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THE OPTIMAL INTERNAL "SHADOW" TAXATION ON CONDITION OF A FIRM EXTERNAL ECONOMIC ACTIVITY

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In the given work, it is made an attempt to build a simplified mathematical model of financial functioning of an enterprise which leads its own internal economic activity in conditions of two parallel existing economies: "light", which is being taxed officially by the state establishments, and "shadow", controlled by the corruption structures by their own schemes of taxation; as well as, external economic activity, at the given consideration without the "shadow" component. The suggested model allows researching the optimal control of the financial-economic process development by the each of the "players": the firm, internal state official and "shadow", as well as the external state structures. The application of the ***subjective entropy extremizaton principle by Professor V.A. Kasianov*** *allows obtaining the canonical distributions of the "players'" individual preferences which demonstrate the presence and intensity of the optimal values of the continuous controlling parameters. Conducted numerical experiments have been illustrated with the corresponding diagrams.*

Key words: Cypriot financial crisis (2012-2013), financial-economic process, optimal control, internal economic taxation, official tax, "shadow" tax, external economic activity, principle by Professor V.A. Kasianov, variational problem of subjective analysis.

Problem formulation

On the background of the recent events (March 2013), related to the financial crisis in the Republic of Cyprus [1], it becomes obvious that for the main participants of the internal-state economic activity of a firm, that is the firm itself, official internal-state institutions of tax-collection, and "shadow" internal-state structures [2], there arises an actual problem of taking into account one more economic "player": external-economic system. That pertains to the matter not only at some crisis periods but also relatively stable ones.

Analysis of the latest researches and publications

Consideration of this problem for an enterprise, which conducts its own external-state activity generally on the economic laws, likewise described in sources [3, 4], leads to the necessity of elaboration of a formalized model of the "players" optimal behavior (the control of the process by each of them in their own field of competency) with the application and further development of the variational methods of subjective analysis initiated in works [2, 5-9].

Task setting

The objectives of this work – to elaborate a rough but principally substantiated model which reasonably takes into consideration the optimal intentions and individual preferences (factors of control) of the economic "players".

Main material

1. Problem setting

In accordance with the statements developed in the monograph [2, P. 3], the flow of resources V_p (financial or material), which is being taxed with both the official and shadow ("contribution") taxes, at any moment of time is dividing into the "light" part $V_p^{(1)}$ and "shadow" part $V_p^{(2)}$, that is, [2, P. 3, (1)]:

$$V_p = V_p^{(1)} + V_p^{(2)}. \qquad (1)$$

Accordingly to the given consideration we will deem the components of the equation (1) as

the flows of the internal-state economic activity of the firm. Thus, their summation flow becomes also the internal-state one.

We will add a component of the external-state economic activity flow of the enterprise to the internal-state flow (1). Then, the total flow of the resources of the firm will have the view of

$$V_{\sum p} = V_p^{(1)} + V_p^{(2)} + V_p^{(3)}, \quad (2)$$

where $V_p^{(3)}$ – part of the enterprise resources total flow that comes up as a result of the external-state economic activity.

In the simplest case the flows are taxed proportionally [2, P 3]:

$$V_T = TV_p^{(1)}, \quad (3)$$

where V_T – incomes from taxation of the firm through the internal-state official form of taxation, which is calculated out of the "light" part of the enterprise total resources flow; T – tax rate assigned by the state, "internal" for the firm; [2, P 3]:

$$V_C = CV_p^{(2)}, \quad (4)$$

where V_C – total "contribution" ("shadow" taxation), it has the "internal-state" sense in the given problem setting as well, that is calculated out of the "shadow" part of the enterprise total resources flow; C – "shadow" taxation rate which is imposed by the shadow structures of the "internal" state; we will conditionally name such player a "racketeer" [2, P v-viii];

$$V_B = BV_p^{(3)}, \quad (5)$$

where V_B – taxation incomes from the firm to the foreign "external" state through its own official form of taxation that is calculated out of the external-state part of the enterprise total resources flow; B – rate of taxation assigned for the enterprise by the "external" state.

The determined model proposed in the work [2] envisages some condition of a certain principle (law) existence that splits the scope of V_p into the two component parts V_p^{C} and V_p^{C}, being formed by the enterprise itself (that is its own competence) and which is called the law of "iceberg" or "Divisor" [2, P. 3-5, (2)]:

$$\frac{V_p^{(1)}}{V_p^{(2)}} = \left(\frac{C}{T}\right)^{\beta}, \quad (6)$$

where β – parameter of the model that shows a degree of the intensity of the firm's reaction upon the change in the rate of taxations.

