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Article

The Efficacy of the Retirement Pension Provision System: Modeling, and Assessing of the Case of Kazakhstan

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Abstract: This research is aimed at developing a methodology for assessing the efficacy of a macroeconomic model of the Kazakhstani pension provision system. A hierarchy of indicators of the pension system efficacy is built using the graph method. The representativeness of these indicators is confirmed by using expert assessment and factor analysis. A multi-factor assessment model is built using an additive convolution of the normalized values of the 2014–2019 resulting indicators with a breakdown by regions, regarding the coefficients of their significance. A regression model is developed to show the dependence of the pension system efficacy on the share of the accumulative system in the structure of retirement scheme financing. The optimal part of the accumulative system amounting to 79.5% of the total system is determined to be the level at which the pension system efficiency is maximized. A neural model for predicting the pension system efficacy under the influence of labor market indicators is built. The size of the minimum required annual payroll deductions from the wages of persons working according to the accumulative system is calculated depending on the length of service; this minimum size ensures a replacement rate of 40% with regard to the optimal ratio of the accumulative and solidarity pension systems. These findings will be useful to state bodies when developing and clarifying directions for reforming the pension system in Kazakhstan.

Keywords: Kazakhstan; pension system; labor market; accumulative pension model; solidarity pension model; pension fund; social insurance; pensioners

1. Introduction

Pension schemes are one of the social issues that is constantly a major focus for governments in any country [1–4]. The Republic of Kazakhstan is no exception. The current pension system of Kazakhstan has functioned since 1997, when the concept of reforming the pension system was adopted [5]. Proceeding from the set goals, Kazakhstan used the Chilean retirement plan model as the basis for its pension reform process [6]. This model assumes fixed contributions on individual pension accounts and the accumulation of individual contributions in the state budget, which subsequently becomes a source of pension payments. Starting on 1 January 1998, the entire working population of the country had to make mandatory contributions at the rate of 10% of monthly income to an individual account in the accumulative pension fund [7]. After the next stage of pension reform in 2013, all pension funds which existed at that time in the country were merged into the Unified Accumulative Pension Fund (UAPF) Joint Stock Company [8]. These radical changes ensured the formation of a three-tier Kazakhstani Pension System, including an accumulative component (voluntary and mandatory pension contributions) and a solidarity component in the form of guaranteed pension payments from the republic's budget (which provides the main level of support). The accumulative

component makes it possible to overcome the risks associated with population senescence and the consequent increased pension payments that would otherwise be required from the state budget [9]. The solidarity component in the form of guaranteed pension payments from the budget also provides major support.

Seemingly, the current Pension System of Kazakhstan is ready for future demographic trends. However, it should be noted that despite its three-tier structure, retirement pension payments only represent two components (payments from the state budget and payments from the UAPF) because of the underdevelopment of voluntary employee contributions to the UAPF JSC or to private financial organizations [10]. At the same time, the state budget of the Republic plays an overwhelming role in pension payments, accounting for about 20% of Republican budget expenditures [11] and 3.3% of Kazakhstan's GDP at the beginning of 2020 [12]. Thus, for example, the share of UAPF contributions amounted to only 6.3% of total pension payments as of 2019 and is constantly decreasing [12], while budget pension expenditures are growing too quickly, outstripping high inflation levels in Kazakhstan by two or three times [12]. The replacement rate in Kazakhstan has remained unchanged since 2013, not exceeding 45% on average, whereas it averages 70% in developed countries [13]. Kazakhstan has already crossed the line of the initial senescence level, and by 2050, almost every fifth citizen of Kazakhstan will be over 60 years of age, while the trend of a steady decline in the birth rate and increased life expectancy will continue in the country [14]. This, in turn, will exert even greater pressure on the country's budget and create the risk of a decreased replacement rate.

The level of recorded pension payments from the budget is guaranteed by the State and depends on the labor market development, growth of tax payments, and other budget revenues. There is an extensive shadow economy in Kazakhstan, which includes not only evasion of official registrations but also unreported income from the production of legal goods and services, either from monetary or barter transactions. These problems apply equally to both the solidarity (paid from the State budget) and the accumulative pension systems (paid for by the UAPF). An excessively high proportion of people with low incomes in the labor market is another big problem for the pension system in Kazakhstan. About half of the employed population of Kazakhstan receives wages of less than 112.2 thousand tenge [15]—the median wage value at the end of 2019. The average wage was 203.9 thousand tenge in the country in 2019 [15], which is around twice the median wage value (throughout 2019, the weighted average exchange rate of Kazakhstan's national currency was set as follows: 1 EUR = 428.63 KZT [16]). The wider the gap between average and median wages, the higher the proportion of workers with low wages. Therefore, the pension payments made remain relatively low.

Based on best practices [9,17,18], most of a decent future pension ultimately consists of individual pension payments, while state payments are provided only as a guaranteed minimum pension level for the unprotected segments of the population. Therefore, according to the Concept for Further Modernization of the Pension System of the Republic of Kazakhstan until 2030 [19], the pension reform is long-term in nature, and a complete transition to the accumulative pension system is expected to be completed by 2038–2040.

However, it should be noted that when developing plans to reform the pension system, it is necessary to consider that pension payments are made at the expense of the future results of economic activities. The choice of suitable reform options, in particular for a pension system, must necessarily consider the specifics of a particular country, and available factors that facilitate or impede the successful implementation of reforms, such as the level of labor market development. However, in this context, it is necessary to highlight two dimensions of the problem. The first is discussions about the problems of the labor market, about the level of poverty of the population in general and the elderly in particular, and about stratification in Kazakhstan. The second is the very structure of the pension system, and its efficacy. This research is aimed at establishing the efficacy of the reforming and functioning of the current pension system in Kazakhstan. This study contributes to science in terms of providing a deep understanding of the importance of the baseline in defining the potential scale and boundaries of pension provision. It allows determining the pace and scope of a viable reform, though assessing the

pension system in relation to all structural components is also required depending on the results that need to be obtained during the reform.

