP (aggregate income), tax elasticity, income elasticity, three kinds of underground economic estimation models, as well as two important tax reform in China in 1994 and 2012 as independent variables, and examined the revenue responsiveness properties of China taxation and underground economy since 1991–2019 using Slutsky identity and SUR-OLSs method for GDP growth.

Taking China as an example, this paper selects tax rate elasticity, income elasticity, three kinds of underground economic estimation models and two important tax system reforms in 1994 and 2012 as independent variables. In methodology, this paper uses SUR-OLSs and Slutsky identity to estimate the impact of underground economy on GDP growth since 1991–2019. As is well known, SUR-OLS estimator achieves asymptotic efficiency gains over OLS by incorporating the long-run cross sectional correlation in the equilibrium errors in estimation. In comparison with traditional literature, the merit of our model is that we directly use SUR-OLS regression analysis to calculate variables, in contrast with current articles, our model does not need to be substituted into the data for complex calculation. On the other hand, in our paper, the Slutsky compensated elasticity coefficient, ξ^c, and the income effects coefficient, η, can be obtained directly through our SUR-OLS model.

Undoubtedly, by comparing with other relevant literature on this issue, our paper has the above merits, our innovative methodology can also be applied to most countries for time series analyses. Also, based on the joint elasticity of taxable income (JETR), in empirical analysis, we decompose tax changes into tax rate effect (change of budget constraint slope) and income effect (change of tax liability), and further analyze the impact of tax elasticity (ETI) on GDP growth. That is, in Model 1–8 of Table 4, the relationship between explanatory variable "tax rate" and "income" of explained variable is analyzed

by SUR-OLS and Slutsky identity, and the substitution effect is negative, reaching a significant level of 1%, which means that when taxpayers face the increase of tax rate, the relative price of declared income and concealed income changes.

At this time, the budget line will move inward, leading to the decrease of declared income. Refering to Tanzi's underground economy approach, we show the increment in cash transactions at the market led to a decline in China's GDP, however, it is worth noting that the result is still not obvious, revealing the increment of cash transactions in market does not necessarily result in a decline in GDP growth. Our results are similar to those of Schneider and Enste. The increase of tax rate leads to the increase of underground economy and the decrease of GDP. However, the income holders of the underground economy will eventually show their hidden income through consumption expenditure, which will partly slow down the decline of GDP.

Also, we show that China implemented the reform of the tax sharing system in 1994, and the fiscal distribution was dominated by the central government. From 1993 to 1995, the total tax revenue was 425.5 billion yuan, 512.6 billion yuan and 603.8 billion yuan, respectively. Since then, the total tax revenue has been increasing year by year. In addition, the implementation of "replacing business tax with value-added tax" started in 2012 to avoid double taxation. According to China's statistical data, the total business tax and value-added tax from 2012 to 2015 are 4261.2 billion yuan, 4604.3 billion yuan, 4863.6 billion yuan and 5042.1 billion yuan, respectively; due to the business tax in 2016 has been cancelled, the value-added tax from 2016 to 2019 is 5221.3 billion yuan, 5637.8 billion yuan, 6153.3 billion yuan and 6234.6 billion yuan respectively, showing an upward trend year by year.

In addition, it is particularly impressive that China implemented two important and representative tax reforms in 1994 and 2012 respectively, denoting the reform of China's tax sharing system since 1994, and the implementation of replacing business tax with value-added tax since 2012, the empirical results show that both the 1994 tax reform and 2012 tax reform have a positive impact on GDP, with high statistical significance respectively. It may be of interest that in line with Chen et al. (2020), our empirical results demonstrate that China's underground economy has significantly slowed down during 1991–2019. Finally, since the hidden cost can not be quantified and presented with specific data, thus it is not included in the research scope. It is expected that the follow-up researchers can adopt different research methods continuing to explore and research, so as to provide tax collection agencies with more contributions in clearing up the underground economic arrears.

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