If we denote $\frac{C}{T} = \xi$, then we will write down [2, P. 5, (3)]

$$\frac{V_p^{(1)}}{V_p^{(2)}} = \xi^{\beta} \quad (7)$$

instead of (6).

The condition of (6) or (7) means that the more the state taxation rate in relation to the "shadow" taxes ("contribution") the bigger part of its own return is hidden into the "shadow" by the firm and, vice versa, the more the "shadow" taxation the more the "light" component partial weight.

Let us apply the mentioned above principle for modeling the division of the total flow (2) into the three components.

$$\frac{V_p}{V_p^{(3)}} = \left(\frac{B}{D}\right)^{\alpha}, \quad (8)$$

where D – total "internal" taxation; α – parameter of the model that shows a degree of the intensity of the firm's reaction upon the change in the rate of the "external" and "internal" taxations correspondingly; in the general case the parameter of α may be different from the analogous by the conception parameter β, of the model of (6, 7).

The total "internal" taxation will be determined from the condition of

$$D = \frac{V_F^{\Sigma}}{V_p}, \quad (9)$$

where V_F^{Σ} – losses of the enterprise because of the double taxation "inside" the country, that is, [2, P. 3]:

$$V_F^{\Sigma} = V_T + V_C. \quad (10)$$

From the equations of (1) and (7) we get, [2, P. 5, (4)]

$$V_p^{(1)} = \frac{\xi^\beta}{1+\xi^\beta} V_p, \qquad V_p^{(2)} = \frac{1}{1+\xi^\beta} V_p. \qquad (11)$$

Let us suppose that the internal-state taxation rate is determined. Then, in relation with (3, 4), [2, P. 5, (5)]

$$V_T = T\frac{\xi^\beta}{1+\xi^\beta} V_p, \qquad V_C = T\frac{\xi}{1+\xi^\beta} V_p \qquad (12)$$

and [2, P. 5, (6)]

$$V_F^\Sigma = T\frac{\xi+\xi^\beta}{1+\xi^\beta} V_p. \qquad (13)$$

Form relations (9, 13)

$$D = T\frac{\xi+\xi^\beta}{1+\xi^\beta}. \qquad (14)$$

Then, model (8) with the use of (1, 2, 14) will be notated in the view of

$$\frac{V_p^{(1)} + V_p^{(2)}}{V_{\Sigma p} - V_p^{(1)} - V_p^{(2)}} = \left[\frac{B(1+\xi^\beta)}{T(\xi+\xi^\beta)}\right]^\alpha. \qquad (15)$$

Having applied expression (7) and indication

$$\varphi = \frac{B(1+\xi^\beta)}{T(\xi+\xi^\beta)}, \qquad (16)$$

we obtain

$$V_p^{(2)} = \frac{\varphi^\alpha}{(1+\xi^\beta)(1+\varphi^\alpha)} V_{\Sigma p} \qquad (17)$$

for the "shadow" component of the total flow.

From where, out of (17), accordingly to (4)

$$V_C = C\frac{\varphi^\alpha}{(1+\xi^\beta)(1+\varphi^\alpha)} V_{\Sigma p}. \qquad (18)$$

Relation (18) contains parameters of control of economic process by all four players. In the given problem setting it is considered the optimal "shadow" taxation. This means that at the other parameters of the model (18) having constant values, the "smart/clever racketeer" is finding the maximum of the total "contribution" V_C with the variation of the parameter C by him.

2. Problem solution

At the given conditions, the extremum (in this case maximum) of the function of (18) is found from the condition

$$\frac{dV_C}{dC} = \frac{\partial V_C}{\partial C} + \frac{\partial V_C}{\partial \xi}\frac{d\xi}{dC} + \frac{\partial V_C}{\partial \varphi}\frac{d\varphi}{dC} = 0. \qquad (19)$$

At the equation (19)

$$\frac{d\varphi}{dC} = \frac{\partial \varphi}{\partial \xi}\frac{d\xi}{dC}, \quad \text{since} \quad \frac{\partial \varphi}{\partial C} \equiv 0. \qquad (20)$$

As in this problem setting T, B, α, β, and $V_{\Sigma p}$ – are given constant values, also the parameters of C and ξ are linearly connected one with the other, then the condition of optimality (19) is equivalent to

$$\frac{d}{d\xi}\left(\frac{\xi\varphi^\alpha}{(1+\xi^\beta)(1+\varphi^\alpha)}\right) = 0. \qquad (21)$$