2. Literature Review

In economics, the adequacy of pension provision to guarantee the material well-being of people of retirement age has ceased to be the only criterion for assessing the pension system [20]. Regarding current demographic trends, the discussion of pension system efficacy is also gaining importance [21–24]. Today, efficacy is also a fundamental criterion for improving pension system reform, based on a comparative analysis of retirement plan models in different countries [6,7,25] and adequately assessing the practical experience of their functioning [2–4]. It is rather difficult to find a definition of the concept of the pension system efficacy in the literary sources. An analysis of the scientific literature indicates two dimensions in approaches to assess the efficacy of pension provision: efficiency both at the macroeconomic level [21,22,26,27] and at the economic agent level (micro level) [21,23,24,28].

Theories of consumption and savings [29,30] and the theory of permanent income [31–33] have laid the foundation for evaluating the efficiency of pension provision. Since pension system efficacy at the macroeconomic level requires the maximization of consumer utility throughout the life of an economic entity [34], it can be argued that at the microeconomic level, pension system efficacy can be assessed in terms of the rate of return, that is by assessing the ratio between the level of pension payments and the level of the economic agent's contributions. In the classic sense, efficacy in this case involves the excess of the indexation of pension payments by the state of the internal rate of return (real yield of pension payments). However, life annuity is of crucial importance for people who are retired [28]. In this case, it can be asserted that the pension system efficacy on a microeconomic scale is commensurate with the level of adequacy of pension payments for economic agents. The higher the level of the efficacy, the more adequate the level of pension payments.

From a macroeconomic level viewpoint, the nature of the pension system efficacy is different and implies that the pension mechanism is a tool for the redistribution of current GDP between generations: between those who work and those who have already retired [26,35]. A distinctive feature of the pension system efficacy at the macroeconomic level is revealed in the assessment of the influence of smoothing the consumption of one economic agent on that of another one, and, in general, on the overall distribution of GDP [22,26,27]. In this case, the pension system efficacy will be manifested in the leveling of the negative impact on the labor market development, economic activity in the economy, etc. under the influence of modern trends in demographic transformation. Consequently, from this point of view, pension system efficacy can be assessed by the ratio of the funding provided to pensioners as pensions and the costs that the working generation faces from supporting this pension funding. Within the framework of this article, the macroeconomic aspect of the pension system efficacy was used as the basis for the research.

Traditionally, two conceptual approaches have been used for providing pension payments. The first assumes the functioning of the solidarity mechanism, which is based on the aggregate payroll deductions of the working-age population, assuming compulsory participation in insurance against the risk of senescence (a solidarity pension system) [7]. The second approach is based on the functioning of an accumulative mechanism, which assumes individual financing of the pension by the employee himself at the expense of a share of wages and investment income (accumulative pension system) [18]. As demonstrated by the world experience [36], conceptually, most scholars [7,21,37,38] tend to believe that the highest level of the efficacy of social guarantees for pensioners is achieved by creating a multi-tier pension system and by simultaneous operation of both models of the pension system. The symbiosis of basic public pension provision, solidarity, and accumulative components forms a stable basis for a balanced pension provision. This practice is actively used by many countries [36], but with the prevailing dominance of the accumulative component in the pension system. This is explained by the fact that countries in which pension provision is based on compulsory payments from the working-age population face the problem of an excess of the number of pensioners over

the number of working people over time [39]. With the increase in the difference between these two groups, the obligations of the state increase in direct proportion.

Also, in the opinion of some scholars [2,9,40,41], an accumulative pension system and voluntary individual contributions in particular should become a full-fledged basis for the formation of pensions, as there is no more effective instrument for pension provision in practice. However, as already noted, an effective pension system, with appropriate fiscal possibilities, should contain elements that provide a guarantee of a basic level of social security in old age for all persons who had a low level of income during their life or had little work experience in the formal sector of the economy [7,38]. Therefore, with a variety of approaches to the efficacy of the pension system formation and its reform, the component structure may be different. However, a proper balance is needed between the structural elements of the system, as well as an understanding that the development of components depends on specific conditions and circumstances.

3. Methods and Materials

3.1. Data

The list of statistical indicators that characterize the efficacy of the pension system of the Republic of Kazakhstan was formed based on an analysis of the literature [21–24] and confirmed using the methods of factor analysis [42,43] and expert assessment [44,45]. The list of these indicators includes a replacement rate indicating the ratio of the pension and previous income/earnings of a pension recipient (*Replac*), a coverage coefficient determining the part of the population covered by the pension system (*Cover*), and a load factor determining the part of pension recipients in the total number of the insured population (*Load*). It also comprises the indicator of the ratio of the average monthly pension to the subsistence minimum (*Pens*), the indicator of the growth rate of the average nominal pension (*Nom_Pens_GR*), the indicator of the growth rate of the average real pension (*Real_Pens_GR*), and the indicator of the ratio of the received wages of all employed persons to the amount of pension paid to all pension recipients (*Wag*). In addition, the required parameters indicate the rate of monthly pension deductions from the employee's total income (*Rate*), the regularity of contributions to the Unified Accumulative Pension Fund of the Republic of Kazakhstan (UAPF) (*Regul*), coverage of the population contributing to the UAPF (*Cover_Accum*), the average period of pension payment—the difference between average life expectancy and retirement age (*Term*), and rate of profit on pension savings (*Prof*).