The expression (21) will have the view of

$$\frac{\partial V_C^{(0)}}{\partial \xi} + \frac{\partial V_C^{(0)}}{\partial \varphi}\frac{d\varphi}{d\xi} = 0, \qquad (22)$$

where

$$V_C^{(0)} = \frac{\xi\varphi^\alpha}{(1+\xi^\beta)(1+\varphi^\alpha)}. \qquad (23)$$

Substituting the expression (16) into the equation (23) we have

$$V_C^{(0)} = \frac{\xi B^\alpha (1+\xi^\beta)^{\alpha-1}}{[T(\xi+\xi^\beta)]^\alpha + [B(1+\xi^\beta)]^\alpha}. \qquad (24)$$

From condition

$$\frac{dV_C^{(0)}}{d\xi} = 0 \qquad (25)$$

we obtain

$$[T(\xi+\xi^\beta)]^\alpha [a(\xi) + \alpha\beta\xi^\beta(\xi-1) - \alpha\xi(1+\xi^\beta)] + \\ + [B(1+\xi^\beta)]^\alpha a(\xi) = 0, \qquad (26)$$

where

$$a(\xi) = (\xi+\xi^\beta)[1+\xi^\beta(1-\beta)]. \qquad (27)$$

The root of the equation (26) gives the sought solution of the problem, the value of the parameter of ξ_{opt}, at which the extremum of the function (18) is possible.

At the condition

$$\left.\frac{d^2V_C^{(0)}}{d\xi^2}\right|_{\xi_{opt}} < 0 \qquad (28)$$

we will have the maximum of the total "contribution" V_C (18).

3. Application of the subjective entropy extremization principle

Let us apply the principle of the subjective entropy maximum, proposed by V.A. Kasianov, professor of National Aviation University, to the finding of the optimal distributions of preferences of continuous alternatives.

Accordingly to the concept of the subjective entropy extremization principle by Professor V.A. Kasianov, the optimal solution is made with the application of the functional postulated in the subjective analysis [2, 5-9], which is taken in the rather general view [5, P. 119, (3.38)], [2, P. 38, (1)]:

$$\Phi_\pi = \alpha H_\pi + \beta\varepsilon + \gamma \mathrm{H} \qquad (29)$$

where H_π – subjective entropy; $\varepsilon = \varepsilon(\pi, U, \ldots)$ – function of subjective efficiency; H – normalizing condition; α, β, γ – structure parameters which can be considered at different situations as Lagrange coefficients, weight coefficients or endogenous parameters that reflect certain properties of psych. The parameters α and β, that enter the content of the functional (29), are not the same parameters of α and β, that have been used above in the modeling relations of the "Divisor" (6) and (8).

Although, for the justice issues, it should be noted that the endogenous parameter of psych β (the subjective temperature) which forms the cognitive function of $\beta\varepsilon$ of the functional (29), at the certain way compiled functional is right happened to the exactly the factor of β which enters the models with the linear-proportional "Divisor" (6, 7), as it was demonstrated as an example at the monograph [2, P. 43, § 2.2, (i-vi)].

At the given problem setting, let us consider the continuous restricted alternative – the value of the shadow taxation rate C. The value of ξ as well as the function of effectiveness in the view of (18) will correspond to this alternative.

Then, the functional, optimized by the "racketeer"

$$\Phi_\pi^C = \int_{\xi_0}^{\xi_1}\left[-\pi_C(\xi)\ln\pi_C(\xi) - \beta_\pi\pi_C(\xi)\,\bar{V}_C(\xi)\right]d\xi + \gamma\left[\int_{\xi_0}^{\xi_1}\pi_C(\xi)\,d\xi - 1\right], \qquad (30)$$

where $\pi_C(\xi)$ – function of the "racketeer's" individual preferences concerning to the continuous alternative C, therefore becomes the function of the parameter of ξ; β_π – indication of the structure parameter of the given functional that differs from the parameter of the model (6, 7) – the degree of the intensity of the firm's reaction upon the change in the rate of taxations β, in order to avoid the confusion between them and their mistaken interpretation; $\bar{V}_C(\xi)$ – relative function of effectiveness, that is from the relations of (16, 18):

$$\bar{V}_C(\xi) = \frac{V_C(\xi)}{V_{\Sigma p}} = T\,\frac{\xi\varphi(\xi)^\alpha}{(1+\xi^\beta)\,(1+\varphi(\xi)^\alpha)}. \qquad (31)$$

Variational problem (30) is solved by the methods of [2, 5-9] and leads, as the result, to the canonical distribution of the individual's preferences function:

$$\pi_C(\xi) = \frac{\exp\left[-\beta_\pi\bar{V}_C(\xi)\right]}{\int_{\xi_0}^{\xi_1}\exp\left[-\beta_\pi\bar{V}_C(\xi)\right]d\xi}. \qquad (32)$$