According to the methodology of the World Bank [46] and techniques proposed in [13,47,48], when assessing the pension system efficacy, replacement rates (*Replac*), coverage (*Cover*), and load (*Load*) coefficients are widely used. The replacement rate is considered as an indicator of the ratio of the pension to the previous income/earnings of the pension recipient. The inexpediency of using this indicator in assessing the pension system efficacy is conditioned by the fact that the pension system in Kazakhstan is in the process of reforming, which began in 1998 and continues until now in terms of the development and improvement of the accumulative system. In this context, comparison of payments with payroll deductions that have a significant time lag does not provide an adequate assessment of the efficacy of both the current and the previous pension system. In its essence, the *Replac* indicator is reflected through the *Wag* indicator. The *Wag* indicator enables us to correlate the size of paid pensions in the *i*-th period and the size of the deduction base (wages) in the *i*-th period, at the expense of which pension payments are made. Thus, this indicator allows for a current assessment of the efficacy, with regard to the retirement burden at the time of assessment.

Indicators *Cover* and *Load* also characterize the workload in physical terms. The indicator *Wag* reflects the ratios that are assessed when calculating these coefficients, though only in value terms. The indicator *Wag* characterizes the economic effect reflected by the indicators *Replac*, *Cover*, and *Load* based on the ratio of pension income and expenses, and not just the number of pensioners, excluding the standards of mandatory and voluntary contributions.

The ratio of the average monthly pension to the subsistence minimum (*Pens*) characterizes the pensioners' standard of living. The indicator *Pens* depends on the size of the base of pension payments for solidarity and accumulative systems, which in turn is determined by the replacement rate (*Replac*), coefficients of coverage (*Cover*, *Cover_Accum*) and load (*Load*), the ratio of received wages to the amount pension paid (*Wag*), the rate of monthly pension deductions (*Rate*), the regularity of contributions to the UAPF (*Regul*), the timing of pension payments (*Term*), and the rate of profit on pension savings (*Prof*). On the other hand, the ratio of the received wages to the amount of the pension paid (*Wag*) depends on the pension size with the inverse nature of the dependence.

The growth rate of the average nominal pension (*Nom_Pens_GR*) and the growth rate of the average real pension (*Real_Pens_GR*) depend on the same indicators as *Pens*. In turn, indicators of the dynamics of pension payments exert an impact on the level of pensioners' income (*Pens*). The relationship between the indicators *Nom_Pens_GR* and *Real_Pens_GR* is reflected in the fact that the real pension dynamics is determined by the nominal pension dynamics, adjusted for the inflation rate in the country.

Further use of the pension system efficacy indicators in modeling the interdependent system will lead to multicollinearity of the model and a decreased accuracy of the estimation results. This made it necessary to structure the aforementioned indicators for the purpose of identifying the resulting indicators that reflect the influence of others. The graph method was used to structure the indicators. The implementation of the method for this study involved building an oriented graph based on nodes and edges. Performance indicators of the pension system were used as nodes. The edges of the graph were characterized by the dependencies between the performance indicators. The levels of the hierarchy of indicators were determined empirically based on the results of the construction of the pension system involving: (1) The set of attainability (S_i)—the graph vertices (indicators) to which there is a path from the i -th indicator; (2) the set of predecessor vertices (P_i)—the vertices that lead to the i -th indicator. The first level of the hierarchy was formed by indicators for which the equality $P_i = S_i \cap P_i$ is fulfilled. At the second iteration, the indicators that formed the first level of the hierarchy were excluded, after which the fulfillment of the equality $P_i = S_i \cap P_i$ was re-checked. According to the results of two iterations, all investigated indicators were attributed to a certain level of hierarchy. The indicators that formed the 2nd level of the hierarchy were used to build the model for assessing the effectiveness of the pension system. These indicators became the result and reflected the impact of the 1st level of the hierarchy.

To assess the Kazakhstani pension system efficacy, the annual values of the resulting indicators by region/city for the period 2014–2019 were used, according to [10,15]. These data represent a homogeneous array, as evidenced by the coefficients of variation not exceeding 10%. The representativeness of the sample of indicators was confirmed by the cumulative percentage of variance being 88.7%, (factor analysis was performed using Statistica 12.0 software). The period of research was chosen in the context of a reform of the pension system of Kazakhstan that occurred in 2013, which resulted in the new structure of the pension system that currently exists. This is the maximum period of operation of the current pension system, so the paper assesses the effectiveness of this system during that period. Studying the experience of the previous system does not make sense because of the ineffectiveness of the previous pension framework.

The results of the statistical assessment, which were obtained using factor analysis, were confirmed by using expert assessments. For this, a group of 40 people representing the UAPF of Kazakhstan with at least 5 years of experience in the field of pension provision was formed. The experts were asked to assess: (1) the feasibility of using each of the indicators when assessing the pension system efficacy; and (2) the sufficiency of the proposed indicators for completeness of the pension system efficacy assessment [49] on a 5-point scale. The feasibility of using these indicators was confirmed by expert assessments. The feasibility of using *Pens* indicator was estimated to be 100%, *Nom_Pens_GR* was estimated to be 89% (by 178 points out of 200 maximum), *Real_Pens_GR* was estimated to be 98.5% (by 197 points out of 200 maximum points), and *Wag* was estimated to be 97.5% (by 195 points out of 200 maximum). The sufficiency of the proposed list of indicators was estimated was estimated

to be 97.5%. The degree of consistency of expert opinions, when assessed using the coefficient of variation, did not exceed 2.87% when assessing the feasibility of indicators, and amounted to 3.07% when assessing the sufficiency of the proposed list of indicators. The values of the variation indicators, not exceeding 10%, indicated the consistency of expert opinions on the representativeness of the indicators *Pens*, *Nom_Pens_GR*, *Real_Pens_GR*, and *Wag* while assessing the pension system’s efficacy in the Republic of Kazakhstan.