4. Numerical experiment

Let us model the relations between the optimal controls (taxations) from the sides of "shadow" and external-state economic structures. In correspondence with the previous theoretical speculations (1-32) at the example with the following initial data: $\xi_0 = 0$; $\xi_1 = 2$; $\beta_\pi = -5$; $T = 0.35$; $B = 0.15$; $\alpha = 2$; $\beta = 2$; we obtain, first the optimal value of ξ_{opt} the value of the "shadow" taxation. The root of the equation of (26) has the approximate value of ≈ 0.29; shown in fig. 1.

In fig. 1, for checking the accuracy of the intermediate derivations, dropped for the matters of conciseness of the scope of the publication, it is shown in the corresponding scales a few different graphs of the equations obtained from the different necessary conditions for the extremum to exist, and all of them have one and the same root. That testifies the correctness of the mathematical transformations and acceptable accuracy of the calculations.

The graphs of the relative total "contribution" $\bar{V}_C(\xi)$ and related function of the individual's preferences distribution $\pi_C(\xi)$ obtained by the equations of (31, 32) in the corresponding scales are presented in fig. 2.

From the diagrams in fig. 2 it is noticeable that maximal values of the relative total "contribution" $\bar{V}_C(\xi) \approx 0.0568$ correspond to the optimal value of the "shadow" taxation $\xi_{opt} \approx 0.29$; also the same to the corresponding function of the individual's preferences distribution $\pi_C(\xi) \approx 0.57$.

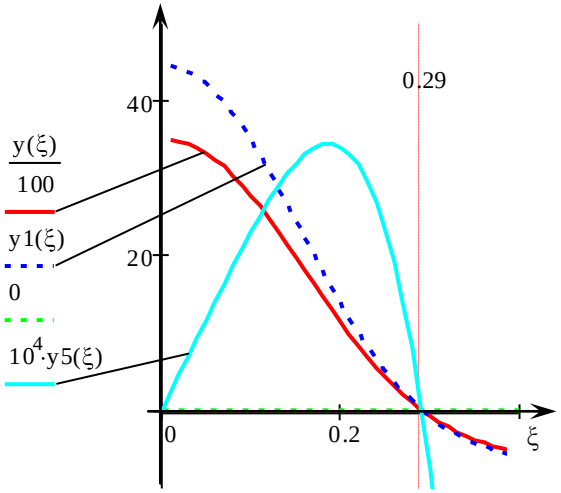

Fig. 1. Optimal value of "shadow" taxation

This gives evidences that the "smart/clever racketeer", at the given conditions of the external-state economic activity of the firm, will assign his own "shadow" taxation at the level of approximately 29% of the rate of the official internal-state taxation.

In such a case he will make the maximal income for himself in the scope of approximately 5.68% of the total material-financial resources flow of the controlled by him enterprise.

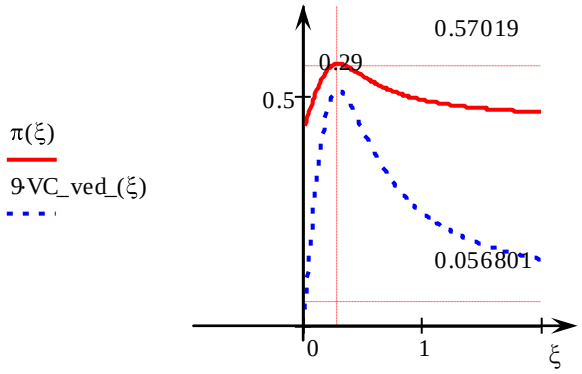

Fig. 2. Function of the individual's preferences distribution and relative total "contribution"

At this, his own subjective preferences will be distributed in such a way that this optimum is the uttermost desired at the level of approximately 0.57, within the restricted diapason of the possible change of the "shadow" taxation rate.

Modeling the situation when it is possible to change the taxation rate of the external-state economic activity of the enterprise gives the results illustrated with the corresponding level curves shown in fig. 3.

From the diagram represented in fig. 3 it is noticeable that the character of the optimal, relative to the official internal-state, "shadow" taxation depending upon the change of the "external" one is nonlinear.

At the increase of the "external" tax up to the loss (unprofitable) levels for the firm, the optimal "internal-shadow" taxation becomes approximately equal the internal-state one by its scope. At this the total "contribution" will stretch up to the scope of more than 14% of the total resources flow of the enterprise.