3.2. Methods

The integral indicator of the efficacy was built on the basis of an additive convolution of the normalized values of the pension system efficacy indicators, regarding their significance coefficients (w). Significance coefficients were determined using a system of formulas:

$$\begin{aligned}
 w_i &= (w_{di} \times w_{ei}) / \sum_{i=1}^n (w_{di} \times w_{ei}) \\
 w_{ei} &= b_i / \sum_{i=1}^n b_i \\
 n &= 4,
 \end{aligned}
 \tag{1}$$

where w_i is a significance coefficient of the i -th indicator when assessing the efficacy of the pension system;

w_{di} is a coefficient of statistical significance of the i -th indicator corresponding to variance percentage of the i -th factor, provided that each factor consists of one statistically significant indicator. The significance of the indicators was determined based on the factor loadings of the indicators and the corresponding factors. Factor loadings $> |0.75|$ were accepted to be significant [42];

w_{ei} is an expert coefficient of statistical significance of the i -th indicator that was determined as a result of expert assessment;

b_i is the sum of points (for an expert group) characterizing the feasibility of using the i -th indicator when assessing the efficacy of the pension system.

Then $I = \sum_{i=1}^n (w_i \times \bar{X}_i)$, where I is an integral indicator of the pension system efficacy, and \bar{X}_i is a normalized value of the i -th indicator.

It was proposed to assess the efficiency of the solidarity and accumulative pension systems by determining the dependence of the integral indicator of the efficacy (I) on the share of solidarity and accumulative pension systems in the structure of pension payments. The adequacy of the constructed model was confirmed by the excess of the empirical value of the F-criterion (104.1) over the tabular value (3.96) at $p = 0.05$.

The state of the labor market is the main factor affecting the efficiency of the pension system [50–53]. Therefore, the indicators of the labor market for 2014–2019 were used as independent variables affecting the forecast indicators of the Kazakhstani pension system efficacy in the context of regions and cities in the Republic of Kazakhstan in line with [15].

To predict the efficacy in the Statistica 12.0 software, a neural network was built, the dependent variable of which was the efficacy indicator (I), and independent variables are labor market indicators; other major factors included the growth rate of the economically active population in units (EAP_GR), the growth rate of the employed population, in units ($Empl_GR$), the growth rate of the unemployed population, in units ($Unempl_GR$), the employment level, in shares ($Empl_R$), and the growth rate of real wages, in units ($Real_Wage_GR$).

The statistical significance of the impact of indicators EAP_GR , $Empl_GR$, $Unempl_GR$, $Empl_R$, and $Real_Wage_G$ on the pension system efficiency at a significance level of $p = 0.05$ was proved by the constructed neural network involving: the percentage of deviation of the dependent variable values calculated by the model from the actual values; the level of educational, control, and test errors.

There is no statistically significant relationship between *EAP_GR*, *Empl_GR*, *Unempl_GR*, *Empl_R*, and *Real_Wage_G*, thereby indicating the absence of multicollinearity in the model.

When using a neural network, the deviation of the calculated values from the actual ones was 1.7%, while this deviation amounted to 16.3% when using a linear regression model and 7.9% when using a vector autoregressive model –7.9%.

4. Results

A graph depicting causal relations between the indicators of the pension system efficacy was built based on a theoretical analysis of the relationship between these indicators (Figure 1). The graph was used to determine the levels in the hierarchy of indicators of the Kazakhstani pension system efficacy (Table 1).

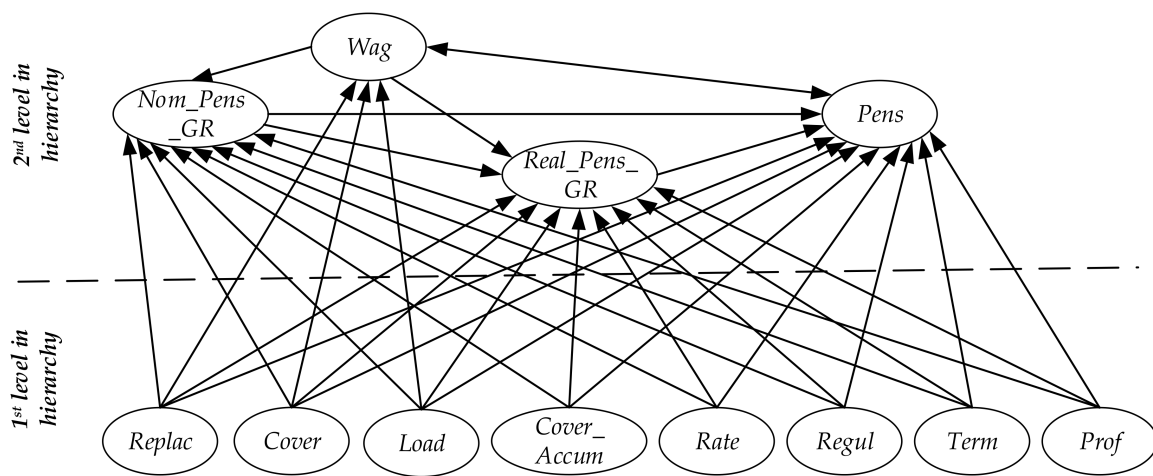


Figure 1. A graph of causal relations between the indicators of the pension system efficacy.

Table 1. Levels in the hierarchy of indicators of the pension system efficacy.

<i>i</i>	<i>S_i</i>	<i>P_i</i>	<i>S_i ∩ P_i</i>	Hierarchy Level
1st iteration				
<i>Replac</i>	<i>Replac, Pens, Nom_Pens_GR, Real_Pens_GR, Wag</i>	<i>Replac</i>	<i>Replac</i>	1
<i>Cover</i>	<i>Cover, Pens, Nom_Pens_GR, Real_Pens_GR, Wag</i>	<i>Cover</i>	<i>Cover</i>	1
<i>Load</i>	<i>Load, Pens, Nom_Pens_GR, Real_Pens_GR, Wag</i>	<i>Load</i>	<i>Load</i>	1
<i>Pens</i>	<i>Pens, Nom_Pens_GR, Real_Pens_GR, Wag</i>	<i>Pens, Replac, Cover, Load, Nom_Pens_GR, Real_Pens_GR, Wag, Rate, Regul, Cover_Accum, Term, Prof</i>	<i>Pens, Nom_Pens_GR, Real_Pens_GR, Wag</i>	-
<i>Nom_Pens_GR</i>	<i>Nom_Pens_GR, Pens, Real_Pens_GR, Wag</i>	<i>Nom_Pens_GR, Replac, Cover, Load, Pens, Real_Pens_GR, Wag, Rate, Regul, Cover_Accum, Term, Prof</i>	<i>Nom_Pens_GR, Pens, Real_Pens_GR, Wag</i>	-
<i>Real_Pens_GR</i>	<i>Real_Pens_GR, Pens, Nom_Pens_GR, Wag</i>	<i>Real_Pens_GR, Replac, Cover, Load, Pens, Nom_Pens_GR, Wag, Rate, Regul, Cover_Accum, Term, Prof</i>	<i>Real_Pens_GR, Pens, Nom_Pens_GR, Wag</i>	-
<i>Wag</i>	<i>Wag, Pens, Nom_Pens_GR, Real_Pens_GR</i>	<i>Wag, Replac, Cover, Load, Pens, Nom_Pens_GR, Real_Pens_GR, Rate, Regul, Cover_Accum, Term, Prof</i>	<i>Wag, Pens, Nom_Pens_GR, Real_Pens_GR</i>	-

Table 1. Cont.

<i>i</i>	S_i	P_i	$S_i \cap P_i$	Hierarchy Level
Rate	Rate, Pens, Nom_Pens_GR, Real_Pens_GR	Rate	Rate	1
Regul	Regul, Pens, Nom_Pens_GR, Real_Pens_GR	Regul	Regul	1
Cover_Accum	Cover_Accum, Pens, Nom_Pens_GR, Real_Pens_GR	Cover_Accum	Cover_Accum	1
Term	Term, Pens, Nom_Pens_GR, Real_Pens_GR	Term	Term	1
Prof	Prof, Pens, Nom_Pens_GR, Real_Pens_GR	Prof	Prof	1
2nd iteration				
Pens	Pens, Nom_Pens_GR, Real_Pens_GR, Wag	Pens, Nom_Pens_GR, Real_Pens_GR, Wag	Pens, Nom_Pens_GR, Real_Pens_GR, Wag	2
Nom_Pens_GR	Nom_Pens_GR, Pens, Real_Pens_GR, Wag	Nom_Pens_GR, Pens, Real_Pens_GR, Wag	Nom_Pens_GR, Pens, Real_Pens_GR, Wag	2
Real_Pens_GR	Real_Pens_GR, Pens, Nom_Pens_GR, Wag	Real_Pens_GR, Pens, Nom_Pens_GR, Wag	Real_Pens_GR, Pens, Nom_Pens_GR, Wag	2
Wag	Wag, Pens, Nom_Pens_GR, Real_Pens_GR	Wag, Pens, Nom_Pens_GR, Real_Pens_GR	Wag, Pens, Nom_Pens_GR, Real_Pens_GR	2

Note: *i*—indicator; $S(z_i)$ —a set of attainability; $P(z_i)$ —a set of preceding vertices.

The efficacy of a pension system is ensured by having a high standard of pensioners’ standard of living in conjunction with a minimum pension burden on workers, which was confirmed by the results of determining the hierarchy of indicators. The indicators that formed the 2nd level of the hierarchy include the ratio of the average monthly pension to the minimum subsistence level (*Pens*), the growth rate of the average nominal pension (*Nom_Pens_GR*), the growth rate of the average real pension (*Real_Pens_GR*), and the indicator of the ratio of the received wages of all employed persons to the amount of pension paid to all pension recipients (*Wag*). These indicators are resultant ones, which reflect the influence of indicators of the 1st level in the hierarchy. Therefore, they were used to assess the efficacy of the pension system in Kazakhstan.

The system of indicators was designed in such a way as to reflect the living standard of pensioners, provided by pension payments, and the burden on workers by comparing the amount of pensions paid with the size of employees’ average wages (the deduction base). The use of the wage indicator was conditioned by the fact that its size influences the amount of deductions to the UAPF and the amount of the individual income tax paid, which is one of the sources forming the revenue part of the Republican budget, which provides pension payments according to the solidarity system.

The factor structure of the pension system efficacy and coefficients of significance of indicators, corresponding to the factor variance percentage were determined using factor loadings (Table 2).

The cumulative factorization percentage of 88.7% (exceeding 80% [42]) is a statistical confirmation that the proposed list of indicators is representative and sufficient to describe the Kazakhstani pension system efficacy. The coefficients of significance of indicators (w_d) correspond to the factor variance percentage with which indicators *Pens*, *Nom_Pens_GR*, *Real_Pens_GR*, and *Wag* have significant factor loadings. The coefficients of significance of the indicators made $w_{dPens} = 0.268$, $w_{dNom_Pens_GR} = 0.168$, $w_{dReal_Pens_GR} = 0.204$, $w_{dWag} = 0.247$. The disadvantage of this approach to determining the relative significance of indicators is that the factor analysis technology does not provide for the presence of a dependent variable. The calculated variance percentages show for how many percent each of the factors (indicators) explains the change in the system described using these indicators. The representativeness

of the indicators *Pens*, *Nom_Pens_GR*, *Real_Pens_GR*, *Wag* when assessing the pension system efficacy and expert assessments for the coefficients of the significance (w_e) of indicators when building an integral model of the pension system efficacy is indicated in Table 3.