Conclusions

The elaborated simplified model of the economic activity of a firm allows adequate consideration of the internal-state official and "shadow" as well as external-state economic structures' interests.

In further researches it should be considered the interrelationships between other participants

of the process. Unexpected sharp changes in taxation. “External-state shadow” taxation.

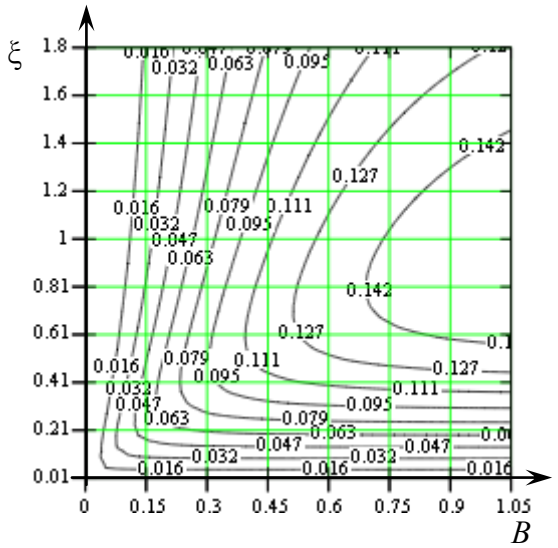

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Fig. 3. Relative total “contribution” depending upon the external-state economic and “shadow” taxation

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ОПТИМАЛЬНЕ ВНУТРІШНЄ «ТІНЬОВЕ» ОПОДАТКУВАННЯ ЗА УМОВИ ЗОВНІШНЬОЕКОНОМІЧНОЇ ДІЯЛЬНОСТІ ФІРМИ

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У даній роботі здійснено спробу побудови спрощеної математичної моделі фінансового функціонування підприємства, яке проводить свою внутрішньоекономічну діяльність в умовах двох паралельно існуючих економік: «світлої», котра офіційно оподатковується державними органами, та «тіньової», керованої корупційними структурами за їхніми схемами оподаткування; а також, зовнішньоекономічну діяльність, у даному розгляді без «тіньової» складової. Запропонована модель дозволяє досліджувати оптимальне керування перебігом фінансово-економічного процесу кожним з «гравців»: фірмою, внутрішньодержавними офіційними та «тіньовими», а також зовнішньодержавними структурами. Застосування ***принципу екстремізації суб'єктивної ентропії професора В.О. Касьянова*** *дозволяє отримати канонічні розподіли індивідуальних переваг «гравців», які демонструють наявність та інтенсивність оптимальних значень неперервних керуючих параметрів. Проведено чисельні експерименти, проілюстровані відповідними діаграмами.*

Ключові слова: фінансова криза у Республіці Кіпр (2012-2013), фінансово-економічний процес, оптимальне керування, внутрішньоекономічне оподаткування, офіційний податок, «тіньовий» податок, зовнішньоекономічна діяльність, принцип професора В.О. Касьянова, варіаційна задача суб'єктивного аналізу.

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ОПТИМАЛЬНОЕ ВНУТРЕННЕЕ «ТЕНЕВОЕ» НАЛОГООБЛОЖЕНИЕ ПРИ УСЛОВИИ ВНЕШНЕЭКОНОМИЧЕСКОЙ ДЕЯТЕЛЬНОСТИ ФИРМЫ

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В данной работе осуществлена попытка построения упрощенной математической модели финансового функционирования предприятия, которое ведет свою внутриэкономическую деятельность в условиях двух параллельно существующих экономик: «светлой», официально облагаемой налогом государственными органами и «теневой», управляемой коррупционными структурами по их схемам обложения; а также, внешнеэкономическую деятельность, в данном рассмотрении без «теневой» составляющей. предложенная модель позволяет исследовать оптимальное управление ходом финансово-экономического процесса каждым из «игроков»: фирмой, внутригосударственными официальными и «теневыми», а также внешнегосударственными структурами. Применение ***принципа экстремизации субъективной энтропии профессора В.А. Касьянова*** *позволяет получить канонические распределения индивидуальных предпочтений «игроков», которые демонстрируют наличие и интен-*

сивность оптимальных значений непрерывных управляющих параметров. Проведены численные эксперименты, проиллюстрированные соответствующими диаграммами.

Ключевые слова: финансовый кризис в Республике Кипр (2012-2013), финансово-экономический процесс, оптимальное управление, внутриэкономическое налогообложение, официальный налог, «теневой» налог, внешнеэкономическая деятельность, принцип профессора В.А. Касьянова, вариационная задача субъективного анализа.

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