Table 2. Factor loadings of the Kazakhstani pension system efficacy indicators.

Indicator	Factor			
	F1	F2	F3	F4
<i>Pens</i>	0.91 *	−0.21	0.07	0.24
<i>Nom_Pens_GR</i>	0.47	0.33	0.51	0.81 *
<i>Real_Pens_GR</i>	0.29	0.13	0.88 *	0.35
<i>Wag</i>	−0.40	0.90 *	0.31	0.16
Factor variance percentage, %	26.8	24.7	20.4	16.8

Note: * marks the significant factor loadings of indicators (>|0.75|).

Table 3. Coefficients of the relative significance of indicators in the integral model for assessing the Kazakhstani pension system efficacy.

Coefficients of the Relative Significance of Indicators	Indicator			
	<i>Pens</i>	<i>Nom_Pens_GR</i>	<i>Real_Pens_GR</i>	<i>Wag</i>
w_d	0.268	0.168	0.204	0.247
w_e	0.260	0.231	0.256	0.253
w	0.312	0.174	0.234	0.280

The results of expert assessments show that indicator *Pens* is the most significant indicator in assessing the pension system efficacy; its relative significance is 0.260. The significance of the indicators was assessed as follows: *Real_Pens_GR* = 0.256, *Wag* = 0.253, *Nom_Pens_GR* = 0.231. All indicators have a direct impact on the pension system efficacy. Taking into account the variance percentage and expert assessments, the coefficients of significance (w) were calculated using Formula (1). According to them, *Pens* (w_{Pens} = 0.312) was the most influential indicator; its priority was proven by the results of factor analysis and expert assessment. The coefficients of the relative significance of other indicators were: $w_{Nom_Pens_GR}$ = 0.174, $w_{Real_Pens_GR}$ = 0.234, w_{Wag} = 0.280.

Regarding the weighting factors, the model for assessing the pension system efficacy can be written as:

$$I = 0.312 \times \overline{Pens} + 0.174 \times \overline{Nom_Pens_GR} + 0.234 \times \overline{Real_Pens_GR} + 0.280 \times \overline{Wag} \quad (2)$$

Based on the normalized values of indicators and their coefficients of significance, an integral assessment of the pension system efficacy was obtained across the regions (Table 4).

Indicators *Pens*, *Nom_Pens_GR*, *Real_Pens_GR*, *Wag* are stimulants; therefore, an increase in *I* indicates an increase in the efficacy. According to the results obtained, the Atyrau Region, East Kazakhstan Region, Nur-Sultan (Astana until 2019), and Almaty cities demonstrate the highest efficacy of the pension system during 2014–2019. Of these, the Atyrau Region, Nur-Sultan, and Almaty cities have the highest percentages of pension payments in Kazakhstan owing to the accumulative system: 27.6%, 24.6%, 19.0%, respectively, with an average national percentage of 11.9% for the period of 2014–2019. The Kyzylorda, Jambyl, and North Kazakhstan Regions showed the lowest efficacy of the pension system, with the accumulative system not exceeding 8% in the pension provision structure in these regions.

Table 4. Values of the integral assessment of the pension system efficacy as broken down by regions/cities of Kazakhstan (*I*).

Region/City	Period					
	2014	2015	2016	2017	2018	2019
Akmola Region	−0.183	0.039	−0.134	−0.213	−0.208	0.228
Aktobe Region	0.395	0.143	−0.122	0.232	−0.076	0.220
Almaty Region	−0.492	−0.355	−0.196	−0.081	−0.173	0.038
Atyrau Region	0.654	0.320	0.599	0.183	0.789	0.376
West Kazakhstan Region	0.279	−0.091	−0.219	0.103	−0.237	−0.264
Jambyl Region	−0.406	−0.166	−0.219	−0.231	−0.138	−0.208
Karaganda Region	−0.441	−0.043	0.162	0.063	0.070	−0.124
Kostanay Region	0.352	0.068	−0.284	0.271	0.132	0.133
Kyzylorda Region	−0.582	−0.891	0.138	−1.145	−0.952	−0.744
Mangystau Region	0.481	−0.094	0.199	0.693	−0.160	−0.095
Pavlodar Region	−0.039	0.321	−0.117	−0.309	0.192	0.004
North Kazakhstan Region	−0.403	−0.016	−0.168	−0.563	−0.094	−0.132
East Kazakhstan Region	0.236	0.437	0.253	0.263	0.621	0.566
Nur-Sultan city	0.666	0.412	0.480	0.842	0.577	0.652
Almaty city	0.004	0.426	0.308	0.500	0.465	0.567

The relationship between the integral indicator of the pension system efficacy and the shares of accumulative and solidarity systems is described by the function:

$$I = -2.24 \times r_a^2 + 3.56 \times r_a - 0.43 \tag{3}$$

where r_a is part of pension payments made through the accumulative system (from the RK UAPF), expressed in shares.

The polynomial function of dependence of the pension system efficiency indicator on the share of the savings system demonstrates the second stage of the function behavior. At the first stage, the growth of the share of the funded system leads to the growth of the efficiency index. This growth slows down at the maximum point, which corresponds to the maximum possible efficiency of the existing pension system of Kazakhstan at this level of economically active population and employment, and through the dynamics of real wages. Further growth of the share of the savings system leads to a decrease in the efficiency of the pension system. The model has been used to determine the optimal ratio of the funded and solidary pension systems, where the efficiency is aimed at maximizing the efficiency of the existing pension system.

Finding the first-order derivative I' enabled us to determine the target value of the accumulative system share in the structure of pension payments, at which the maximum level of the pension system efficacy is achieved ($I = max$). When $r_a = 0.795$ $I' = 0$, $I = max$. Within the range of values of the indicator $r_a \in [0; 0.795]$, an increase in the share of the accumulative system promotes an increase in the pension provision efficacy, after which a further increase in the accumulative system share will lead to a decrease in the overall efficacy due to an increase in the burden on the potential pension recipient. The optimal participation of the state makes 20.5%. We have developed a model for forecasting the effectiveness of the pension system of Kazakhstan under the influence of the state of the labor market; its characteristics are shown in Table 5.

Table 5. Statistical characteristics of the model for forecasting the Kazakhstani pension system’s efficacy.

Neural Network Hierarchy	Training Error	Test Error	Validation Error	Deviation of Calculated Values from Actual Ones, %
MLP 5-8-4-1	0.0003	0.0008	0.0006	1.7

The adequacy of the constructed neural network was confirmed by the fact that the deviation of the calculated values of the resulting indicator, obtained using the constructed model, from the actual ones does not exceed 5%, with the training, test, and validation errors not exceeding 0.0008. Determined coefficients of elasticity of the dependent variable on the independent variable indicate that:

When indicator *EAP_GR* grows by 1% as compared to the 2019 value, the integral indicator of the efficacy increases by 1.38%;

When indicator *Empl_GR* grows by 1% as compared to the 2019 value, the integral indicator of the efficacy increases by 1.76%;

When indicator *Unempl_GR* grows by 1% as compared to the 2019 value, the integral indicator of the efficacy decreases by 1.93%;

When indicator *Empl_R* grows by 1% as compared to the 2019 value, the integral indicator of the efficacy increases by 1.58%;

When indicator *Real_Wage_GR* grows by 1% as compared to the 2019 value, the integral indicator of the efficacy increases by 1.83%.

To determine the prospects for the development of solidarity and accumulative pension systems, the authors used the dynamics of the values of *EAP_GR*, *Empl_GR*, *Unempl_GR*, *Empl_R*, and *Real_Wage_GR* as a whole for the Republic during 2002–2019. Descriptive characteristics of indicators for this period are given in Table 6. The transition from the regional level of analysis (which was used to build an integral model for assessing the pension system efficacy and a model for forecasting its efficacy) to the Republican level (which was used to obtain predicted values for the pension system efficacy indicator) was conditioned by the need to determine the general development prospects for the pension system in Kazakhstan.

Table 6. Descriptive characteristics of the indicators of the Kazakhstani pension system efficacy for 2002–2019.

Indicator	Descriptive Characteristics				
	Z_{min}	Z_{max}	Z_{av}	V	GR_{av}
<i>EAP_GR</i>	0.989	1.035	1.012	1.2%	1.0012
<i>Empl_GR</i>	0.991	1.041	1.015	1.4%	1.0005
<i>Unempl_GR</i>	0.885	1.005	0.969	3.6%	1.0068
<i>Empl_R</i>	0.907	0.952	0.937	1.6%	1.0029
<i>Real_Wage_GR</i>	0.977	1.091	1.028	4.1%	1.0023

Note: Z_{min} —the minimum value of the indicator for the period of 2002–2019; Z_{max} —the maximum value of the indicator; Z_{av} —the arithmetic mean of the indicator; V —the coefficient of variation of the indicator, %; GR_{av} —the average chain growth rate of the indicator.

During 2002–2019, values of indicators *EAP_GR*, *Empl_GR*, *Unempl_GR*, *Empl_R*, and *Real_Wage_GR* were at a stable level, as evidenced by the coefficient of variation of 1.2–4.1%. The geometric average growth rate of the indicators for this period was 1.0012 for *EAP_GR*, 1.0005 for *Empl_GR*, 1.0068 for *Unempl_GR*, 1.0029 for *Empl_R*, and 1.0023 for *Real_Wage_GR*.

Average growth rates of indicators (GR_{av}) were used as the basis for forecasting the pension system efficacy. If the current trends in the labor market development are observed, in the future the indicator of the Kazakhstani pension system efficacy will decrease by 0.20% annually.

The growth in the number of the unemployed exerts the main destabilizing effect on the pension system efficacy. The average increase in this indicator for the period 2002–2019 is 0.68%. A rising

unemployment rate leads to a decrease in the potential base for pension payments. A decrease in the total amount of wages received (due to the lack of wages for the unemployed) results in a decrease in the amount of income tax as a source of budget replenishment and basic pension payments, a decrease in the amount of mandatory contributions under the accumulative system, and reduced opportunities for increasing voluntary contributions. In addition, unemployment leads to higher state payments being needed, which creates an additional burden on the budget. Therefore, further growth of the unemployment index by 0.68% leads to a decrease in the integral indicator of the pension system efficacy by 1.31%.

The negative impact of unemployment growth on the pension system efficacy is compensated for by the growth of the economically active population (a growth of the integral indicator by 0.16%), the employment rate (a growth of the integral indicator by 0.09%), the employment level (a growth of the integral indicator by 0.45%), and real wages (a growth of the integral indicator by 0.42%).

5. Discussion

An approach to the economic and mathematical substantiation of target indicators is needed for the participation of solidarity and accumulative pension systems. This approach is based on determining the impact of part of the solidarity and accumulative systems on the integral efficacy of the pension system. The methodology of the current and prospective assessment of this efficacy as exemplified by this Kazakhstan case study reflects the macroeconomic level of the pension provision efficacy. It assumes an integral assessment rather than an assessment by particular indicators, in contrast to the existing techniques used [6,7,20].

The method for determining the weight factors of indicators in the model of the current assessment makes it possible to combine statistical and expert characteristics of indicator significance, which ensures high accuracy of the assessment results. This approach enables assessing the synthetic efficacy of the pension system rather than the impact of pension provision on economic activity in the country from the viewpoint of the adequacy of pension payments in relation to the pensioners' standard of living [20]. Thus, the pension system efficacy is perceived as a macroeconomic category and, with regard to specific conditions, it is substantiated as the ratio between the pension system adequacy (including protection against poverty and consumption smoothing) and its cost, pension costs, and negative effects on the economy, especially in the labor market.

Taking into account the different opinions of scholars as to pension provision models, the presented methodology for determining the pension system efficacy made it possible to consider the peculiarities and development trends of the pension system in the country. It ensures the development of a flexible component structure of pension provision, focused on specific goals, provides consideration of specific conditions, and assumes the identification of criteria by which the pension reform will be compared with the existing schemes. The presented empirical calculations make it possible to compare solidarity and accumulative pension systems within one country, and quantitatively assess the time intervals in which one system is preferable to the other, as well as the efficiency and proportionality of their combination. Overall efficacy is significant when comparing pension systems because it is synthetic and takes into account many aspects of the pension system operation.

The results of the study enabled us to conclude that for Kazakhstan, it is advisable to employ a mixed model of the pension system (solidarity + accumulative) at the current stage of development. At the same time, there is an urgent need to increase the accumulative part of the pension system to 79.5% in the structure of financing pension payments, which will ensure maximum efficacy of the pension system at the macroeconomic level. According to the Labor Code of the Republic of Kazakhstan and the Law "On Pension Provision in the Republic of Kazakhstan" [8], persons of working age include citizens aged 16–58 years (women) and 16–63 years (men) with an envisioned increase in the working age for women to 63 years until 2027. Considering these amendments in legislation, the maximum employment duration for pension provision by 2027 will be 47 years. The real rate of return on UAPF deposits is 2.5% [10]. Under these conditions, taking into account the annuity scheme

for calculating interest rate on pension contributions, the frequency of deductions and interest charges once a year, calculated for the optimal participation of the accumulative system (79.5%) to ensure a replacement rate of 40%, as recommended by the International Labor Organization, the annual rate of contributions to the UAPF must be at least 17.05% of an average person's wages. With the employment duration of 45 years it should be 17.55%; in the case of 40 years' employment duration it should amount to 18.87%, and it should be 20.26% in the case of 35 years of work experience. Under the current circumstances of the labor market development in Kazakhstan, this is only possible with the implementation of radical reforms based on taking the following measures: introducing flexible rates of pension contributions to the UAPF, providing economic substantiation of minimum pension guaranteed by the state, developing an effective mechanism for declaring the income and expenses of the population, ensuring the coverage of the working population make adequate contributions to the pension system up to a level of at least 90% of the efficient level, etc. The practical implementation of this system of measures will contribute to the financial stability of the pension system in Kazakhstan, as well as the adequacy of pension payments for a decent standard of living at the retirement age.

It should be noted that the deep problems and reform of the pension system in Kazakhstan and the rapid acceleration of changes in the existing economic conditions complicate the real achievement of its effectiveness in practice. In view of this, attention should be focused on the need for innovative development of funded pension provision in the country [54,55]. In view of the functioning of the pension system of Kazakhstan in conditions of fundamental and institutional problems that cannot be quickly resolved, the need to use an open innovation strategy has been determined. It is open innovations that make it possible not to waste resources on expensive R&D, but instead to concentrate on the most profitable innovative projects to achieve synergy of efficiency in the implementation of pension reform in the country. For the Kazakhstani realities of the pension system, this can be especially relevant in connection with the need to retain promising students, graduate students, and scientists. Since open innovations take a variety of forms, the main effect of their implementation in the pension system of Kazakhstan should be based on innovative start-ups for the implementation of business models of the future, ensuring they can achieve financial security for life and protecting the value of participants' pension contributions from market fluctuations by transferring them to funds with a lower level of risk as we approach the date of retirement. In modern conditions, the pension system is entering a new stage of innovation, when the sources of the innovative potential of pension provision are outside this system [55]. Open innovation strategies based on the principles of individual decision-making and personal lifestyles can also help diversify the pension investments of the population in appropriate funds in order to best generate an appropriate level of pension benefits when people retire.

The possibilities of using a predictive model for assessing the pension system efficacy in Kazakhstan are limited because of the lack of sufficient data. This does not allow for a more accurate forecast of the development dynamics of the accumulative pension system for a long period. The models are constructed based on data for Kazakhstan; in this regard, certain targets for the development of accumulative and solidarity pension systems (their ratio in shares) are applicable only for Kazakhstan. In addition, labor market indicators should be considered as relevant to the entire pension system, as not only public, but also private schemes can influence decisions to leave the labor force. For this reason, the analysis of the efficacy carried out using the proposed approach may require further and deeper study of the pension provision efficacy. This research can be treated as a contribution to the discussion on the reform of the pension system in the former communist countries belonging to the Soviet Union. These countries struggle with many serious social problems, including corruption, as indicated by Transparency International. From such a perspective, this article seems useful. However, the proposed methodology is universal and can be used in assessing the pension system efficacy and determining the prospects for its development for other countries that use solidarity and accumulative pension systems.

6. Conclusions

Based on this research, the following conclusions were drawn. Under conditions of a low birth rate, increased life expectancy, low income of the population, and an extensive shadow economy, the functioning of the synthetic model for pension provision seems appropriate for the current pension system of Kazakhstan, with the accumulative model dominating in the structure of pension provision. Since the labor market is determined to be one of the fundamental factors of the Kazakhstani pension system's efficacy, the share of the accumulative model in the structure of the pension system should be increased to 79.5%, while the annual rate of dedications to the UAPF should be at least 17.05% of average wages. This will ensure maximum efficacy of the pension system on a macroeconomic scale. If the current trends in the labor market development persist, then the indicator of the Kazakhstani pension system efficacy will annually decrease by 0.20%. This decrease would be caused primarily by the increasing unemployment rate.

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